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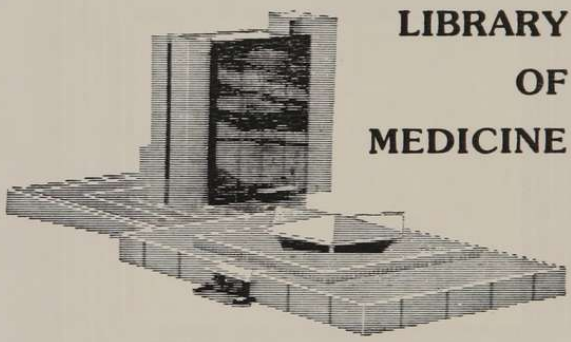

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AN AMERICAN

TEXT-BOOK OF SURGERY,

FOR

PRACTITIONERS AND STUDENTS.

BY

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TO THE

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PREFACE TO THE SECOND EDITION.

THE success of the AMERICAN TEXT-BOOK OF SURGERY, as evinced by its extraordinary sale and its adoption as a text-book in over sixty medical schools in this country, as well as by a large sale abroad, has been most gratifying both to the editors and to their colleagues. The three years that have elapsed since the first edition was published have been years fruitful in surgical progress, and, accordingly, a number of topics have been added to the text, as well as others expanded which seemed to have had inadequate treatment in the first edition. An endeavor has been made to take advantage of the kindly criticism in the medical press to make good many deficiencies and to correct some errors. It is impossible to enumerate all of the many changes in the text, but among others may be mentioned the effect of modern small-arms in military surgery; a new section on Acromegaly; the Hartley-Krause method of removing the Gasserian ganglion; the osteoplastic method of resection of the skull, with a number of additions to operations and methods in endocranial and spinal surgery; in the surgery of the chest, a description of Schede's operation; in the surgery of the digestive tract, Witzel's method for gastrostomy; the use of Murphy's button in intestinal anastomosis; the consideration of retro-peritoneal tumors and of castration for enlarged prostate; a chapter on Symphyseotomy; Macewen's method of compressing the aorta in amputation at the hip-joint, etc.

The sections dealing with Fractures and Dislocations, Appendicitis, the Radical Cure of Hernia, and the more recent methods in Amputations of the Breast have been especially enlarged, particularly in the matter of treatment. Displacements of the Uterus have been also regrouped and the chapter largely rewritten.

Many of the illustrations have been redrawn, and a number of new ones have been substituted for old ones. In the present edition each illustration that is not original has been credited to its author immediately under the cut, instead of the credit being given in a List of Illustrations. The names of instrument-makers have been removed from the cuts, and credit has been given to the makers in a separate list, which will be found at the end of the Index.

WILLIAM W. KEEN,
J. WILLIAM WHITE,
Editors.

PHILADELPHIA, November, 1895.

PREFACE.

THE great advances which have been made in the Science and Art of Surgery within the last few years have created a need for new sources of reference, both for the student and the practitioner—a need which has been met to some extent abroad, but not so thoroughly in this country. For this reason the present Text-Book has been prepared by American authors who are teachers of surgery in leading medical schools and hospitals. Many of the most important subjects are considered from a new standpoint, and especial prominence has been given to Surgical Bacteriology, and to the most recent methods of treatment, particularly in relation to Asepsis and Antisepsis, and to the newer methods in those departments in which of late such notable progress has been made, as in cerebral, spinal, abdominal, and pelvic surgery, etc.

The entire book has been submitted in proof-sheets to all of the authors for mutual criticism and revision. As a whole, the book may therefore be said to express upon important surgical topics the consensus of opinion of the surgeons who have joined in its preparation, although it must be understood that, while it thus represents in general the views of all the authors, each individual author is free from absolute responsibility for any particular statement. Minor differences of opinion necessarily exist, and are recognized in the text.

The Editors assume the responsibility for the orthography, for the general plan of the book, and for the method of mutual criticism and of unsigned chapters.

Very many of the illustrations are original, among them the bacteriological colored plates and the numerous half-tone plates, which are reproduced with great fidelity from photographs of patients or of specimens, and which it is believed add to the value of the work both artistically and surgically. A large number of the wood-cuts and some of the colored plates have been taken from other authors, and are credited to them in the List of Illustrations; and the Editors desire to express their thanks, not only to the authors, but to the publishers of the various works, both American and foreign, from which these

illustrations have been taken, for their uniform courtesy and liberality in aiding their work as far as possible.

The Editors desire also especially to thank Dr. J. Chalmers DaCosta for preparing the index and for valuable aid in other ways, and Mr. Joseph McCreery for his very careful revision of the proof-sheets, and to express their appreciation of the unvarying courtesy and efficient co-operation of Mr. Saunders.

WILLIAM W. KEEN,
J. WILLIAM WHITE,
Editors.

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AN AMERICAN TEXT-BOOK OF SURGERY.

BOOK I.

GENERAL SURGERY.

CHAPTER I.

SURGICAL BACTERIOLOGY.

Bacteria or **micro-organisms**, or **microbes**, as they are variously called, belong to the lowest order of the *vegetable kingdom*, and are closely allied to the algæ. They derive their name from *βακτήριον*, a rod, which some of them resemble in shape. The developed organism is, in form, a cell, consisting of a membrane enclosing a protoplasm. This protoplasm can be strongly stained by aniline dyes. The membrane, with difficulty separated from the contents, consists of a substance closely allied to cellulose. It is not usually visible, but when treated in water its outer layer may swell and form a gelatinous envelope or capsule. During the process of division this holds the organisms together, and as they multiply may form the zoöglea or glue-like mass in which they are sometimes grouped. Many bacterial growths are highly colored, being red, yellow, or blue; according to some observers the coloring matter is in the protoplasm; according to others, it lies in granules which have been exuded—both theories are true. Many forms of bacteria possess no movement whatever, as is the case with the micrococci and the anthrax and tubercle bacilli. The great majority are at times capable of motion.

The **principal forms** of bacteria are the **micrococcus** or globular form (*κόκκος*, a berry), the **bacillus** or staff shape (**bacillus**, a little rod or staff), and **spirillum** or spiral shape.

The micrococci, when developing rapidly, are seen often in the stage of division, and, being grouped in "pairs," are called **diplococci**. When arranged in rows or "chains" they are called **streptococci** (*στρέπτος*, a chain); when bunched together in "grape-like" masses they are called **staphylococci** (*σταφυλή*, a bunch of grapes.)

These forms undergo no essential changes, although under differing conditions they may have an altered appearance. They multiply by fission, the

process being more readily observed in the cocci than in the bacilli. A number of the bacilli and a few spirilla undergo germination, spore-formation taking place within the cell before it is finally destroyed. There may be only one spore to each cell, the spore thus formed possessing an extremely dense enveloping membrane, which protects it from external influences until it can find conditions favorable for future growth. The cell is usually distended either in the middle or at one end by the spore, and when the latter has reached its full development the cell-membrane undergoes a gelatinous softening, the cell breaks up, and the spore is free. When the spore begins to develop into a bacillus it loses its tough envelope, and is then much more readily destroyed.

Bacteria are to be found everywhere, even occasionally in the interior of the healthy living tissues. They exist in the air, the soil, the water, in our clothing, on the surface of our bodies, and on the mucous membrane of the intestinal and respiration tracts. They grow best in alkaline or neutral media. They multiply under favorable conditions with great rapidity: according to Cohn, a bacillus divides into two in the space of an hour, into four at the end of a second hour, and so on. In twenty-four hours the number of bacteria derived from a single bacillus will amount to sixteen and a half millions. It is chiefly in dead organic substances that they find a favorable soil, and it is through them that the process of decomposition is carried on. Those concerned in this process are called **saprophytic** or **saprogenic**. A certain number grow in the living body, causing by their presence morbid conditions, and are known as the **pathogenic** or disease-producing bacteria. Those which produce pus are known as **pyogenic** bacteria.

Pasteur divided bacteria into *aërobic*, or those which live best in the presence of oxygen, and *anaërobic*, or those which live without oxygen. The greater portion of the bacteria are aërobic. Some are so sensitive that a slight diminution in the amount of oxygen is sufficient to prevent their development. These are called the *obligate* aërobic bacteria. Others, however, can grow well in media rich in oxygen, but are also able to grow where there is no oxygen. These are called the *facultative* aërobic bacteria. Most of the pathogenic bacteria belong to this variety, the oxygen of the body not being found in large quantities and being soon consumed by the micro-organisms in their growth. It is rare that we find a strictly anaërobic pathogenic form. An example of this variety is the bacillus of tetanus. The presence of sunlight is unfavorable to the growth of bacteria.

During the process of decomposition very powerful poisons known as **ptomaïnes** (πτῶμα, a dead body) are developed in the presence of saprophytic bacteria. They resemble alkaloids in their physiological action, and when absorbed into the body may produce more or less marked constitutional disturbance. The sepsin of Bergmann and the cadaverin and putrescin of Brieger are examples of these chemical substances. To this class probably belong the "toxines." Some of these substances appear to have an inhibitory influence upon the micro-organisms, and it is in virtue of this action that many of the artificial cultures of bacteria after a period of growth cease to develop. *Leucomaïnes* are animal alkaloids which result from tissue-metabolism in the body independently of bacteria. Their rôle in pathology is as yet not well defined.

It is not yet fully settled *how the bacteria act* upon the living tissues of the body: by some it is supposed that the symptoms of infectious disease are produced by the chemical substances which they elaborate as a sort of specific excretion; others believe that the phenomena of disease are produced by the changes brought about in the tissues by the organisms during their growth,

and that it is not necessary to assume the development of a particular virus. Such action of the micro-organisms will produce locally what is known as irritation or inflammation. The chemical substances produced are, moreover, diffused throughout the body, and in virtue of a ferment-like action greatly increase the tissue-metamorphosis and act also upon the thermic centres, producing fever or "constitutional disturbance." Occasionally we have an absorption of ptomaïnes alone, which may be introduced in large amounts, producing grave disturbances. Such a condition is known as septic intoxication or toxic infection, as distinguished from septic infection of bacteria.

The effect of the virus of certain diseases upon the tissues of the body is often such as to afford a *protection against future attacks*. This is thought by Pasteur to be due to the exhaustion of a supposed chemical substance necessary for the growth of the micro-organisms. According to Fraenkel, certain products of bacterial action are left behind after the first invasion, and prevent a return of the same kind of organism. Metschnikoff has advanced the theory that the leucocytes, seen in such large numbers in inflammatory processes, possess the power to attack and destroy the invading bacteria, taking them up into their protoplasm. He gives these amœboid cells the name of **phagocytes.** The general weight of opinion seems to be that predisposition to disease means chiefly that the tissues of the body offer a soil the chemical composition of which is favorable to the growth of bacteria, and that immunity is possessed by those tissues which furnish a soil unfavorable for their development. The chemical constitution of the liquor sanguinis is therefore an important element in the solution of this question.

Pfeffer has recently called attention to the faculty possessed by all motile bacteria of moving toward or away from certain substances which attract or repel them, and has given to it the name of *chemiotaxis*. The leucocytes and various others cells possess the same property, and their phagocytic action is but a part of the general power which they have of incorporating into themselves and then removing foreign dead or offending material. Further investigation in this direction may explain immunity in some instances.

The question of the direct *transmission* of microbic disease from parent to offspring is one not susceptible of easy demonstration. There are two routes through which hereditary disease may be communicated: through the placenta during intra-uterine life, or during the act of conception through the semen as a vehicle. Placental infection has been observed in small-pox, erysipelas, typhoid, and intermittent fever. Glanders has been transmitted in this way from mare to foal, and the bacilli of anthrax, glanders, and malignant œdema have been shown by experiment to pass through the placenta to the fœtus. The tubercle bacillus has been found in the seminal fluid of consumptives not suffering from tuberculosis of the genital organs. Tubercular lesions have been found in the human fœtus at varying periods of intra-uterine life. There is therefore no doubt that this disease may be transmitted from parent to child: it is merely at the present time a question of the frequency and method of transmission of the disease (Baumgarten). It is also well known that syphilis may be acquired through both the semen and placenta, although the fact that no specific organism has as yet been discovered renders it impossible to furnish the bacteriological proofs.

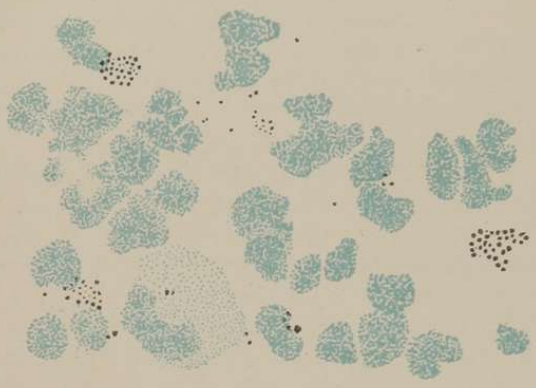
Most bacteria grow best at a *temperature* varying from 86° to 104° F. The saprophytic or putrefactive organisms prefer a temperature of about 75° F., or the ordinary house temperature. The pathogenic bacteria grow best at a temperature of from 95° to 104° F. Subjecting solutions containing bacteria to freezing temperatures does not generally kill the micro-organisms. They

all lose the power of movement and reproduction at this temperature, but may preserve the power to resume their activity at a higher temperature. Cohn has reduced the temperature of liquids containing bacteria as low as —186° F. without destroying their vitality. Cold is therefore an agent which cannot be employed to destroy these organisms. Experiments show that organisms containing *spores*, like the bacilli of anthrax, *are much more difficult to kill* than the micrococci, which do not contain spores. If dry heat is used as a means of sterilization, it is necessary to expose the latter to a temperature of 212° F. for an hour and a half in order to destroy them. Bacilli containing spores, however, must be subjected to a temperature of 284° F. for three hours before they are rendered incapable of further growth. The dry heat, moreover, does not always penetrate easily to the centre of articles subjected to this process, and most materials, and particularly instruments, are permanently injured by such high temperatures.

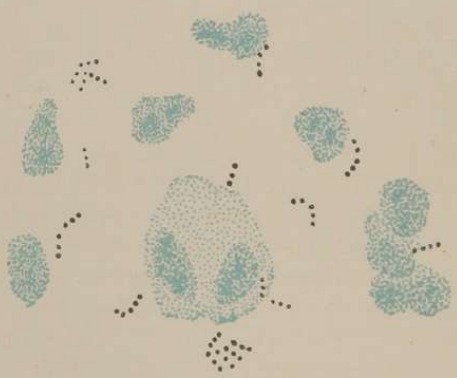
The fact that *boiling water* will kill all kinds of organisms and spores in a few minutes suggested the application of hot steam for the purpose of disinfection. Experiments showed that moist heat had in fact a much greater germicidal value than dry heat. In Koch's sterilizer all kinds of bacteria are destroyed in half an hour when subjected to a temperature of 212° F., even in those cases where the organisms were surrounded by voluminous dressings and materials of different kinds. Most of the ordinary pyogenic bacteria are micrococci, and therefore produce no spores. They are not tenacious of life, but are easily destroyed by heat. The bacilli of anthrax, malignant œdema, and tetanus, spore-bearing surgical bacteria, can practically be left out of consideration in the sterilization of surgical instruments. The following experiment shows how readily the ordinary surgical bacteria can be destroyed: Agar-agar tubes planted with a mixed growth of cocci were exposed to the action of steam in the Arnold sterilizer, and one tube was removed at the end of five minutes, a second tube at the end of ten minutes, and so on. A second series of tubes was inoculated from the first tube removed, and all of them remained sterile. No further growth occurred in the original tubes, showing that the micrococci were destroyed by the action of the steam for the minimum length of time, five minutes (A. K. Stone).

The Arnold sterilizer, which is cheap and convenient, and is in common use in America at present, furnishes a rapid and easy method of generating steam, and when in action can prepare a set of instruments for a surgical operation in five minutes' time. The short period during which the instruments are exposed to the heat renders them much less liable to injury, which is almost certain to follow longer exposure, and which has rendered unpopular this mode of sterilization among many surgeons.

The most powerful of *bactericidal drugs* is corrosive sublimate. A solution of 1 : 1,000,000 exercises a marked retarding influence upon the development of bacteria. A solution of 1 : 20,000 kills the spores of bacilli in ten minutes, and a solution of the strength of 1 : 1000, according to Koch, destroys the most powerful organism in a few minutes, without any previous preparation of the object to be disinfected. Aqueous solutions of carbolic acid, in the strength of 1 : 100, destroy in two minutes sporeless anthrax bacilli, and in the strength of 1 : 30 is sufficient for all ordinary surgical purposes, as it retards the development of the spores and kills the mature organisms. But solutions in oil have not the least influence upon the life of micro-organisms. Boric acid and salicylic acid have been regarded as useful antiseptic drugs, but their germicidal power is now known to be almost nil. Iodoform is not a germicide, but markedly retards the growth of bacteria; used as a powder, it



1. Staphylococcus pyogenes aureus and albus: *a*, pus-cell with nuclei; *b*, free nuclei.
[*Camera Lucida. Zeiss Apochromatic objective 2.0 mm. ocular b.*]



2. Streptococcus pyogenes in pus: *a*, pus-cell with nuclei; *b*, free nuclei.
[*Same power as fig. 1.*]

has a tendency to stop serous oozing, a condition favorable to bacterial growth. When moistened it liberates iodine, which has a certain antiseptic value. It does not procure asepsis of material, instruments, or wounds.

The *microscopical study* of bacteria has been greatly facilitated by the use of the Abbé condenser, which is placed beneath the object-glass and throws a cone of rays with a very broad base, thus giving powerful illumination of the section and making it possible to use higher powers which would otherwise cut off the light. By this means the section is flooded with light and the structure of the tissues is made quite transparent. If now we use aniline dyes, which stain the micro-organisms, and wash the sections afterward in alcohol or acetic acid, the coloring matter will be in great part removed from the tissues, and the bacteria alone will retain the dye. In this way the bacteria are readily distinguished from other objects, when examined with suitable lenses. For this purpose immersion lenses alone are reliable. Furthermore, contrast-stains can be often advantageously employed, by means of which the tissues are given a decidedly different though paler hue. Fragments of tissue which it is desired to examine for bacteria should be cut in pieces half an inch square and placed immediately in absolute alcohol. This should be changed once or twice, and in two days the specimen is ready for cutting. The sections are placed for five to fifteen minutes in dilute solutions of fuchsin or gentian-violet. They are then decolorized in acidulated water, and afterward washed in water; after alcohol has been used to remove the water from the specimen it is mounted in Canada balsam.

It is often necessary to examine the *urine* or the *sputa* for tubercle bacilli, for the purposes of diagnosis. The urine, which should be collected in considerable quantity, is allowed to deposit a compact sediment. A small portion of this sediment is spread upon a thin cover-glass held by a pair of forceps. It is best to let this become nearly or completely dry, and then to pass the cover-glass three times gently through the flame of an alcohol lamp in order better to fix upon the glass the material it is proposed to examine. If the sediment is light, a second or even a third drop is added, and each time evaporated to dryness. The cover-glass is now placed in the following solution, (Ziehl), which has been slightly warmed, for from five to ten minutes:[1]

Fuchsin,	1 gram;
Carbolic acid solution (5 %),	80 c.c.;
Alcohol (95 %),	20 c.c.

It is then decolorized by placing it in a 5 per cent. solution of strong sulphuric acid, which removes the fuchsin from all but the bacilli. The length of time necessary for the bleaching process must be determined by experiment. The cover-glass is next washed thoroughly with distilled water, and is then placed in a strong watery solution of methyl-blue for about five minutes. The glass is finally washed in distilled water, dried thoroughly, and mounted in Canada balsam upon a glass slide. The bacilli appear under the microscope as minute red rods scattered about upon a blue background. The same

[1] *Koch-Ehrlich Stain for the Bacillus of Tuberculosis.*—1. Sections or cover-glass preparations are left in aniline-water fuchsin (or gentian-violet) solution for twenty-four hours in the cold. 2. Transfer to a solution of nitric acid (1 part to 3 of water if sections, 1 part to 4 of water if cover-glasses) for two to three seconds (just long enough to pass them through). 3. Then transfer to 60 per cent. alcohol for a moment, to complete the decolorization. 4. Wash in water. 5. A contrast-stain may be made with a watery solution of methylene-blue (if fuchsin be the first stain) or vesuvin (if gentian-violet be first used). 6. Wash thoroughly in water, dry, and mount, if cover-glasses. Dehydrate, clear in oil of cedar, and mount, if sections.

method of staining is applicable to the detection of the tubercle bacillus in the sputa of phthisical patients. A drop of the sputum is selected from one of the tough yellow clumps floating in the sputum and placed upon the cover-glass; a second cover-glass is then placed on top of it, and the sputum is pressed out into a thin layer. The glasses are then separated and dried, and furnish two specimens for the coloring process.

Bacteria are *not usually found in the healthy tissues* of the body, although occasionally they may be concealed in certain structures which show no symptoms of disease, and first make themselves manifest after the infliction of an injury or during the course of some inflammatory process. Cocci and spores may remain latent in cicatrices for a considerable length of time, awaiting a suitable opportunity for development. It is not uncommon to discover the presence of tubercle bacilli in individuals apparently healthy. An injury or a slight bruise under such circumstances would offer an opportunity for their development either as a local or a general tuberculosis. Micrococci are often found temporarily in the blood of individuals whose vital powers are enfeebled. They may disappear quite rapidly—even in a few hours—without having given rise to any well-defined pathological process.

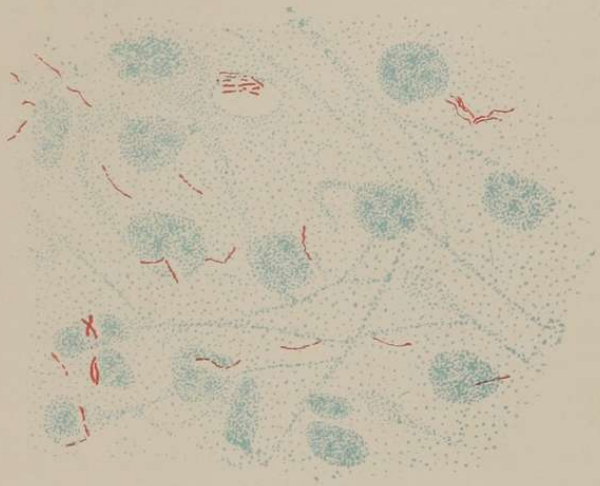
Bacteria are *found in all kinds of true inflammations.* The term "simple inflammation" is intended to designate that variety in which no microorganisms are found. This form of inflammation is a more limited one than was formerly supposed, and is confined chiefly to those processes which follow injury and are concerned in repair if bacteria are excluded (Senn).

The *forms* of bacteria most frequently met with in surgical diseases are those which produce suppuration. These organisms are known as the pus microbes or pyogenic cocci.

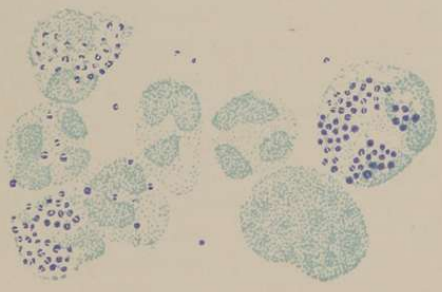
The **Pus microbes** consist of several varieties, but the most common form is the **staphylococcus pyogenes aureus** (Pl. I, Fig. 1), so called from the grouping of the cocci in clusters. Its shape is globular, and it measures from 0.7 to 0.87 micromillimeters in diameter. It multiplies by division, but the line of fission is difficult to see. It is a very durable organism, and requires several minutes' boiling or steaming to destroy its power of growth. It is readily stained by all the coloring agents. It grows well at the ordinary house temperature, but is more active when growing at a temperature nearer that of the body. It does not need a large amount of oxygen for its growth. When cultivated in the test-tube upon beef gelatin it forms at first a yellowish-white layer, which later changes to an orange color; hence the last part of its name —aureus. If thrust deeply into the gelatin, the upper surface softens as the growth forms, and becomes liquefied in virtue of peptonizing action exerted by the organism. It has a peculiar odor of sour paste. The aureus is found abundantly outside of the human body. It can be obtained from dirty dish-water, the soil, or the air, particularly in foul hospital wards, but its most common seat is the superficial layers of the skin, particularly of the axillæ and other moist parts, and also under the ends of the finger-nails. It is also found in the mucus of the pharynx and digestive tract.

Other forms of the pyogenic cocci, but less frequently seen than the aureus, are the **staphylococcus pyogenes albus** and the **staphylococcus pyogenes citreus.**

The **Streptococcus pyogenes** (Pl. I, Fig. 2), is an important variety of the pus cocci. The arrangement of the organism is in chains or rows, six to ten being usually attached together. These cocci measure about one micromillimeter in diameter. On culture-media the growth reaches its development in four or five days, and has at first a transparent whitish look, but later a



1. Bacilli of tuberculosis in sputum.
[*Camera Lucida. Zeiss apochromatic objective 2.0 mm. ocular 6.*]



2. Gonococcus from gonorrheal pus.
[*Same power as fig. 1.*]

3. Bacillus tetani. Cover-glass preparation from culture by Kitasato.
[*Same power as fig. 1.*]

brownish color. The streptococci are found under normal conditions in the saliva, secretions of the nostrils, vagina, and urethra.

The **Bacillus pyocyaneus** is an organism which is found in green or blue pus. It is a small, thin rod with distinctly rounded ends, and unites in chains of five or six links. It has a very active motion. The pigment is deposited from the bacilli when in contact with oxygen, and is then seen principally on the exposed edges of dressings. The substance thus found is termed *pyocyanine.*

The pyogenic cocci are found in all acute abscesses. The staphylococci are found in circumscribed abscesses, as boils, carbuncles, suppurating glands, empyema, osteomyelitis, etc. The streptococci are more frequently seen in the spreading inflammations, as phlegmonous cellulitis, erysipelas, ulcerative endocarditis, and metastatic abscesses such as are seen in pyemia.

In order that suppuration should take place it is not simply necessary that the pyogenic cocci should be introduced into the living tissues. It is found that other conditions are of equal importance. Cheyne has shown by experiment that the *number of bacteria injected* is an important factor. The dose must be sufficiently large. It is owing, probably, to this fact that many cases of imperfect asepsis in surgical operations often heal well. Doses of less than 18,000,000 of the Proteus vulgaris when injected into the muscular tissue of a rabbit seldom cause any result, and it requires so large a number as 250,000,000 to produce a circumscribed abscess.

But the *state of the tissues* in which the organisms are arrested is also a matter of great importance. Tissues which have been damaged by injury or inflammation are not so resistant to the action of bacteria as when in a state of health. A healthy peritoneum may receive and absorb a large number of bacteria, but if damaged during a laparotomy, so that a considerable portion of its secreting surface has been destroyed and at the same time considerable oozing of blood and serum has taken place from the injured surfaces, a soil favorable for the growth of the organisms is provided and a septic peritonitis may result. Tense sutures are more likely to be followed by "stitch abscesses" than where the sutured margins of the wound come easily together.

The question has arisen, *Can suppuration take place without the presence of bacteria?* Steinhaus has shown that calomel, and also nitrate of silver, when injected into the tissues can produce pus in certain animals. Even the chemical substances formed by the pyogenic cocci, when separated from them and injected, can produce non-bacterial pus. But, as Senn remarks, the matter remains practically where it was before, as clinically we do not meet with examples of acute suppuration without the introduction of the pyogenic cocci into the system. Foreign bodies or mechanical irritation cannot produce pus without the aid of bacteria. The pus-producing power of the cocci lies in their ability to liquefy the fibrinous exudation of inflammation.

The pyogenic cocci are not usually found in *cold abscesses.* It was supposed that this form of abscess was produced by the tubercle bacillus only, but Ernst and others have found the aureus and albus in several cases of psoas abscess. It is possible that the failure to obtain cultures from this kind of pus is due to the dying out of the organism owing to the age of the abscess.

The **Streptococcus erysipelatis** resembles closely in all respects the streptococcus pyogenes, and the weight of evidence is at present strongly in favor of their identity. In all cases it is the cause of the disease, and direct proof has been given of its power by inoculation of open wounds in the human subject.

The **Gonococcus** (Pl. II, Fig. 2) is the specific organism which produces gonorrhea. It measures 1.25 micromillimeters in diameter, and is

usually arranged as a diplococcus. One of the most striking peculiarities which distinguishes it from nearly all other forms of micrococci is its ability to penetrate cells and multiply rapidly within them. In this way it may be readily recognized under the microscope. It is difficult to cultivate, as it will only grow on blood-serum and when isolated from other cocci. The gonococci are stained well with methyl-blue, and may be prepared for examination by the cover-glass method mentioned previously. The organisms grow more readily on those mucous membranes which possess a cylinder epithelium or one closely allied to it, as the membranes of the male and female urethra, the uterus, and the conjunctiva. It does not penetrate below the epithelial layer, the more deep-seated suppuration, such as bubo, being due to the presence of the pyogenic cocci.

The **Tetanus bacillus** (Pl. II, Fig. 3) is a large, slender rod with somewhat rounded ends. Spore-formation takes place at the end of the bacillus, and, as it enlarges the cell considerably, gives it the so-called drumstick shape. It is movable, belongs to the strictly anaërobic organisms, and rapidly dies when exposed to the air. It is readily colored by methyl-blue and fuchsin. It can be cultivated in cultures of gelatin mixed with grape-sugar, and grows well at the bottom of the inoculation puncture, whence it sends out innumerable little prolongations, giving the growth the appearance of the fir tree. It is difficult to separate from other organisms, but several American and foreign bacteriologists have succeeded in obtaining pure cultures. The spores are found in garden soil, in masonry, in decomposing liquids, and in manure. Hence the frequency of the disease in those employed about stables. It is quite frequently met with in the dust of the streets, but owing to its anaërobic nature is not easily inoculated into the living tissues. Brieger has obtained from cultures a number of toxines, to one of which he has given the name tetanin, and inasmuch as the same group of symptoms are obtained experimentally by the toxines as by the bacilli, and as the latter are hard to find in the blood and internal organs in individuals who have died of tetanus, it has been thought probable that the symptoms of the disease are produced, in a great measure, by this substance.

The Tubercle Bacillus (Pl. II, Fig. 1).—This organism was first seen under the microscope by Baumgarten, but Koch cultivated and fully identified the organism with the disease in 1882. The bacilli are small, thin rods, two to four micromillimeters in length—that is, about one-half the diameter of a red blood-corpuscle. The rod is slightly bent in the middle and its ends somewhat rounded. The longest rods are usually seen in phthisical sputa. They are usually single, occasionally being found in pairs or arranged in the form of the letter V. They do not possess the power of motion. The bacillus possesses great powers of resistance to destructive agencies, the organisms in tuberculous sputa being destroyed only after twenty minutes' boiling. The expectoration can be kept for months and even years in a dried state without destruction of the bacilli. They are stained by the ordinary aniline dyes with far greater difficulty than any other bacteria, and, in common with the bacilli of leprosy, which they closely resemble, do not yield to bleaching fluids like all other bacteria. The bacilli are found between the leucocytes in the tubercles, in the epithelioid cell, and also in large numbers in the giant cell, being generally seen at its periphery. The organism is very difficult to cultivate, and grows well only on a hardened blood-serum or a combination of the ordinary nutrient media with glycerin, for which latter agent it appears to have a special predilection. When cultivated on agar the first signs of the growth appear at the end of fourteen days, and one to two weeks more pass before full development has taken place. It appears then as thick scales of a dull grayish-white color, which are very dry

1. Bacillus of malignant œdema. Cover-glass preparation from spleen of white mouse.
[*Camera Lucida. Zeiss apochromatic objective 2.0 mm. ocular b.*]

2. Bacillus anthracis. Cover-glass preparation from spleen of white mouse.
[*Same power as fig. 1.*]

and brittle. The material for culture is usually obtained by inoculating a guinea-pig with tuberculous sputum. Cover-glass preparations show the bacilli growing in S-shaped or scroll-like masses.

The tubercle bacilli are true parasitic organisms, as they are unable to grow outside of the living tissues of man and animals. Inoculation may take place through the skin, following slight bruises or cuts. The organism is very resistant to the action of the digestive fluids, and animals fed experimentally with tubercle bacilli have developed general tuberculosis. It is probable, therefore, that they can penetrate the mucous membrane, and may be carried into the system with the food. H. C. Ernst has shown that *six drops* of the milk from a tuberculous cow, injected subcutaneously into a guinea-pig, may develop a tuberculosis. The milk of tuberculous cows is therefore a very dangerous article of food. The breathing of infected air is the most frequent mode of acquiring the disease. The frequency of pulmonary tuberculosis is suggestive of this mode of infection. Cornet has shown that the dust of infected localities is dangerous. The organisms are distributed through the air when in a dry state, and are found in the dust of hotels or hospitals occupied by consumptives, and in factories and prisons. The tuberculous sputa should not be allowed to dry, being harmless when kept moist. All tuberculous patients therefore should expectorate into a cup containing an antiseptic solution.

Bacillus of Malignant Œdema (Pl. III, Fig. 1).—This bacillus was first described by Pasteur, but its present name was given to it by Koch. It is occasionally found in traumatic gangrene. It is a saprophytic organism, and is found in decomposing substances and in rich garden soil. The bacilli have an active motion and contain large spores. The cultivation is attended with the evolution of gas, and when the bacilli are inoculated into animals they produce a gangrenous œdema as in man. The *pseudo-œdema bacillus* is also sometimes found in this form of gangrene, as well as the streptococcus.

In *noma*, a gangrenous inflammation of the mouth and female genitals in young children, Lingard has found long bacilli, and Ranke has found streptococci. No specific organism for *traumatic gangrene* has yet been found. It is probable that the ptomaïnes play an important part in the process. No bacterial examinations have been made of *hospital gangrene*, as, thanks to antisepsis, it is now almost an historical disease only. Studies made as early as 1872 show the presence of enormous numbers of streptococci, but these are unreliable from a more modern standpoint.

The Syphilis Bacillus.—It is very probable that syphilis is of bacterial origin, but the organism has not yet been satisfactorily identified. Lustgarten described a bacillus in 1884 which is slightly curved or S-shaped and is found in the tissues and discharges of syphilitic ulcers, but he was unable to cultivate it. It has been grown upon a gelatin prepared from the bladder of the Russian sturgeon. Similar bacilli have been found in the preputial and vulvar smegma. Bacilli and also micrococci have been found in the blood and tissues of syphilitic patients by other observers. Fragments of chancres have been placed in nutrient bouillon, and the bacilli thus obtained have been inoculated into monkeys, and eruptions resembling those of syphilis have been observed. All these observations require repetition and confirmation.

Bacillus Mallei.—This organism was discovered in 1882 by Löffler and Schütz in the tissues of animals afflicted with glanders. They cultivated it artificially, and made successful inoculations in animals, reproducing the disease. It is shorter and thicker than the bacillus of tuberculosis. Grown on boiled potato, these bacilli form a characteristic yellow, transparent, honey-like layer which appears on the second day. Later, the border acquires a greenish hue.

The bacilli are found grouped in the centre of the diseased nodules. Horses acquire the disease by inhalation, but man is usually inoculated through cuts or scratches.

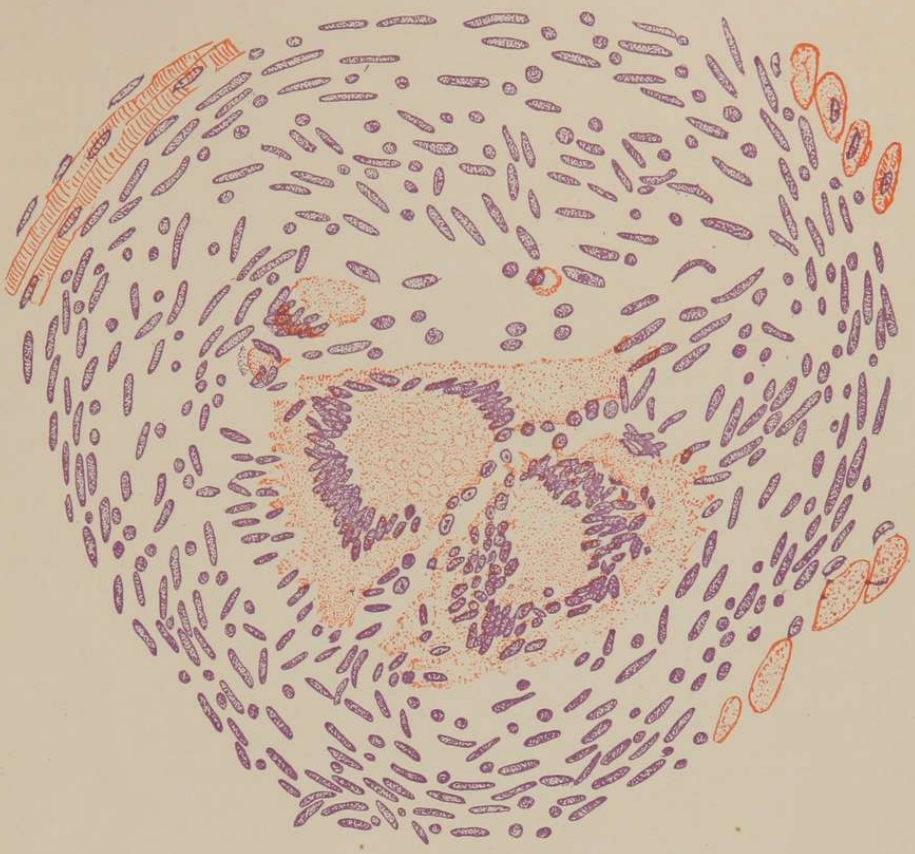
Bacillus Anthracis.—This bacillus (Pl. III, Fig. 2) produces the disease known in man as malignant pustule and wool-sorters' disease, and in animals as anthrax. It was discovered by Davaine in 1850, and has been called the keystone to the arch of bacteriology. It is very large, being 1.5 micromillimeters in thickness and 3 to 6 micromillimeters in length. The spores when forming are seen as bright, glistening bodies in the centre of the rods. The bacilli are comparatively delicate, but the spores belong to the most durable of bacterial organisms, and are therefore generally used as a standard test of the values of disinfectants. In animals, chiefly cattle, they produce the disease known as anthrax or splenic fever, and are found in immense numbers in the capillaries of the internal organs. Pasteur succeeded in weakening the strength of these bacilli by cultivating them at high temperatures or for a long time, and thus produced an attenuated virus by means of which he was able to protect animals from the disease by "vaccination." The immunity, however, is not permanent, and does not protect against infection through the intestinal canal.

CHAPTER II.

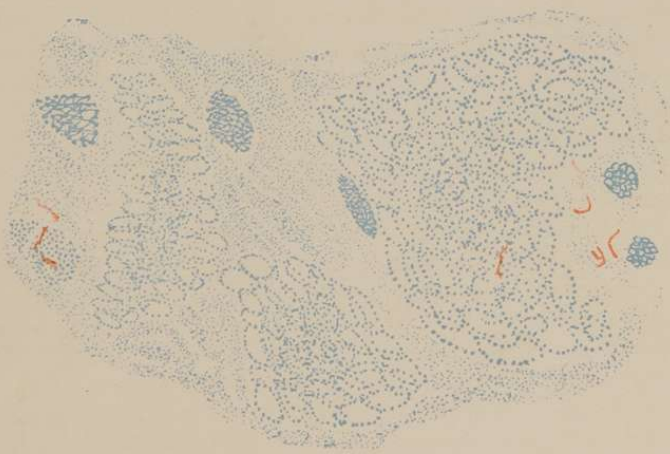
INFLAMMATION.

INFLAMMATION is a disturbance of the mechanism of nutrition, and affects the structures concerned in this function. It is "the response of living tissue to injury." It was formerly supposed to be an increased nutrition of the part, but the more modern view, as expressed by Sanderson, is that the condition is the result of damage which, if not severe enough to cause death of the part, will be followed by a series of characteristic changes in the blood-vessels and the surrounding connective tissue. As the result of this disturbance, however, we have conditions favorable for the process of repair or for the neutralization or removal of the primary microbic cause. These changes give rise to the *five cardinal symptoms of inflammation*—**pain, heat, redness, swelling,** and **impaired function** (dolor, calor, rubor, tumor, functio læsa).

In an acute inflammation of the connective tissue (cellulitis) we find the part greatly swollen and sensitive. The tissues also become much firmer than they were before. The skin is not only redder than natural, but is much warmer to the touch. The patient complains of a throbbing pain in the part, and if an incision is made through the skin the flow of blood is unusually rapid and copious. The function of the limb affected for the time being is impaired, and the muscles in the immediate neighborhood become more or less rigid. As the disease progresses all these symptoms are intensified, and finally at the point of severest pain the part becomes softer, an examination shows that fluid is collecting beneath the skin, and we recognize that suppuration has taken



1. Section of human tongue showing giant-cells of tuberculosis, surrounded with inflammatory tissue [submiliary tubercle]: *a*, muscular fiber. [*Camera Lucida. Zeiss objective DD ocular 4.*]



2. Giant-cell of tuberculosis of human tongue before stage of cheesy degenerations showing bacilli.
[*Camera Lucida. Zeiss apochromatic objective 2.0 mm. ocular 6.*]

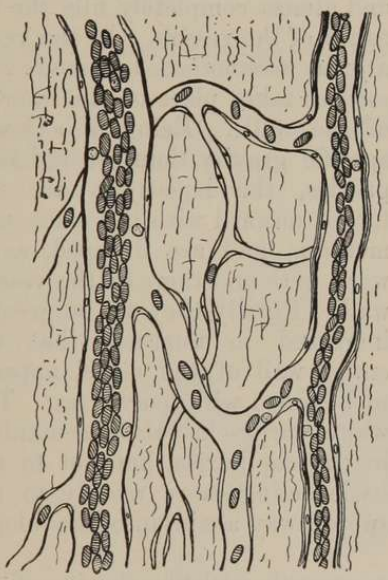
place. The symptoms may, however, begin to abate before this stage is reached, and the part may gradually return to its normal condition. The inflammation is then said to have terminated by resolution.

In order to understand the meaning of these symptoms a study of the pathology of inflammation is necessary.

The **changes seen in the blood-vessels** claim our first attention. The experiments of Cohnheim in 1867 greatly increased our knowledge of this part of the process. Previous to that time the great number of cells found in an inflamed part were supposed to be due to the proliferation of the cells of the connective tissue, but Recklinghausen showed that many of the connective-tissue cells possessed the power of motion and wandered into the inflamed tissues. They are called *amœboid* cells from their resemblance to the *amœba*. Following this discovery came that of Cohnheim, who identified the cells in the inflamed tissue with the white corpuscles of the blood or the leucocytes.

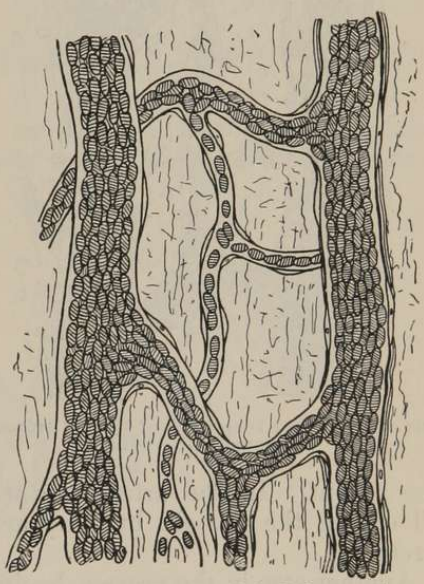
If we paralyze a frog with curare, and draw a loop of his intestine through an incision made on one side of the abdomen, we obtain in the exposed mesen-

FIG. 1.



Normal Vessels and Blood-Stream (original).

FIG. 2.



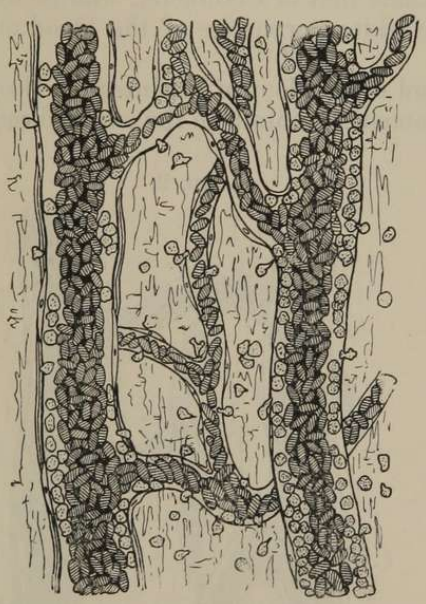
Dilatation of the Vessels in Inflammation (original).

tery a thin, transparent membrane, in which the circulation can be studied with ease under the microscope. It may also be readily observed in the web of a frog's foot or in the frog's tongue. The exposure of the mesentery is sufficient in itself to produce an inflammation, but an application of a caustic will be necessary, in the case of the web or the tongue, to bring about the same result. If we examine such an area under the microscope, we can generally see an arteriole with its rapid pulsating current of blood, and near by a small vein in which the blood flows with a more steady movement. The red blood-corpuscles occupy the axis of the blood-vessel, and the few white corpuscles which are seen float in the more sluggish stream of plasma which occupies the borders of the lumen and appears as a transparent layer (Fig. 1). The capillaries are not readily seen, but careful observation

will detect the channels through which, occasionally, a few blood-corpuscles pass.

At the beginning of the inflammatory process the *rapidity of the flow of blood is greatly increased* and a greater amount of blood is observed in the part. The *lumen of the artery is greater* than before, and the column of red corpuscles is much broader and fills a comparatively greater portion of the lumen of the vessel. The capillaries are now quite distinctly seen, and are crowded with blood-corpuscles. They appear to be considerably larger than they were before. The flow of blood is also more rapid in the veins, and it is of a brighter and more arterial color. This condition of the circulation is known as *hyperemia* (Fig. 2), and is presently succeeded by a *slowing of the current*, which soon becomes much more sluggish than in the normal state. This is first noticed in the capillaries, and soon after in the veins. The pulsation, however, continues in the arteries. As a result of this diminution of speed the column of blood-corpuscles becomes broader, and almost completely fills the interior of the vessels. In the veins a great *accumulation of white corpuscles* takes place on the interior of the walls. Being of a lower specific gravity than the red corpuscles, the leucocytes are not forced onward with the same momentum, and are dropped, as it were, here and there on the vessel-wall. Finally they are so greatly increased in numbers that the entire wall of the vessel appears to be lined with leucocytes. The white corpuscles also accumulate in the capillaries, but not to the same extent. In the arterioles these corpuscles cling more readily to the wall during the diastole, but they are soon swept away again into the blood-current.

FIG. 3.

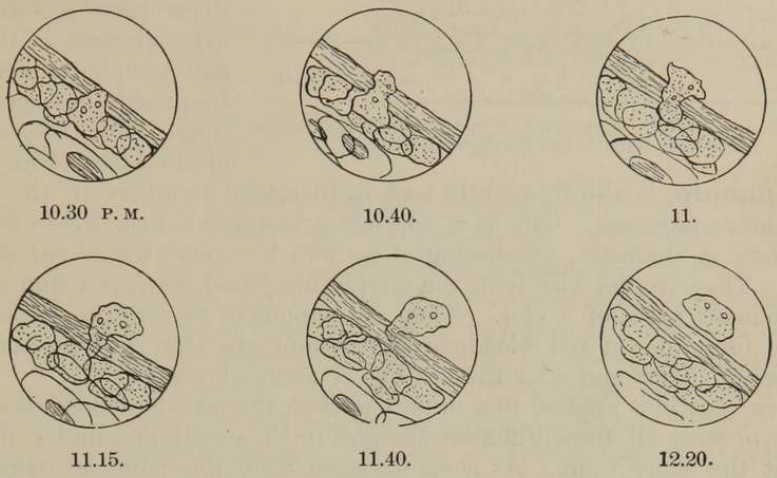


Stasis of Blood and Diapedesis of White Corpuscles in Inflammation (original).

Another step in the process, beginning concurrently with the slowing of the blood-stream, is the *emigration of the leucocytes* from the interior of the veins (**diapedesis**) (Figs. 3 and 4). Many leucocytes, by a change of shape, send out little prolongations of protoplasm into the substance of the wall, and slight protuberances are soon seen projecting from its outer surface. These enlarge, and we now see the corpuscles presenting an hour-glass appearance. The portions within the vessel soon follow those without, and the leucocytes escape from all contact with the vessel. Many corpuscles appear to follow one another through the same point in the wall. Whether there are actual holes (stomata) between the endothelial cells of the vessel through which the leucocytes escape or not is still a disputed question. The amœboid movements of the leucocytes are effected by a power of those cells to change their shape. Processes (**pseudopodia**) are thrown out from the protoplasm of the cell, which now becomes elongated or flask-shaped. As the protoplasmic mass resumes its more or less globular form, the main portion follows the protruded mass, and

a change in the position of the cell results. The white corpuscle is a minute mass of granular, or, according to some authors, reticulated, protoplasm, con-

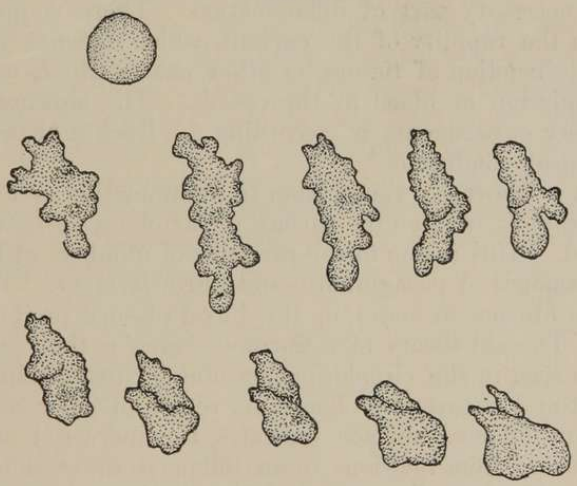
FIG. 4.



Stages of the Migration of a Single White Blood-corpuscle through the Wall of a Vein in Two Hours and Ten Minutes (mesentery of the frog; Caton).

taining one or more nuclei, and without any limiting membrane. The cells which accumulate in large numbers outside the walls of the blood-vessels in

FIG. 5.



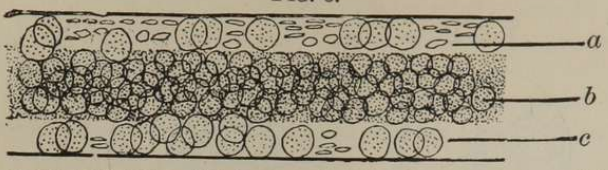
Changes seen in the Leucocyte of a Frog during Ten Minutes (original).

inflammation have the same appearance. Migration takes place to a limited extent also from the capillary vessels, but no such process is observed in the walls of the arteries.

A considerable quantity of liquor sanguinis also escapes from the blood-vessels into the meshes of the surrounding tissues, where it coagulates and encloses many of the leucocytes. When the inflammation has been severe the increased determination of blood to the part—or *congestion*, as it is usually called—is much greater; many red corpuscles may be forced through the vessel walls,

and we then find among the leucocytes occasionally a few red corpuscles. There is a considerable *increase in the number of white corpuscles* in the blood, and those organs in which leucocytes abound, as the spleen and lymphatic glands, are frequently enlarged at this time. The *third corpuscle* of the blood (Fig. 6, *a*), or **blood-plaque,** is also frequently seen in increased numbers in the blood in inflammatory processes. This is a colorless protoplasmic disk 1.5 to 3.5 micromillimeters in diameter, numbering about one to every twenty red corpuscles (Osler). They are not visible in the circulating blood, but are found in masses as component parts of a clot. They are supposed by some to be connected with the formation of red blood-corpuscles, and are seen in large numbers at the crises of fevers and after the healing of acute abscesses.

FIG. 6.



a, blood-plaques or third corpuscles; *b*, red corpuscles; *c*, white corpuscles (Eberth and Schimmelbusch).

When caustic is applied to a minute spot in the centre of the frog's tongue, we may observe all these different changes in the circulation under the microscope at the same time. At some distance from the point of irritation the circulation is normal; nearer are seen the dilated vessels, with slowing of the blood-current; next comes a zone in which a free emigration of leucocytes has taken place. As we approach the centre the circulation becomes still slower, and when we finally reach the spot where the reagent has acted directly upon the vessels, the blood no longer flows through them: this is the condition known as **stasis.** The slowing of the blood-current was regarded by Cohnheim as characteristic of inflammation. Recklinghausen, however, does not consider this a necessary part of inflammation. There is probably considerable variation in the rapidity of the current, which depends upon the amount of swelling, or destruction of tissues, or other causes which may mechanically impede the circulation of blood in the vessels. The slowing of the current seen in laboratory experiments is, according to Recklinghausen, due principally to mechanical conditions.

When blood is drawn by venesection in inflammation or fever, coagulation takes place less rapidly, and on the surface of the clot a *buffy coat* (crusta phlogistica) is formed. This is due to the presence of numbers of leucocytes which contain a large amount of paraglobulin and fibrin ferment. These substances, uniting with the fibrinogen found in the blood-plasma, produce the fibrin of the blood-clot. The old theory of a fibrinous crasis is thus explained.

The changes seen in the circulation account for two of the cardinal symptoms—viz. **heat** and **redness.** The rapid return of color seen after pressing the finger on an inflamed surface indicates the increased amount of blood. The copious bleeding from incisions in an inflamed tissue shows the increased determination of blood to the part and the distention of even the smallest capillaries. The bright scarlet redness is also an indication of the active hyperemia which exists in acute inflammation. In the more chronic forms, or in those in which the congestion is very intense and the flow of blood is consequently not so rapid, there is a bluish tinge to the reddened surface. If the color cannot be entirely pressed away with the finger, this is due either to decomposition of the coloring matter of the blood, which leaves a yellowish tinge behind, or, if a reddish tint remains, it is caused by the presence of red blood-corpuscles which have been forced out of the vessels by the intensity of the pressure. This "hemorrhagic" form of inflammation has often

a much deeper and more irregular coloring than is usually seen in acute inflammation. Redness is entirely absent in bloodless parts, as in the cornea, but in this case we find a hyperemia of the vessels of the conjunctiva, and later an actual development of vascular loops in the direction of the inflamed spot. It was at one time supposed that the increased warmth of the part was due to a local production of heat. It is now known that the local rise of temperature is due to the greater amount of blood which flows through the vessels.

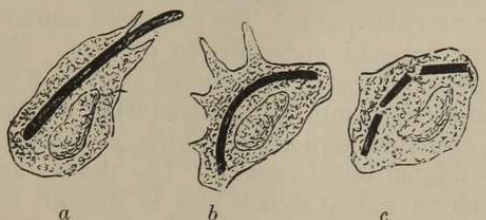
One of the most constant symptoms of inflammation is the **swelling.** This is rarely absent, and is seen even in non-vascular parts. The increased amount of blood in the vessels of the part does not add materially to its size. We must seek for an explanation of this phenomenon in the altered condition of the tissues of the part. On making an incision into an inflamed spot we find the meshes of tissue distended with an abundant exudation, which, as we have seen, escapes through the walls of the dilated blood-vessels. The tissues are saturated with this material often to such an extent that it may be difficult for the surgeon to recognize the difference between muscles, fasciæ, and vessels. The exudation consists not only of leucocytes, but, in addition, of a certain amount of fluid which closely resembles the liquor sanguinis, and from which fibrin is formed giving a certain firmness to the part. The tissues are also crowded with leucocytes. The increased number of cells in the part was at one time attributed to the division or "proliferation" of the pre-existing cells of the inflamed tissues, but Cohnheim maintained that the new cells were the escaped white blood-corpuscles, and that the so-called fixed connective-tissue cells played no part in the process, being incapable of proliferation. This doctrine he illustrated by experiments upon the cornea. The opacity produced by an artificial inflammation was found to be due to the presence of numberless leucocytes, while the corneal corpuscles were found to be unchanged. Subsequent observations have, however, shown that the fixed cells of the cornea also undergo proliferation and take part in the process. Cohnheim thought that the immense number of cells found in an inflamed part were all derived from the white corpuscles, and that by subsequent proliferation they were increased in number and formed what is known as *granulation-tissue*, which he assumed played a prominent part in the healing process. It is a well-known fact, however, at the present time, that the fixed connective-tissue corpuscles and other cells in tissues of the body are capable of division. According to the latest views on the origin of the granulation-tissue, the round cells with single nuclei are mostly formed by the proliferation of connective-tissue and other fixed-tissue cells. Later, many of these cells, as also the leucocytes, become polynuclear cells, and as such are incapable of taking any further active part in the process. According to Ziegler, the polynuclear leucocytes appear to be taken up and destroyed by the proliferating connective-tissue cells, the leucocytes apparently serving simply as nutriment for these cells. The process of multiplication by cell-division is now much better understood than formerly, and the mode of indirect division (karyokinesis, p. 29) in which the nucleus plays a prominent part is the one most frequently observed.

The meshes of the tissue are distended with coagulated lymph, and the connective-tissue fibres are swollen and softer than usual, and here and there terminate suddenly, as if broken off, giving them a club-shaped appearance. In the organs affected we find the epithelial cells altered in appearance, being in the condition known as that of "cloudy swelling;" that is, their protoplasm is granular and more opaque, and containing frequently fatty granules. During the development of the inflammatory process the leucocytes are seen infil-

trating the tissue between the pre-existing cells, arranged in rows or irregular masses or scattered about singly. They are more numerous in the immediate neighborhood of the small veins and capillaries. At the height of the inflammation the part may be completely filled with small round cells, many of them leucocytes and many of them derived from the cells of the inflamed part.

Various views are held as to the *function of the leucocytes*. Cohnheim regarded them as the active agents in the process of repair. By others they have been regarded as the scavengers which appropriate to themselves the broken-down materials which result from inflammation, and thus aid in the process of absorption. Fragments of dirt or blood-clots or carmine granules, when used experimentally, are found in the protoplasm of these cells. Metschnikoff has advanced the theory known as **phagocytosis**, according to which the cells of the inflamed part, in virtue of their ability to consume foreign substances, attack and destroy the invading bacteria (Fig. 7). These cells are called **phagocytes** (φάγω, to eat, and κύτος, a cell). If they are able to destroy the bacteria, the system is protected from the invading organisms. The leucocytes are called micro-phagocytes (or microphages), and the larger cells developed from the fixed connective-tissue cells are called the macro-phagocytes (or macrophages). The latter may consume the smaller cells after their struggle with the bacteria, and thus assist in the process of absorption. A large number of experiments were performed by Metschnikoff in support of this theory. Other writers have, however, shown that the leucocytes may be the vehicles by which the bacteria are conveyed to distant portions of the body, and that they are therefore capable of spreading infection. The doctrine has not been generally accepted as an explanation of the immunity which certain animals or individuals possess against the attacks of certain diseases. The rich cell-infiltration of an inflamed part may, however, exert a protective influence in other ways. The lymph-spaces of inflamed tissue are usually crowded with leucocytes, and absorption of chemical or bacterial poison is thus prevented. The mechanical protection which the granulating surface of a wound affords is in striking contrast to the rapidity with which a freshly-exposed tissue will absorb a virus.

FIG. 7.



A Phagocyte destroying a Bacillus (Landerer).

Returning to the microscopical changes to be seen in inflamed tissues, we find that when granulation-tissue has formed the *intercellular substance* is not so easily seen as before, and the part appears to be composed almost exclusively of cells. It is, however, rich in blood-vessels, as can be easily demonstrated by special methods of preparation. Much of the intercellular substance and many of the fibers have disappeared, and a granular intercellular substance has taken their place. This condition exists usually in the more indurated portions of the inflamed part, and gives rise to the characteristic "cake-like" hardening so often felt. In the surrounding softer and more pulpy structures we find a large amount of coagulated fibrin and serum, which latter substance may at times be excessive in quantity, and then produces a condition that is known as *inflammatory œdema*. Such collections of the fluid products of inflammatory transudations are most marked in loose connective tissues, as in the eyelids and the prepuce. When an œdematous swelling of this character takes place in the mucous membrane of the larynx fatal complications may arise.

When mucous membranes are inflamed the exudation usually shows itself in the form of an increased and altered secretion on its surface, in certain conditions even assuming the consistence of a false membrane. When serous surfaces are inflamed the transudation will take the form of an effusion into the serous cavity involved, as in the pleura or the cavity of the knee-joint. The cells which are a part of the exudation may, however, form a membrane on the walls of these cavities, and give rise to adhesions which interfere with the motion of the two surfaces upon each other.

The next symptom of inflammation is **pain**, which is due to the pressure or tension produced by the swelling upon the terminal branches of the nerves; it may also be due to exalted sensibility from hyperemia, and to the chemical irritation of ptomaïnes. It is most severe in the early stages of the inflammation, before the tissues have had an opportunity to accommodate themselves to the pressure exerted by the exudation. It will vary greatly with the anatomical nature of the part. In bone, where the tissues yield less rapidly than elsewhere, it will be very severe, and even in the chronic forms of inflammation the pain will be of a boring character, which is proverbially hard to bear. The throbbing pain is due to the pulsation of the hyperemic vessels of the part, and the peculiar lancinating pain which pus causes in its efforts to escape is characteristic of an abscess which is about to discharge. Pain may, however, be entirely wanting. This is the case in nerveless tissues, and also in severe inflammations which rapidly destroy the vitality of a part.

The fifth symptom of inflammation, **disturbance of function**, will show itself in various ways, according to the part affected: an inflamed muscle will become rigid and contracted; an inflamed gland will cease to give forth its natural secretion. The special senses may also be impaired, or even permanently affected, by the inflammatory process.

Inflammation *does not begin spontaneously.* Old writers recognized an idiopathic form of inflammation, but the term, if intended to mean more than non-traumatic, should be discarded. Inflammation is due to some cause which acts in an injurious or destructive manner upon the tissues, such as heat, cold, chemical action, injury or trauma, the temporary removal of blood from a part, as in laboratory experiments or in frost-bite, and, finally, infection, or the action of micro-organisms and their products upon the tissues. There is a tendency at the present time to ascribe all inflammation to the action of bacteria. According to Senn, inflammation proper should be made to embrace pathological conditions which are caused by the action of micro-organisms or ptomaïnes upon the histological elements of the blood and fixed tissue-cells. Hueter also believed in the universal agency of bacteria in inflammation, and regarded it as an epidemic and contagious disease existing everywhere. All other forms of inflammation would, according to this view, be regarded as the phenomena accompanying the process of repair.

The question of the *action of the nerves* in inflammation, at one time discarded, has been recently revived by Lister. It is claimed that the most striking clinical example of this type of inflammation is the so-called urethral fever which follows the use of the catheter. The inflammation of the genito-urinary tract thus brought about, and the accompanying chill and fever, are supposed to be due to a reflex action of the nerves of the part. Doubtless many of these cases may be ascribed to a septic infection by the instrument or to injury of already infected organs. The value of counter-irritation as a method of treatment is brought forward to show the probability of an abnormal action of the nerves. The so-called trophic action of the nerves in inflam-

mation was at one time regarded with favor. Division of the vagus nerve in animals was found to be followed by pneumonia. These cases are, however, now explained satisfactorily by bacterial infection following removal of the protective nerve influence of the part. The list of inflammations to be ascribed to the action of the bacteria and their products is no doubt constantly enlarging, but we are not yet in a position to discard all other supposed inflammatory agencies.

Cohnheim believed that all these agencies acted upon the walls of the blood-vessels and produced a molecular change in them by means of which the phenomena of inflammation were produced. Virchow advanced the "abstraction" theory, in which the cells of the tissues played a prominent part. Landerer does not think we ought to separate the capillaries from the tissues in which they lie in considering the seat of inflammation. When the cause of inflammation acts upon the tissues they become relaxed, the equilibrium between blood and tissues is disturbed, and we have a leakage or exudation into the inflamed part.

Most traumatic inflammations take their origin in the tissues, as these are acted upon directly by the inflammation-producing agent. Other inflammations, as the more deep-seated forms, are produced by an agent acting through the blood-vessels or the lymph-channels. In this way those types of inflammation known as parenchymatous or interstitial are produced.

From a study of the pathology of this affection we are justified in assuming, therefore, that the phenomena of inflammation are evidences of injury to the nutrition of the part, while the consequent flushing of the part with increased blood-supply, by preventing mural implantation of bacteria, and exudation, assist in the removal of injurious substances, and leave the tissues in a condition favorable to a return to the normal state.

There are several **varieties of inflammation** to be considered. Formerly the terms *traumatic* and *idiopathic* were used to designate respectively inflammation caused by injury and that which arises spontaneously; but we hear little of the idiopathic form at the present time. Inflammation may be *simple* or *infective*. The simple inflammations are limited in extent, and tend to recovery as soon as the inflammatory agent ceases to act. The infective inflammations are caused by bacteria, and have a tendency to spread.

Inflammations are said to be *sthenic* or *asthenic* according to the severity of the symptoms. The sthenic type is seen in a young and vigorous subject when affected with acute inflammation. The asthenic forms occur chiefly in old and feeble individuals. In the *parenchymatous* inflammations the part attacked is the specific cells of an organ or its parenchyma. These cells undergo a "cloudy swelling," and later proliferation may occur, or even destruction of the cells may result. An inflammation is called *interstitial* when the connective-tissue stroma which supports the parenchyma appears to be the part principally affected. We see then a cellular infiltration in the stroma of the organ. There is no essential difference in these two types, as the connective tissue is usually increased in direct proportion to the destruction of the parenchyma.

When an inflammation affects the walls of a serous cavity, we may have considerable accumulation of fluid. The term *serous inflammation* is then used to denote the type which produces a collection of fluid in the joints or the pleural cavity. The amount of serum discharged from a wound may at times be very large, and drainage-tubes are often employed to conduct away the fluid. *Adhesive* or *fibrinous inflammations* are seen best in the peritoneal cavity when two surfaces of peritoneum are quickly united by the process. The rapidity with which this membrane may become united to itself exceeds that

of any other in the body. In a few hours the adhesion will already have formed, and the peritoneal cavity may in this way be protected from the intrusion of poisonous substances such as pus or feces. The same result may be obtained in the interior of joints or the pleural cavity. The motion of the parts will stretch these new adhesions, which may thus be drawn out into bands of considerable length. When extensive adhesions occur between the opposing surfaces of a joint or in the folds of its capsule, anchylosis or great impairment of motion will result.

When bacteria are present, particularly the pyogenic cocci, these organisms exert a solvent action upon the exudation, and fibrin does not form; the tendency is therefore to a liquefaction of the tissues, and suppuration takes place. This we call *suppurative inflammation*, or, less correctly, *phlegmonous inflammation.*

Hemorrhagic inflammations occur when the red blood-corpuscles are present in unusual numbers in the exudation-fluid. This condition is found in very intense forms of inflammation, when the congestion has been extreme and large numbers of corpuscles are forced through the walls of the vessels by the unusual pressure. Black measles and hemorrhagic small-pox are familiar types, as are also some of those extremely septic forms of inflammation which the surgeon meets with. Small hemorrhages may occur in the inflammations of the aged and feeble or those affected with cardiac disease, or in scorbutic patients. The presence of blood in a serous exudation is suggestive of intense congestion of a part, as in strangulated hernia, or of the existence of malignant disease.

When a false membrane forms upon the surface of an inflamed mucous membrane the inflammation is called *croupous.* The exudation-cells and newly-formed cells of the part are caught in a fine reticulum of fibrin which forms on the surface and prevents their escape in the mucous discharges. There is more or less destruction of the epithelial cells which, when intact, exert a preventive influence against the formation of such a membrane. This form of inflammation is due to the presence of bacteria, which, as they invade the tissues more deeply, produce a sort of coagulation-necrosis of the more superficial layers of the tissues, and form what is known as a diphtheritic membrane. The principal distinction between a croupous membrane and a diphtheritic membrane lies in their anatomical situation. The former is on the surface of the mucous membrane, the latter is situated in the mucous membrane itself. There is probably no important etiological difference between the two processes.

Coagulation-necrosis is caused by arrested nutrition or by the action of chemical or thermal agencies. The changes seen in the dead tissues are due partly to a coagulation of lymph which flows into the part, and partly to a change in the cells of the part, the nuclei of which lose their power to be stained by dyes. The cells and intercellular substance become subsequently transformed into a more or less homogeneous tissue.

Gangrenous inflammations belong to the most malignant types. Death of a part may occur either from the virulence of the poison which invades it or from the great distention of the tissues by swelling, and a consequent stasis of the blood-current. The anatomical character of the tissues affected will serve as an important factor. In bone, which is unyielding, we frequently see death or necrosis of the tissue in acute inflammation.

The non-bacterial forms of inflammation have no tendency to spread. In simple inflammation the disease is confined to the part originally affected. In the infective inflammations we find the tissues involved for a considerable

distance from the original starting-point. In mucous membranes the inflammation has a tendency to spread along the surface rather than to deeper parts, and the same is true of inflammation of the skin. In the phlegmonous types of inflammation the process will involve deeper parts, and the subcutaneous connective tissue may become the seat of abscesses. Dense fasciæ and bone may resist the invasion of the inflammatory process, but the softer tissue of the interior of bones is a frequent seat of infective inflammations.

Not only will the part attacked feel the influence of the inflammatory agent, but the whole system may be affected, and we then have what is known as constitutional disturbance—*i. e. fever.* The nature and extent of the febrile process depends upon the materials which are taken up and absorbed from the inflamed area.

In *chronic inflammations* the symptoms are much less marked. The swelling is only moderate in amount, and there is very little increase of temperature. There will be some pain, of a neuralgic or boring character according to the locality of the part, but it will not be continuous, as in the acute form. Microscopically we find an abundant connective-tissue growth, containing a large amount of fibers, but comparatively few cells. Many degenerative changes are seen in such tissues: the fibers are often transformed into a gelatinous transparent tissue, and they appear to have been absorbed or destroyed. The number of leucocytes in such forms of inflammation is probably small, and the new cells found in the tissue are probably derived chiefly from the fixed cells of the part. We find degenerative changes in their nuclei and protoplasm, and also evidences of proliferation of the cells going on at the same time. Here and there we see clusters of granulation-cells with epithelioid and giant cells. In other cases a dense fibrous tissue is formed, or, in bone, bony growths which lead to an hypertrophy of the part. The causes of this form of inflammation are malnutrition of the part and a continuous action of the inflammatory agent. Loss of nerve-supply by section of the nerve or injury to the spinal cord so diminishes the vitality of the tissues that the slightest injuries give rise to inflammation. Repeated slight injuries will also produce a chronic inflammatory process. The most frequent causes are the chronic forms of bacterial disease, such as syphilis or tuberculosis. The results of such inflammation may lead to adhesion in joints or thickening and deformity of bones. A class of swellings known as the granulomata are produced by the bacterial growths. Chronically inflamed parts are often much discolored and pigmented, and slight injuries may lead to ulceration which heals with difficulty.

Subacute inflammation is a term used to denote a type intermediate, in regard to the severity of its symptoms, between acute and chronic.

Inflammation may *terminate* by resolution, suppuration, gangrene, or tissue-production. *Resolution* implies that the various symptoms gradually subside, and the part will return to its normal condition without any appreciable alteration of its tissues. The granulation-tissue which has formed will gradually disappear by absorption of the leucocytes and effused lymph. Many of the leucocytes return into the circulation through the lymphatic vessels and the capillaries and veins; others are broken down and disintegrated. The same fate meets also the proliferated cells of the part. New fibres are formed in the place of those which have been destroyed during the inflammatory process, and the injury done to the tissues is thus repaired. With the absorption of the products of inflammation the inflammatory agents also disappear.

When *suppuration* takes place there is a loss of substance, and after the pus has been discharged a more extensive process of repair is needed to produce a healing of the wound and the formation of the cicatrix.

Very severe forms of inflammation will lead to *gangrene*. The dead tissue is gradually separated from the living, to which it is attached, by the formation of a line of demarcation—that is, by suppuration—and when the slough has separated healing by granulation takes place. As absorption takes place, the red blood-corpuscles found in the exudation are broken up and part with their coloring matter, which remains behind and frequently produces pigmentation. Many of the cellular elements undergo fatty degeneration, which may occasionally occur on so extensive a scale that the material is not all absorbed, but remains behind as masses of cheesy degeneration. In some cases lime-salts are eventually deposited in the unabsorbed material, and calcareous concretions are formed. *Tissue-production* is considered in the next chapter.

Treatment.—The principal method of treating inflammation a generation ago was the so-called antiphlogistic treatment. This was based on the theory that inflammation was an inflammable condition of the part, which, like a fire, must be subdued by appropriate measures. It did not take into account the causes of the process, which are now so much better understood. This method consisted in the use of emetics, venesection, cupping and leeching, and the administration of drugs, like mercury, which were supposed to have an antiphlogistic tendency. This method has given place to antiseptic treatment, which has the important advantage of dealing directly with the cause of disease. Some of the older measures are, however, still retained, and may occasionally be used to advantage in relieving some of the symptoms of inflammation.

Local Treatment.—*Venesection* is an operation rarely seen at the present time, and may be said to have been wholly abandoned as a surgical therapeutic measure. The local abstraction of blood under certain conditions may, however, be used to advantage. Nancrede has attempted to formulate these conditions. He has shown by study of the microscopical changes in the web of the frog that removal of blood from the venous side of the circulation produces an increase in rapidity with a lessened force in the circulation of the part, and favors an absorption of the exudation. The use of drugs, like ergot, which constrict the arterioles he regards as harmful at this stage, as tending to produce stasis; but such remedies might be given with advantage during the preliminary stage of hyperemia.

In cases of extreme congestion, where there is danger of death of the part from a general stasis, the use of *leeches* is of value, as also frequently in less severe forms, when the removal of pressure brings with it great relief to pain and assists in bringing about that natural termination of inflammation—resolution.

As the majority of surgical inflammations are of a septic nature, the antiseptic treatment will be the more rational method to pursue in most cases. This method will be described in its appropriate place, as also the aseptic treatment, which may be regarded as the prophylactic treatment of surgical inflammation.

Counter-irritation was another of the weapons of the antiphlogistic system, but, although much less used at the present time than formerly, has not been wholly discarded. It is a remedy of more value in chronic inflammations than in those of an acute type, and may act, possibly, through the nerves of the part by a reflex process, and thus produce a change in its nutrition and promote absorption. The actual cautery is still occasionally used in deep-seated inflammation of the joints. It should be lightly applied at a white heat over a considerable extent of skin near the inflamed part, and should act only on the superficial layers of the skin. Repeated blistering is also of benefit in producing absorption in an enlarged gland or a "weeping sinew," or

of an exudation which is slow to disappear. Iodine may be used for the same purpose, but probably acts in virtue only of its power to produce a local irritation on the surface, and not from any special sorbefacient quality possessed by the drug itself.

Compression is a valuable agent in the treatment of both the early and the late stages of inflammation. In the acute stage it restrains the tendency to excessive swelling of the part and the collection of serous or bloody discharges between the lips of a wound. It must be applied, however, with great care during this period, as sloughing or even gangrene may be the result of tight bandages on a part when the circulation is enfeebled by injury. In the later stages compression may be employed with great advantage, and is one of the most valuable agents which the surgeon possesses to promote absorption and resolution. It is most useful in chronic inflammation. The beneficial effect of pressure upon a varicose ulcer by plaster or a rubber bandage is an admirable illustration of this power, as is also the effect produced upon the serous effusion in a knee-joint by elastic bandages made of rubber or flannel. A most efficient means of obtaining compression of the knee-joint is with compressed sponge: two coarse sponges may be flattened over-night under a heavy piece of furniture; one is put on either side of the joint, which is placed on a posterior splint; a long cotton bandage is now firmly applied, after which a stream of water is allowed to trickle into the sponges. This dressing may be left on for one or two days, sufficient moisture being supplied to keep the bandages tight.

Cold and heat are used for the purpose of reducing the hyperemia and to relieve pain. *Cold* may be applied either by evaporating lotions or by the use of ice. Evaporating lotions can be used on exposed parts, but must be changed very frequently to have the desired effect. They are less used than formerly. Ice may be applied in thin rubber bags. Cold can also be applied by the "ice-coil," by means of which a current of ice-water is allowed to flow through a coil of rubber or metal tubing over the part. Care must be taken to avoid freezing the superficial layers of the skin if a prolonged use of the remedy is intended. The ice-bag is comforting in cases of rapid swelling following injury, to a tender and swollen knee-joint, or to an inflamed throat. It is dangerous in cases of extreme congestion, as in strangulated hernia.

Heat may be applied in the form of fomentations, hot-water bags, or the hot douche. It acts, doubtless, in various ways. A hot fomentation when first used produces a powerful counter-irritation; later, it acts through the circulation, relieving stasis and favoring an absorption of exudation. If the heat be maintained at a high point by frequent application of the hot douche, a constriction of the blood-vessels takes place, and congestion is thus diminished. The flaxseed poultice is now discarded in the treatment of wounds, but may still be used with advantage when no wound exists. The antiseptic poultice, now used for wounds in certain cases, is practically a hot fomentation to which some antiseptic agent has been added.

Incisions are often of great value in certain types of inflammation, even when suppuration has not taken place. In cases of intense congestion of the inflamed part, when the integuments are thick and brawny, one or more incisions are followed by a free gush of blood and serum which greatly relieves the tension of the part and wards off not only threatening deep-seated suppuration, but also gangrene of the parts. The incision should be made completely through the skin and cellular tissue, but should not be over two inches in length in most cases. Early interference of this kind is imperatively needed in the rapidly spreading forms of inflammation such as occur often in the hand and forearm, which may not only ruin a hand, but endanger a life.

Elevation of the inflamed part, combined with rest by splints, etc., is of the utmost importance in controlling the progress of an inflammation. Other remedies will be of little use if the congestion is favored by allowing the limb to be dependent, and if motion is permitted to interfere with the natural tendencies toward resolution and repair.

Physiological rest of injured as well as of internal organs is also indicated, to enable the disturbed function to be restored. The importance of absolute rest after injuries to the brain has long been recognized. A chronic cystitis may be cured by cystotomy when all other remedies have failed.

Parenchymatous injections were proposed at one time to arrest the progress of bacterial infection. Hueter employed 3 per cent. solution of carbolic acid in this way around the area of erysipelatous inflammation. This method, in general, has not met with favor. It is possible, however, that the hypodermatic syringe may have a future in surgical diseases which is not yet apparent.

The results of inflammation which remain in the shape of stiffened joints, contracted or enfeebled muscles, and thickened integuments can best be dealt with by *massage*, which not only favors absorption, but is a powerful restorative of the physiological action of the part.

Constitutional Treatment.—It is essential to remember that local treatment, whatever its nature may be, is not the only method to be employed to restore the patient to health. The careful surgeon will always pay due attention to the general condition of the patient. The presence of organic disease elsewhere must not be allowed to pass undiscovered.

Stimulants may be used during the progress of the fever to sustain strength. Alcohol can be used freely in all cases where there is an abnormal consumption of tissue, whether the result of acute febrile disturbance or of chronic wasting disease. Here alcohol becomes a food, and one of the most valuable kind. Patients who cannot bear the usual doses of alcohol often experience benefit from minute quantities. Dram doses of whiskey are often well borne, and are of service in such cases. In the "typhoidal" state which accompanies profound septic infection astonishingly large quantities will be assimilated even by patients unaccustomed to its use. Flushing of the face is an indication that the dose should be diminished in quantity. Champagne is a good substitute for whiskey or brandy where the stomach is sensitive. Beer and ale are useful during convalescence or in chronic types of inflammation.

The use of *antipyretics* has little permanent influence on the pyrexia, and does not appear to give that relief to symptoms which is obtained by it in so-called medical diseases. A much more reliable method of controlling the constitutional disturbance is careful attention to the local conditions of the wound or inflamed part.

A large variety of medicines have been used in former times on account of their supposed virtues in arresting or shortening the inflammatory process. Among these may be mentioned quinine and mercury. *Quinine* is still much used, on account of its tonic action even during the febrile state. Its employment in large doses of 20 grains or more is confined chiefly to malarial regions, where perhaps there is a tendency to use it to excess. In doses of 5 grains it may be given, three times a day, in any form of fever in which a tonic effect is desired. It is still used largely in erysipelas.

Mercury was formerly used internally in every form of inflammatory process, on the theory that it had a powerful antiphlogistic action. It was supposed to dissolve the fibrinous exudation. Much of its reputation was probably due to the effect it had upon unrecognized forms of syphilis. Calo-

mel, in which form it was usually administered, has now given place to corrosive sublimate, which as an antiseptic takes the highest rank. Calomel may also have exerted a beneficial effect in virtue of its cathartic action.

Purgatives were used freely as part of the antiphlogistic system of treatment, and are still valuable in certain forms of inflammation. They are part of the routine treatment of head injuries, and, if administered promptly in coma following these injuries or in apoplexy, are supposed to remove sources of irritation and to leave the system in a condition unfavorable to meningeal or cerebral inflammation. Six grains of calomel placed upon the tongue is an easy means of acting upon the bowels under these circumstances. The dose may be followed in two hours by an aloes enema (one dram of powdered aloes to a pint of hot soapsuds). Such a mode of treatment is supposed to exert a "derivative" action, by means of which irritation is removed from the brain and its coverings to distant parts of the economy. The tendency to hyperemia is in this way diminished. The treatment of peritonitis by purgatives, particularly after laparotomy, has lately come into vogue. It seems to be based upon the power of the cathartic to remove gas, and consequently to relieve the tympanites, and by its production of watery stools also to relieve the engorgement of the intestinal vessels, and eliminate germs or ptomaïnes by causing the emptier vessels to absorb the peritoneal exudates. A Seidlitz powder or a dose of Epsom salts will often promptly remove alarming symptoms. Smaller doses of salts, repeated every hour or half hour, may be substituted for the single larger dose.

Diaphoretics, although but little used in surgery, may occasionally be found of value, owing to their antipyretic action. Water can almost always be given freely if taken in small quantities from time to time. Sweet spirits of nitre in dram doses, when largely diluted in water, will favor diaphoresis, and at the same time is useful as a sedative and also as a diuretic.

The importance of *diuretics* in inflammation of the bladder need not be insisted upon here. Their value will be discussed in another chapter.

Emetics have long since been discarded as a means of controlling inflammation, though they are useful when the stomach is overloaded. They were formerly used in connection with venesection.

Anodynes are of the greatest value in the treatment of inflammation. They relieve the most disagreeable symptom of inflammation—namely, pain—and also the malaise and nervous disturbance which are the accompaniments of fever. First among these is opium, which not only relieves pain, but contracts the peripheral vessels. The crude drug is rarely given except in a suppository. Morphine is on the whole the most useful of its derivatives. The subcutaneous injection of morphine should be reserved for the more acute forms of pain. It is well to avoid the habit of giving the alkaloid in this way too freely, as it is a powerful remedy, acting with double the power of the same dose when given by the mouth, and is sometimes followed by symptoms of collapse or opium narcosis. The liquor morphinæ sulphatis (gr. j to ʒj) can be given by the mouth in teaspoonful doses, and repeated every hour or half hour until pain is relieved. If it is desired to avoid the disagreeable effects of morphine upon the stomach, it can be given by suppository. This is an exceedingly convenient way of administering opium for pain in any part of the body. The relief from pain brings with it rest—a most important element in the treatment. The production of obstinate vomiting by even the smallest dose of opium or its derivatives is of occasional occurrence. It is usually a personal idiosyncrasy. In important cases its possible existence should not be lost sight of. The nervous disturbance will be also relieved by this drug, but we must

rely more upon chloral, the bromides, sulphonal, or other hypnotics for the relief of this symptom and to obtain sleep.

The *diet* is of the greatest importance in all forms of inflammation. The fallacy that low diet is necessary under these circumstances is now well exposed. The stomach should be supplied with food of the most nutritious character, but in a form that can be easily digested. Milk is the most valuable of all liquid forms of food. It may be given pure, mixed with lime-water, peptonized, or sterilized, or it may be taken in the form of gruel. Alcohol may be given with it. A very excellent combination is wine-whey. Clear beef-tea has but little nourishing power. Meat-broths are, however, nutritious and valuable articles of diet for the sick. Pure beef-juice is a most reliable form of concentrated and digestible nourishment. When food cannot be taken by the stomach, enemata may be given by the rectum. These may consist of beef-broths, with or without brandy. Some of the various peptonized forms of meat may be found useful for this purpose. A few drops of laudanum may be given with the enema when there is any difficulty in retaining it.

After the inflammation and fever subside the solid forms of food may be used more freely. Light wines or beer can be used if any alcohol be needed at this period. Tonics are now indicated, as iron, quinine, calisaya-bark, and the phosphites. They improve the appetite and favor the local process of repair and the return of the system to a normal condition.

CHAPTER III.

THE PROCESS OF REPAIR.

It was formerly supposed that inflammation was necessary for the healing of a wound, but from the present point of view the processes of inflammation and repair are regarded as distinct from one another. Under the condition of asepsis we are now able to see wounds heal without the usual phenomena of inflammation. The symptoms of inflammation are brought about by the disturbed functions of tissues which have been damaged. Repair, on the other hand, is the result of an active process by means of which the cells of the part are enabled to replace tissues which have been destroyed.

Healing of a wound is said to take place either by first intention or by second intention.

In healing by **first intention,** or primary union, repair takes place without suppuration. When an incision is made through the skin and superficial tissues, the edges of the wound separate from one another according to the elasticity of the different structures which have been divided: the wound is said to gape. The bleeding of the smaller vessels soon ceases spontaneously, owing to the contraction of their lumen and to the retraction of the arterioles into their sheaths, where they are soon obstructed by the formation of a clot. The largest vessels are controlled by pressure, torsion, or ligature. When the blood has been washed or wiped away the edges of the wound are carefully adjusted by means of sutures. If such a wound has been kept perfectly aseptic—that is, if no bacteria have been allowed to gain access to it—we shall see but little change in the appearance of its edges during the healing process. There will be a slight swelling of the lips of the wound, and the tissues in the immediate neighborhood of the linear incision and around the stitch holes will be some-

what firmer than in the natural state. This is due to the disturbance in the circulation owing to division of the vessels, and to the injury done to the tissues. There is no redness, as hyperemia is usually absent, but a moderate amount of exudation occurs, which results in the formation of fibrin, by means of which the surfaces brought in contact are temporarily glued together. In large wounds the amount of exudation may be considerable, and, unless it be conducted off by a drainage-tube, may accumulate in spaces which have not been accurately brought in contact, and thus separate the opposing surfaces. In order to avoid this either buried sutures or pressure must be employed to keep the raw surfaces of the wound in contact, or a drainage-tube must be inserted to conduct off the exudation, and thus allow the raw surfaces to adhere.

It was at one time thought that the edges of a wound might unite by what was called immediate union—that is, by an adhesion of the microscopical structures of the part, without any reparative effort. It is now known that such a union is merely the temporary adhesion of fibers to fibers by means of fibrin, which is preliminary to final union by the formation of new tissue.

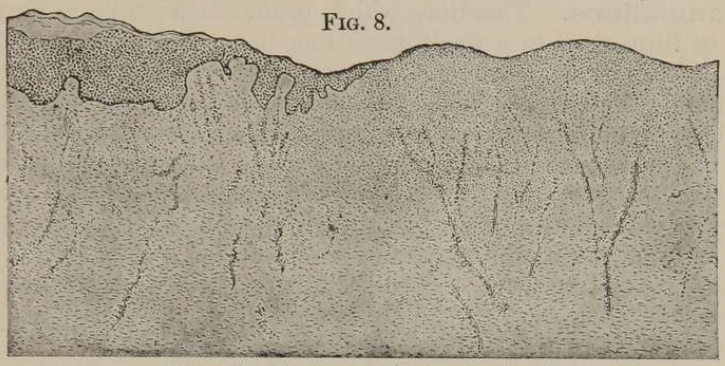
In all large wounds, no matter how careful the adjustment of the parts has been, there are always places where the walls have not come accurately in contact. If we examine under the microscope a wound healing by first intention, we find these small spaces occupied by blood-corpuscles and masses of coagulated fibrin. There will also be found some fragments of bruised and injured tissue, and here and there small portions of tissue which have undergone a necrosis owing to the impairment of their blood-supply. At the end of the first twenty-four hours there will be an accumulation of leucocytes along the line of the wound. The number of these cells is usually small, but when inflammation is present to any extent they may accumulate in sufficient numbers to obscure the pre-existing elements of the tissue. At this period the vessels are not seen near the margins of the wound, but Thiersch has shown by injection preparations that a system of plasma-canals exists, which communicate directly with the adjacent vessels, and that many of the red blood-corpuscles and masses of fibrin, apparently extravasated in the tissues, lie in these spaces, which thus are able to provide nutriment to the part until new blood-vessels are formed. As the process of repair proceeds the number of cellular elements of the part—*indifferent cells*, as they are called—increases perceptibly (Pl. V).

As the cells increase the fibers of the old tissue become more obscure, and many of them, and of other elements which have undergone retrograde changes, disappear, and the cells seem soon to be supported in a new granular or fibrillated or reticulated intercellular substance, and the so-called **granulation** or **embryonic tissue** is formed. At first this is composed of round cells; in the course of a few days, however, a large number of spindle-shaped cells are found mingled with these, and other large cells with one or more nuclei, which are called epithelioid cells. A high-power microscope will show, in fact, the greatest variety of shapes at this time. Later the spindle-shaped cells become more numerous, and the new tissue begins to present a fibrous appearance. The origin of the cells of the granulation-tissue is a subject about which there has been much dispute. According to Cohnheim, these cells are the emigrated leucocytes, which are able by proliferation to produce other cells like themselves, and are the active agents in the formation of the new tissue. The view that the fixed cells of the connective tissue and the parenchyma cells of organs are able to proliferate and form new cells during the process of repair has been gradually regaining its lost position, and the very latest views are as follows:

Left margin of wound healing by first intention on the 3d day: *a*, epidermic layer showing cells undergoing karyokinesis; *b*, leucocytes accumulating on the edge of the wound; *c*, blood-clot filling dead space—commencing "organization;" *d*, vein from which leucocytes are emigrating.

Granulation-tissue contains many leucocytes, but they take no active part in the healing process, serving simply as food for the other cells as soon as they have reached a certain stage in their career, known as the polynuclear stage, a point beyond which they are unable to develop. The cells coming from the proliferating tissue-cells are the constructors of the new tissue, and they have in early life amœboid movements (Ziegler). It is not possible to distinguish the two kinds of cells in granulation-tissue, and when cells of either kind become polynuclear they are no longer able to take an active part in the growth of tissue (Grawitz). It is proposed by Marchand to call the leucocytes found in granulation-tissue "exudation-cells," and the proliferating connective-tissue cells the "formative cells." Soon after the first day of the healing

FIG. 8.



Wound healing by Granulation (original).

process new vessels begin to form in loops which develop from the pre-existing vessels. On the surface of a capillary loop a mass of granular protoplasm is seen, which gradually increases in size and grows to an elongated mass of solid nucleated protoplasm which projects toward the edge of the wound. These prolongations either become attached to the wall of another vessel, or unite with similar outgrowths from other vessels or with the cells of the surrounding tissue. Later, the central portion of these newly-formed structures melts away, and they become hollow and establish a communication with the vessels from which they spring. The wall of the new vessel is at first homogeneous, but later becomes nucleated and lined with endothelium. In this way a mass of capillary loops form on either side of the wound, eventually becoming united and forming an exceedingly rich capillary network in the new tissue. As cicatrization completes itself many of the spindle cells and round cells disappear. Some undergo granular degeneration and are absorbed; others wander into the adjacent lymph-spaces, and are taken up again into the circulation; many, after reaching a certain stage of development, are destroyed by the more active cells in the reparative process. As the cells vanish new fibers make their appearance, and the wound becomes thus firmly united. In the mean time, on the surface a clot or crust of broken-down blood-corpuscles, epithelial scales, and exudation-material has formed, underneath which new epithelium develops from the deeper layers of the rete mucosum which covers in the surface of the wound.

When from loss of tissue or other cause it has not been possible to close a wound, and the lips are separated widely from one another, union can only take place by the process of healing by granulation, or **second intention** (Fig. 8). If we watch such a wound with the naked eye we shall observe, in the course of an hour, that a film has formed upon the surface; the wound has become glazed by the deposition of a thin layer of coagulated fibrin. This layer, at first transparent, soon becomes stained with masses of coagulated blood and fragments of

fibers torn from their surroundings and lying upon the surface. This layer is also soon occupied by numbers of emigrated leucocytes. In this way the wound is covered over so that the structures beneath can no longer be recognized. The discharge which flows from the wound is at first of a reddish hue, and consists chiefly of bloody serum in which are floating fragments of broken-down tissue. This gradually changes to a grayish color, and is found to contain more white corpuscles and fewer red corpuscles as time goes on. In a few days the dirty layer covering the surface of the wound is washed away by the discharge, which has now assumed the yellowish-white or creamy color of pus, and the wound is said, in surgical parlance, to clean off. As the débris is swept away we find underneath a surface of bright and irregular-shaped nodules which are called **granulations.** The time which granulations take to form may vary from two or three days to a week, according to the health of the individual or the nature of the tissue involved. Microscopically, the tissue consists chiefly of small round cells mingled with epithelioid or larger cells, such as are seen in the so-called granulation-tissue, the origin of which has already been described. The velvety appearance of a granulating surface is due to the little elevations on the surface produced partly by growth of cells near the blood-vessels and partly by the œdema of certain portions of the tissue.

The cavity of the wound is gradually obliterated, partly by the growth of the granulations and partly by cicatricial contraction by which the edges of the wound are approximated. In the mean time the epidermic cells by proliferation begin to cover in the margins of the open surface of the wound, and a thin bluish-white border indicates the presence of a fresh epithelial cell-growth. New formation of epithelial cells cannot occur in the center of the wound unless some fragment of epithelial structure, such as a portion of a papilla, sweat-ducts, or hair-follicles, may have remained, from which such an outgrowth could take place; hence cicatrization always progresses from the circumference toward the centre. Occasionally the growth of granulations is so exuberant that they project above the surface of the skin, and the epithelium may then be unable to cover in all the surface. This "proud flesh," as it is popularly called, must be removed with the knife or caustic before the healing process can be completed. Healing may take place by direct union of granulating surfaces, or "*healing by third intention.*" It readily occurs in wounds rendered aseptic and kept so by the use of iodoform or sterilized gauze. The gauze being removed on the second or third day, the surfaces from which little or no secretion exudes are brought in apposition and unite.

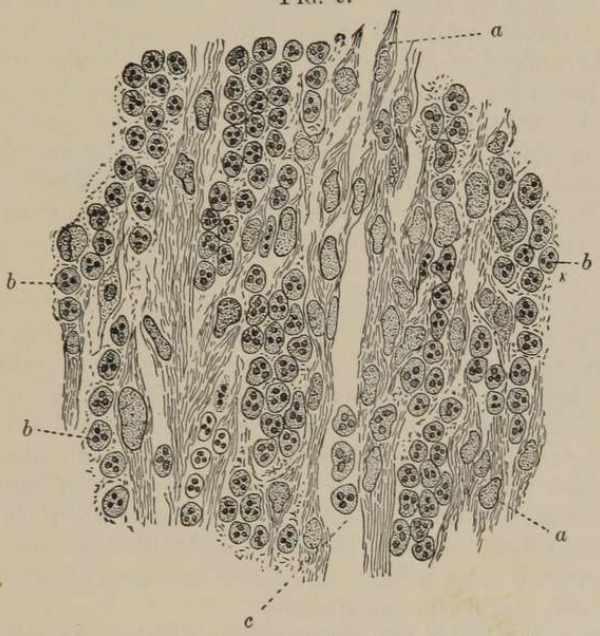
After the *cicatrix* has freely developed, it consists of fibers interwoven in various directions possessing great contractile powers, which cause many of the delicate vessels to disappear and the red scar to grow pale. In extensive scars this contraction gives rise to great deformities, particularly when the wound is situated in regions where two adjacent portions of the body may be thus bound together by a dense scar. Examples of this may be seen after burns on the neck or at the flexures of the joints (see *Burns*).

Granulations are not always firm and red: occasionally they are pale and flabby, which appearance is due to an unusually œdematous condition. These are often seen in tubercular processes. Erethistic granulations bleed easily and are excessively painful. They appear to be caused by some mechanical disturbance of the wound. The surface of the wound will sometimes be found covered with a membrane which has a diphtheritic appearance, and is caused by imperfect development of the capillary vessels or is due to their obstruction by inflammation. A coagulation-necrosis of the upper layers of the granulation is thus produced.

The **healing of subcutaneous wounds** does not differ essentially from the process already described. Repair, however, usually takes place without suppuration. In this case we find the seat of the wound occupied by a blood-clot, sometimes of considerable size. As repair progresses the extravasated blood is gradually absorbed, and granulations push out from the surrounding connective tissue and ramify in the clot, which furnishes a favorable culture soil for the new cell-growth. The amount of inflammation which will accompany this process depends upon the degree of injury or upon bacterial infection. In the case of infection by sloughing of the integuments or of intravascular infection, suppuration will take place and an abscess will form.

The same mode of **healing under a blood-clot** occurs when an open sterile wound has been filled with an aseptic blood-clot which is allowed to remain. The layer of clot which covers the surface becomes hard and dry, and gradually loses its dark color. As the clot shrinks the epithelial margins follow close upon its edges, while the connective tissue-growth beneath has been substituting itself for the fibrin and blood-corpuscles which are gradually absorbed. When the wound has healed the remains of the surface clot break up and come away with the dressings, and a firm cicatrix is disclosed. If infection of the wound has taken place, the clot will break down and be swept

FIG. 9.



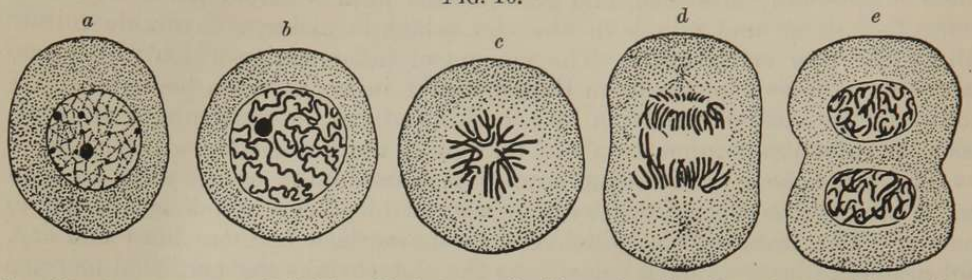
Process of Repair of a Wound: *a*, cells forming connective-tissue; *b*, leucocytes; *c*, newly-formed blood-vessels (original).

away with pus which forms, and the wound will then heal by granulation. This method of healing by organization of the blood-clot, as it has been called, is the one which usually occurs in ruptures of the internal organs, such as the liver or the kidneys.

The formation of fibrillar connective tissue is accomplished by the proliferation of the fixed cells of the connective tissue. Cell-division takes place either directly or indirectly. **Direct cell-division** (Fig. 9), which is simply a segmentation of the nucleus followed by a division of the whole cell, was thought to be the ordinary mode of cell-growth, but the **indirect** method is the one which usually occurs. This latter is known as **karyokinesis** (Fig. 10). When such

a mode of cell-division is about to take place, the delicate reticulum of fiber of which the nucleus is composed when in the quiescent state—and which is called chromatine substance, from its capacity to take staining fluids—becomes con-

FIG. 10.



Karyokinesis, or Indirect Cell-division (Ziegler): *a*, cell with nucleus in quiescent state. The nucleus contains nucleoli and a network of threads; *b*, formation of coarse chromatine threads in nucleus; *c*, disappearance of nucleolus and membrane of nucleus; arrangement of threads in loops forming the "rosette"; *d*, angles of loops directed toward the poles of the cell, which are formed of achromatic threads; *e*, beginning division of the cell; this is followed by a gradual return of the nucleus to the quiescent state (*a*).

verted into a skein of contorted filaments, which gradually assumes the shape of a rosette, and subsequently a star. Meanwhile the wall of the nucleus has disappeared. In a later or equatorial stage of the process the star-shaped mass of filaments separate into two groups, which dispose themselves around the two poles of the nucleus, leaving a clear space in the plane of the equator. When the nucleus has thus divided the filaments return to their former quiescent state. The protoplasm is contracted along the line of equatorial division, and the division of the cells becomes complete (Quain). The new cells, or *fibroblasts*, as they are called, become elongated by the formation of prolongations from their extremities, and, as shown above, develop fibrillæ by a differentiation of their protoplasm.

Examples of *wounds of bloodless tissues* are seen in the cornea and in cartilage. When the cornea is divided and the wound gapes, it is filled in at first partly by a coagulum of fibrin, and partly by a growth of epithelial cells. At the end of a few days the corneal corpuscles begin to proliferate and push aside the elements which occupy the cleft, and thus permanently close the wound. In cartilage, owing to the poor supply of nutriment, the cells appear to take but a feeble part in the process of repair. Incised wounds of joint-cartilage are found many weeks after the injury filled with a clot of fibrin, which eventually is replaced by connective tissue. The cartilage-cells near the wound become polynucleated, and the intercellular substance becomes fibrillated, but this is probably only a retrograde metamorphosis.

New epidermis is formed by proliferation of the epithelial cells. New epithelial cells possess amœboid movements, and may wander a short distance from the margin of the wound. The deep layers of the rete mucosum furnish cells which multiply rapidly, and it is this layer of the skin which is utilized by Reverdin in transplanting small grafts to the granulations. The success of the Thiersch method, which consists in the transplantation of portions of skin several inches in length to the freshly-cut surface of open wounds, is due to this fact. The grafts are cut with the razor and are exceedingly thin, so that only the most superficial portions of the skin are removed.

Regeneration of striped muscular fiber occurs to some extent in slight injuries. The cicatrix following a wound in the muscle is, however, usually composed of connective tissue, and the fragments of the muscle are thus united by a tendinous mass. At first an increase in the size and number of the muscular nuclei

are seen. Some observers have noticed karyokinetic changes in these nuclei. These new cells or sarcoblasts assume a spindle shape and are arranged in rows, and at the end of the third week begin to show striations. Each spindle cell elongates, and finally forms a muscular fiber. Regeneration of muscular fiber has been observed in myocarditis, and has also been produced experimentally in animals. Attempts to graft the muscle of a dog into a wound of the biceps following extirpation of a tumor did not succeed. Large loss of substance of muscle, however, may not be followed by much impairment of motion.

Regeneration of nerve-tissue is sufficiently perfect to unite the ends of divided nerves which have been sutured, and to restore even the continuity of nerves which have been resected in their trunks for the cure of pain. Views differ as to the histological changes which occur during the process of repair. Growth appears to be more active from the central end, although it may take place from the peripheral end also. The axis-cylinders become elongated and divide into several fibers, which later are covered by the medullary sheaths. According to another view, the axis-cylinders may be formed by a growth of spindle cells, *neuroblasts*, which takes place from both ends of the divided nerve and unites the two fragments. Around these cylinders medullary substance is deposited later, and new sheaths are thus produced. The completion of the process takes several months. When the ends of the nerve are separated by a distance of over one inch in length, repair can rarely take place spontaneously. The ends of the nerves have then a club-shaped enlargement, due chiefly to a growth of the neurilemma, and many of the fibers become degenerated. Suturing of the ends of a divided nerve, with restoration of function, has been accomplished over a year after the injury.

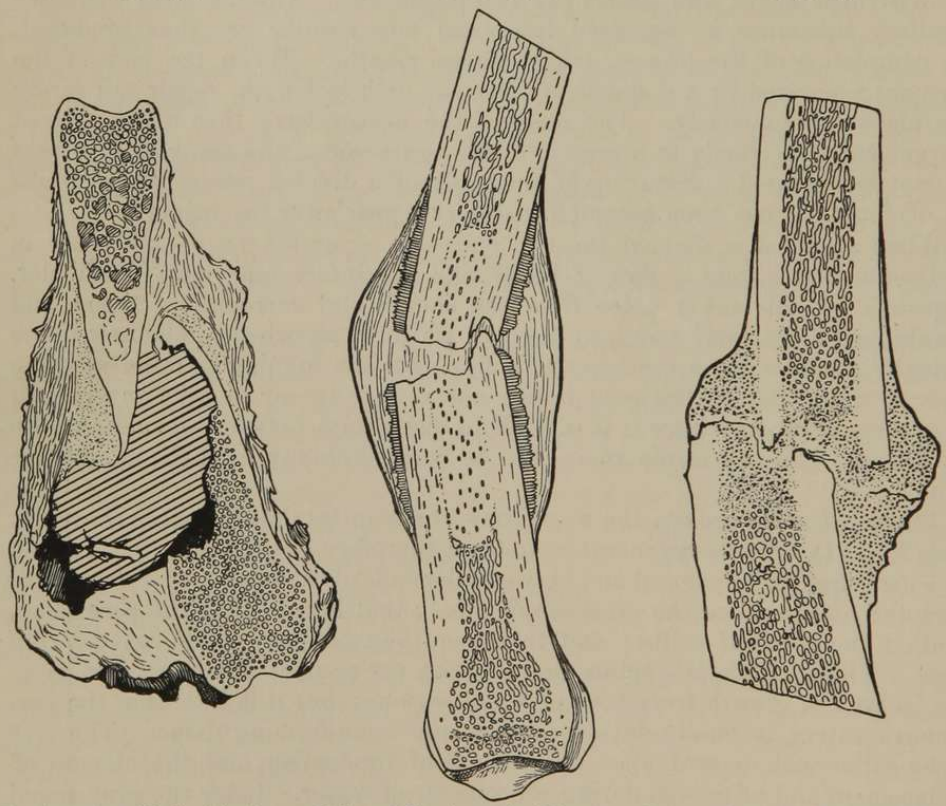
When a *tendon* is divided the two ends are separated from each other in the tendon-sheath, and a flow of blood fills the intervening space with clot. A growth of cells takes place from the sheath and surrounding tissue, and granulations force their way into the clot, which is absorbed. The new tissue gradually assumes the appearance of a fibrous tissue running parallel with the fibers of the tendon. The tendon does not at first appear to take any part in the process of repair; later it is difficult to distinguish between the old and the new fibers. The new tissue appears to be derived chiefly from the connective tissue.

When a *bone* is broken the new tissue which unites the fragments is usually bone (Fig. 11). A true regeneration of bone, therefore, does take place. The tissue which first forms around and between the ends of the bone is of a temporary character, and is called the *provisional callus;* that formed from the periosteum is called the *external* callus; and that from the medullary tissue, the *internal* callus. The *intermediate* callus lies between the ends of the bone, and is at first, in part, a growth from both of these regions; but it is here that the permanent cicatrix is finally developed from the bone-forming tissue. The size of the callus will depend upon the amount of traumatism and the amount of displacement and of motion during the process of repair. Later the provisional callus is absorbed, and cicatrization is sometimes so perfect that it is difficult to detect the precise seat of an old fracture. In *growing bone* the cells which are most active in the process of development are found in the deeper layers of the periosteum. Here an active cell-growth takes place, and medullary spaces containing the bone-forming cells or *osteoblasts* are developed. A growth of bone also occurs in the deeper layers of the cartilage. Bone-salts are deposited between the cartilage-cells, and the spaces occupied by them are converted into medullary spaces, and the medullary cells, and probably also cartilage-cells,

become converted into osteoblasts. The osteoblasts form new bone by a change of their protoplasm into a finely fibrillated or homogeneous material, which by a deposit of lime-salts is transformed into bony lamellæ. Absorption of bony substance is accomplished by giant cells, now known as *osteoclasts*, which are derived from the protoplasm of the various kinds of cells which come in contact with bony tissues (Tillmans). These cells are said to form carbonic dioxide, which dissolves the lime-salts.

The ossification of the external callus is accomplished by the osteoblasts. These cells are observed developing in the granulation-tissue which has formed between the bone and the periosteum. The osteoblasts develop an osteoid tissue which subsequently, by deposit of lime salts, becomes true bone; or the bone-formation may be preceded by the development of cartilage from these formative cells. In the second week an osteophytic growth is already seen on the surface of the bone, and by the end of the third week the periosteal callus usually consists of firm, spongy bone. A similar formation of bony tissue occurs in the medullary cavity in the development of the internal callus (Fig. 12). The amount of this growth varies greatly in different

FIG. 11. FIG. 12. FIG. 13.



Fracture One Week: blood-clot containg fragment of bone (original).

Callus of Fracture (dog) Four Weeks: commencing ossification of external callus (original).

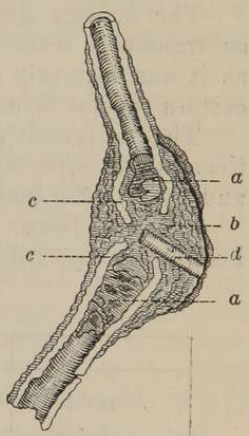
Femur of a Child Fifth Week after Fracture (original).

cases. Formation of cartilage also occurs here near the seat of fracture, but is not so constant or extensive as in the periosteal callus. The provisional callus becomes converted into a permanent cicatrix by a condensation of its tissue. An absorption of its more superficial and deeper portions also takes place—a process which is brought about mainly by the action of the osteo-

clasts. The dense cortical bone at the point of fracture shows at first no change, but subsequently becomes porous and finally unites with the adjoining fragment. It is eventually changed again into dense bone by the action of the osteoblasts. The medullary cavity of the bone, sometimes completely broken in its continuity by an overlapping of the fragments, is finally more or less completely restored (Fig. 13).

The *healing of arteries* after ligature is not unlike that of bone in the sequence of events. We have here also a provisional growth which forms around the ligature and encloses the two ends of the vessel; as in the bone, the size of the "callus," as it may be called, will depend upon the amount of traumatism. In the interior of the vessel a thrombus forms, which in purely aseptic operations is exceedingly small, and it has been maintained by some observers to be absent altogether under these conditions. The proximal thrombus is usually larger than the distal one. The external growth or "callus" is composed of granulation-tissue, and as the walls about the ligature are infiltrated with leucocytes, the ligature loosens its hold upon the vessel, and the two ends retract and separate slightly from one another, but are still held enclosed in the external callus. The ends of the vessel now open slightly, and admit a growth of granulation-tissue which infiltrates the thrombus. Subsequently this granulation-tissue is absorbed, and as it disappears it becomes apparent that a growth has taken place from the walls of the vessel which forms the permanent cicatrix. In the interior a formation of new tissue has taken the place of the thrombus, which now has disappeared. If the thrombus has been a large one, there will be a considerable growth of connective tissue filled with vascular spaces. A new growth of endothelium covers this tissue and lines the new vessels contained in it. In aseptic wounds the amount of connective-tissue growth is small, and we then find, when the process is completed, a crescent-shaped cicatrix at the end of the cul-de-sac formed by the ligatured vessel. The surface of this cicatrix is covered with a new endothelium; below this is a new layer of muscular cells which have developed from the media, and externally is a connective-tissue growth from the adventitia (Warren). The two ends of the vessel are now united by a ligamentous bond. The usual method of ligature is to apply a single thread around the vessel with sufficient force to rupture the internal coats. Unless this is done there is a possibility that the lumen of the vessel may not be obliterated. According to Senn, however, two ligatures can be applied near each other, without sufficient force to rupture the coats, with speedy obliteration of the vessel. Ballance and Edmunds believe that the cicatrix. is composed of ordinary scar-tissue formed from the connective-tissue elements in the vessel-walls. They also recommend a double ligature, the material being tendon or peritoneum. Their *stay knot*, recommended for large vessels, is tied as follows: The first hitch of a reef knot should be made on each ligature separately, and the ligatures should be so tightened that the loop lies in contact with the vessel without constricting it. Then, taking the corresponding ends of the two ligatures in the two hands, constrict the vessel so as to occlude it. Then complete the reef knot, treating the two ends in each hand as if they were a single thread. In amputation-stumps the ligatured

FIG. 14.



Carotid Artery of Horse, Two Months after Ligature: *a*, thrombus; *b*, callus; *c*, arterial wall; *d*, ligature sinus (original).

artery does not terminate abruptly in a cul-de-sac at the point of ligature, but is partially obliterated for some distance from the ligature by a growth from the intima and other coats of the vessel. This compensatory end-arteritis adapts the vessel to the greatly diminished blood-supply needed for the stump. After ligature in continuity the branches given off above and below the ligature become enlarged, and, anastomosing with one another, establish a collateral circulation.

CHAPTER IV.

THE TRAUMATIC FEVERS.

THE fever which occurs after the infliction of a wound may be *aseptic* or *septic*, according to the conditions which prevail at the time of the trauma or injury.

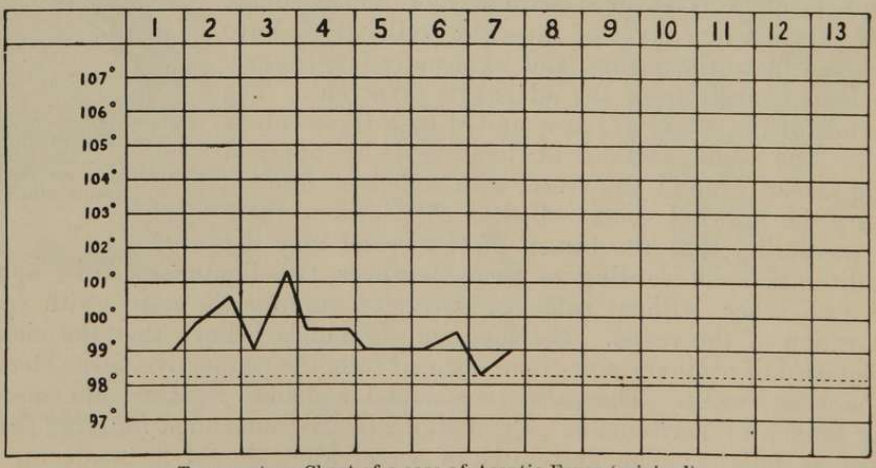
Clinically, surgical fevers may be divided into two main groups, the benign and the malignant types of fever. It is the former group only which is considered in this chapter.

The benign group includes those forms which are described usually as traumatic fever, and includes aseptic fever, septic or "surgical" fever, as it was formerly called, and suppurative fever. To these may be added certain special forms, such as surgical scarlet fever and urethral fever.

The malignant group comprises septicemia, sapremia, and pyemia.[1] Septicemia and sapremia may be regarded as malignant types of surgical fever, and pyemia the malignant type of suppurative fever.

Aseptic fever is characterized by a pyrexia which accompanies wounds healing by first intention. It was formerly supposed that fever was a symp-

FIG. 15.



Temperature Chart of a case of Aseptic Fever (original).

tom necessarily associated with infection of the wound, but after the antiseptic treatment of wounds was perfected it was discovered that many wounds thus treated were accompanied by a considerable rise of temperature, par-

[1] See pp. 59 and 62.

ticularly those in which a large amount of blood-clot existed between the lips of the wound, or in large wounds where, necessarily, more or less bruising of the tissues has occurred (Fig. 15).

It has been shown by experiment that a large number of chemical substances when introduced into the circulation will produce a rise of temperature. Among them is the fluid obtained from defibrinated blood, which contains a substance known as fibrin-ferment. When injected into animals this ferment produces extensive coagulation of blood in the vessels and death. Other substances, as pepsin, and even water, when injected will produce febrile disturbance.

During the healing of a large wound there is necessarily a breaking down of minute portions of tissue and blood-clot, which, with effused serum, are absorbed in greater or lesser quantity. These chemical substances are but slightly altered from their normal condition, but when absorbed appear to have what is known as a pyrogenous or fever-producing action.

The normal temperature of the body is 98.4° F., or 37° C. During this form of constitutional disturbance the temperature may rise to 102° F., and not return to normal for several days. Beyond the pyrexia there are but few symptoms in aseptic fever. The patients thus affected do not suffer from malaise or delirium, and are rarely conscious of feeling ill. They may be able to sit up in bed or to move about the room.

This form of fever is seen during the healing of simple fractures and of wounds in which no drainage has been employed, or in very large wounds which are healing by first intention.

Traumatic, Septic, or Surgical Fever.—Before the introduction of the antiseptic method of treatment all wounds healed with more or less inflammation, even when suppuration did not occur, and this was supposed to be a part of the process of repair. The amount of constitutional disturbance was considerable, and was called surgical or traumatic fever. Examples of this type are seen to-day in wounds that have not been treated antiseptically, particularly those which are due to injuries and have been exposed to septic infection. The presence of bacteria of various kinds in the secretions of such wounds gives rise to a fermentative process during which ptomaïnes are developed and are absorbed, producing fever. Very few bacteria are found in the blood during this type of fever, and if present they are rapidly eliminated. There is no progressive development of bacteria in the system, as in septicemia.

Surgical fever is not to be confounded with suppurative fever, for, although suppuration may occur in inflammations which produce the former, the temperature falls when suppuration takes place, and the decomposing fragments of tissue, together with the ptomaïnes they produce, are washed away. This fever is produced by the products of decomposition rather than those of suppuration.

The constitutional symptoms correspond pretty accurately with the condition of the wound and the amount of inflammation. There is a sharp rise of temperature a day or two after the operation or injury; the skin is hot and dry, the pulse rapid, and the tongue coated. The subjective symptoms are also more marked; the patient suffers greatly from heat, thirst, and restlessness, and there may be delirium. The urine is scanty and highly colored. On the evening of the second day the thermometer indicates a temperature of 102° or more in the axilla. The following morning the temperature drops a degree, to rise higher than before in the evening. On the third or fourth day, when suppuration is established, the wound cleans off, granulations spring up, the chemical substances which have caused the pyrexia are

no longer absorbed, and the temperature falls. Surgical fever does not last over a week, by the end of which time the symptoms of fever have entirely disappeared.

The constitutional disturbance in this form of fever usually corresponds pretty accurately with the local condition of the wound. When, therefore, all symptoms are well marked, infection of the wound should be suspected and the dressing should be removed for a thorough examination. The lips of the wound are usually found red, swollen, and tender, and on pressure decomposed blood-clot, and perhaps pus, may ooze at one or two points from between the lips of the wound. The stitches should be removed, the wound opened and disinfected, and a moist dressing in the form of antiseptic fomentations should be applied.

In slight disturbances such a dressing may suffice to carry off all decomposing secretions without removing the stitches, and the wound may heal after all by first intention. Experience only will enable the surgeon to decide whether to interfere or to leave the wound undisturbed.

Suppurative fever, or, as it is sometimes called, **secondary fever**, is a term employed to denote that febrile condition which prevails after suppuration has been established. It occurs only in those cases in which pus is retained, so that some of its constituents are absorbed.

If at the usual period of defervescence of surgical fever we find the temperature remains high, or there is a rise after the usual fall, it is highly probable that an accumulation of pus has taken place between the lips of the wound and is unable to escape. The pyrexia is probably produced by the absorption of a chemical substance which has been formed by the pyogenic organisms. The micrococci are not found to any extent in the blood or tissues, and the fever curve drops as soon as the pus is evacuated. It is evident, therefore, that there is no progressive infection of the system by virus already absorbed, as in pyemia.

When pus is confined in a wound the constitutional disturbance is usually well marked. There is a sharp rise of temperature, accompanied perhaps by a chill. If the pus is evacuated promptly, the suppurative process may be arrested, but occasionally the surrounding tissues become affected and the pus burrows in various directions.

The fever corresponds pretty accurately with the degree of local inflammation. During the acute stage the fever remains high with slight diurnal variations; later, when a state of chronic suppuration has been established and pus is to be found accumulating at the bottom of numerous sinuses, the fever curve assumes a remittent type, falling in the morning to the normal point, to rise again several degrees in the evening. This is the type of the so-called hectic fever (ἑκτικός, a habit), accompanying the chronic suppurations which are so marked a complication of the tubercular process. With the continuance of the fever there are marked emaciation and prostration. The pulse becomes weak and rapid. Diarrhea and night-sweats are often prominent symptoms, and unless the suppuration is checked the patient may succumb to septic poisoning or to exhaustion. In the more chronic form the emaciation is gradual. Enlargements of the lymphatic glands and amyloid degeneration of the internal organs are often found.

The **treatment** of acute suppuration consists in the establishment of thorough drainage with disinfection of the entire suppurating surface. For this purpose free incisions should be made in order to lay open the pus-cavity and render its walls accessible to the curette. After all the infected material that can be removed is scraped away, the remaining surfaces should be

thoroughly cleansed with peroxide of hydrogen or sulphurous acid (1 : 30) and disinfected with solutions of carbolic acid, corrosive sublimate, or zinc chloride.

When joints are involved the question of resection must be considered. The presence of an amyloid degeneration of the kidneys, as revealed by an examination of the urine, is a contraindication to resection, and in these cases amputation may offer a better chance of saving life.

Free stimulation and a nutritious diet are indispensable. In many cases placing the patient in the open air for several hours daily may bring about a decided improvement, even in serious cases. When, however, those processes are associated with tuberculosis the prognosis is most unfavorable.

Surgical Scarlet Fever.—A scarlet rash may occur after surgical operations, and the eruption may be followed by desquamation. In many of these cases there has been an infection of the system through the wound with the virus of scarlet fever. Such infections are more likely to occur if the wound involves a mucous membrane, as in cases of lithotomy. The appearance of the symptoms of surgical scarlet fever are, according to Paget, quite "disorderly," the period of incubation, for instance, being much shorter than usual. Scarlet rashes may occur also as the result of vaso-motor disturbances, or from the absorption of a chemical poison from the wound, or from bacterial invasion, as in pyemia and septicemia.

Urethral fever is a term given to the chill and pyrexia which often follow the introduction of a catheter or sound into the bladder. It has been cited as an example of the purely nervous origin of fever.

Many of these cases are probably due to the infection of a wound of the mucous membrane caused by the instrument, but some cases are not to be accounted for in this way, but are to be explained only by reflex nervous action.

Traumatic Delirium.

This term is used to denote those forms of delirium which occur as the result of injury, and are not due to alcoholism.

The anatomical seat of delirium is in the cortical gray matter of the brain. The delirium is due either to functional disturbance or anemia of that region or to inflammations of the cortex and meninges—more particularly of the middle and posterior lobes (Hunt). The causes of delirium are as numerous almost as the injuries which give rise to constitutional disturbance, but there are certain lesions which seem more prone to this form of functional disturbance than others. In some cases of shock there is considerable mental exaltation and excitement which are quite characteristic, the condition being known as "prostration with excitement." There is usually no marked delirium, but at times a temporary mental aberration of a well-defined character. It may precede and accompany cerebral lesions, such as hemorrhage from trauma, or thrombosis and embolism.

Delirium is often noticed in children after capital operations, being out of proportion to the amount of fever which exists. In traumatic fever of a severe type, as we have seen, delirium may be present. Among other surgical lesions, severe burns and scalds and facial erysipelas may be mentioned as particularly liable to be accompanied by delirium. In some individuals pain alone is often sufficient to produce a temporary mental aberration, which disappears immediately upon the subsidence of the pain. This form of delirium is allied to the so-called *delirium nervosum* of the German writers—a condition of nervous disturbance which comes on after injuries in hysterical subjects. It may occur in the stage of convalescence following erysipelas and other inflam-

matory diseases in nervous patients. It is characterized by considerable mental depression. Transitory psychical disturbances may also follow surgical operations, and there may be developed at times not only melancholia, but a suicidal mania. A nervous delirium without fever is occasionally noticed after operations upon portions of the body supplied with unusually sensitive nerves. The operation for phimosis, with an unusual amount of irritation of the glans penis, is an example. Severe nervous disturbance and delirium following operations or injuries, without a corresponding amount of inflammation or fever, should cause the surgeon to inquire as to the possibility of poisoning by iodoform or carbolic acid—conditions readily shown by an examination of the urine.

The **treatment** of this form of delirium consists in the removal of all local sources of irritation, in the application of ice to the head in some cases, and in the use of the bromides and hypnotics. If due to cerebral anemia from loss of blood, suitable stimulation is indicated. Opium is usually not well borne, and should be reserved for those violent cases which cannot be controlled in any other way.

Delirium Tremens.

This disease is a form of mental disturbance characterized by delirium, and accompanied by a peculiar tremor of the muscles, occurring in individuals habitually intemperate in the use of alcoholic stimulants. It follows either a debauch or some injury which suddenly confines such a patient to bed; hence its consideration here. It is said to be much less common in countries where wine and beer are the national beverages than in those in which spirituous liquor is consumed. The habitual use of various drugs is said to produce it, as opium, tobacco, and cannabis indica, and even tea and coffee. The term *mania-a-potu* is used to denote an acute type of delirium following a debauch, in which the patient may become maniacal.

Delirium tremens was formerly supposed to be due to an inflammation of the brain. Usually, however, the post-mortem appearances indicate no sign of active inflammation beyond some thickening of the meninges. According to Hunt, there is a condition so characteristic that it has been called "wet brain," consisting of a passive congestion with serous exudation in and under the pia mater, filling the ventricles and following the convolutions. Chronic gastric catarrh is also found to exist, and atheromatous degeneration of the arteries, fatty liver, and Bright's disease.

The **symptoms** of delirium set in gradually. The patient, removed from his ordinary surroundings, complains of feeling uncomfortable; he is restless and tremulous; there is much depression of spirits, and his sleep is disturbed with nightmares; he talks in his sleep, and may wander about during the night, but the next morning asserts that he has slept well. When it follows an injury, the onset of the disease is usually sudden. With the full development of the disease there is complete insomnia, with a muttering delirium frequently broken by loud cries, and a peculiar tremor of all the muscles. The patient is constantly employed pulling the bed-clothes about, tearing off dressings and splints, and endeavoring to get out of bed. He appears to be more or less insensible to pain, and may walk upon a broken leg without showing any signs of suffering. He is the victim of all manner of delusions, usually of a horrible nature. The hallucinations take the form of hideous animals and insects; occasionally they are obscene in character. The patient may be momentarily recalled to himself sufficiently to give an intelligent answer, but relapses immediately into his previous condition. There is little fever, although occasionally there may be a marked rise of temperature. The

pulse is weak and quick, and there is rapid loss of strength, due to the small amount of nourishment taken during the debauch and the later inability to retain food.

In favorable cases, after two or three days of insomnia sleep comes suddenly, and on awakening the delirium is found to have disappeared. In severe or fatal forms the prostration increases rapidly and is a marked feature, the pulse failing greatly in strength. The patient may die suddenly from heart failure. Pneumonia, a complication unusually frequent in alcoholic subjects, may supervene, and bring about a fatal issue. The prognosis of the disease is, however, usually favorable. Among the most reliable symptoms which give a clue to the patient's condition are the pulse and temperature. The weak and rapid pulse is a measure of the prostration, and the rise of temperature is a warning of complications such as pneumonia or septic infection of the wound.

The prophylactic **treatment** consists in the employment of alcoholic stimulants in moderate quantities, of capsicum and digitalis, and of nourishing food. The last is only secondary in importance to sleep. By these means the nervous system is steadied and the strength of the patient maintained. Any indication of nervousness or insomnia should be met with a free use of the bromides. An attack may in this way be warded off. During the attack mild stimulation with liquor or beer is usually advisable, although the use of stimulants must be determined by the circumstances of each case. The drugs which are most frequently used at the present time are chloral hydrate and the bromides. It is probable that sulphonal in sufficient doses to cause sleep has rather too depressing an influence upon the heart's action. The question of the use of opium in this disease has been much discussed. In mild cases it is not necessary, but it may be of much value in quieting restlessness when it is of great importance that splints or dressings should not be disturbed, or when the delirium is of so acute a type that all other remedies fail to control the patient.

CHAPTER V.

SUPPURATION AND ABSCESS.

SECTION I.—SUPPURATION.

SUPPURATION is due to the action of the pyogenic cocci upon the tissues, and is the usual termination of infective inflammation. It is the process by means of which the exudate and the tissues involved become liquefied and converted into pus. The organisms most frequently found in pus are the staphylococcus pyogenes aureus and albus. They have a tendency to accumulate in clusters, and when growing in the tissues produce circumscribed forms of suppuration. The streptococcus, which is sometimes present, on the other hand, shows less tendency to cause local suppuration, but spreads rapidly through the tissues by the lymphatics, and eventually gives rise to a diffused form of suppuration. When grown on beef gelatin the staphylococcus causes a liquefaction of the culture medium in virtue of its peptonizing action, which is due to the presence of a soluble peptonizing ferment, and it is in consequence of this action that the fibrinous exudate and the inflamed tissues become converted into pus.

That the pyogenic cocci are the cause of suppuration has been abundantly

shown by microscopical investigation and experiment. They are found in the pus of all acute abscesses, and sometimes in cold abscesses. The failure to find them in the latter class of abscess has been explained in various ways. By some these abscesses are supposed to be caused by the bacillus of tuberculosis alone, but the most probable explanation is the dying out of the organisms and the deposition of their remains as a sediment. Experiments on animals show that these organisms when injected in sufficient quantity under the skin will produce suppuration. When absorption takes place rapidly, however, a larger quantity can be injected without producing suppuration. In man inoculation through abrasions or wounds, and even through the uninjured skin, will cause suppuration. Garré produced furuncles of the forearm by rubbing in a culture of the aureus. The question of suppuration without the agency of bacteria has been carefully studied recently. Experiments on animals with the injection of calomel, mercury, turpentine, and croton oil show that certain drugs can produce in certain animals pus, or, as it would be better called, "puruloid material," containing no bacteria. Non-bacterial pus can also be produced by introducing cultures of cocci which have been sterilized by heat. In this case the organisms have been removed, but their chemical products still remain, and are undoubtedly important factors in the production of inflammation and suppuration. Practically, however, the surgeon never has to deal with non-bacterial suppuration.

Among the predisposing causes of suppuration may be mentioned diminished vitality of the tissues. The healthy body is intolerant of bacteria, and will resist the invasion of a mass of organisms which an inflamed or diseased part may be unable to withstand. The milder types of inflammation seem particularly well adapted to encourage bacterial growth. Some of the severest types of suppuration, such as acute osteo-myelitis, follow often slight blows or injuries. The delicate reticulum of blood-vessels found in the medullary cavities of bones furnishes a convenient lodging-place for swarms of bacteria, owing to the slowness of the blood-current and the tortuous course of the blood-channels. When the circulation has been impaired or arrested by an extravasation of blood or a congestion of the part, the conditions are favorable for an intravascular infection if organisms happen to be circulating in the blood at the time. As we have seen, micro-organisms may from time to time be found in the circulating blood, particularly in individuals of feeble constitutions. The anatomical nature of the part will therefore favor suppuration in certain localities. A most familiar example is the lymphatic gland tissue. There the organisms which have invaded the tissues through a wound, and have found their way into the lymphatic vessels, are arrested, and a glandular abscess results. The condition of the blood is also a predisposing cause, as the tendency to carbuncular inflammation in diabetes shows.

The material which forms as the result of suppurative inflammation is pus.

Pus is a yellowish-white fluid of the consistency of milk or cream, of an alkaline reaction, and commonly nearly odorless. It has a specific gravity of about 1030, and when allowed to stand it separates into a clear fluid known as pus serum, and a sediment which averages from 10 per cent. to 20 per cent. of the whole amount.

The *liquor puris*, or pus serum, is a pale greenish-yellow fluid which does not coagulate spontaneously, and contains an albuminous substance known as peptone. The salts which it contains are present in about the same proportion as in the blood.

The sediment consists of pus-corpuscles, the pyogenic cocci and the other

forms of micro-organisms that may be present, and fragments of broken-down tissue.

Most of the *pus-corpuscles* are the altered leucocytes which have escaped from the blood-vessels with the exudation; others are derived from the proliferated fixed connective-tissue cells. When first taken from a fresh abscess many of them are found to possess amœboid movements. They are a little larger than the white blood-corpuscles. Their protoplasm is somewhat granular, and when acetic acid is added to them they are found to contain several nuclei. This polynuclear condition was supposed to be evidence of an ability of the pus-corpuscles to proliferate, but it is now recognized as a sign of degeneration. They also occasionally contain drops of fat; others are full of large granules, which, when they break up, liberate a granular detritus which may be seen suspended in the fluid.

The color of pus is occasionally blue. This is due to the presence of the bacillus pyocyaneus, ordinarily considered a harmless organism, but the presence of which indicates slowness of repair. Orange-colored pus is caused by the presence of hematoidin crystals, and is found in some forms of inflammation. It is probably due to the fact that many red corpuscles in the exudation have been broken up by the septic process.

The peculiar foul odor of pus which comes from the neighborhood of the vagina or rectum is due to the presence of the bacillus pyogenes fœtidus. The thick creamy, odorless pus which flows from an acute abscess was formerly known as healthy or laudable pus. It contains comparatively few bacteria. Pus may occasionally undergo decomposition; in this case the micro-organisms of putrefaction also are found in it, and the pus-corpuscles are broken down and much diminished in number. This is known as *ichorous* pus, and when mixed with blood which is seen flowing from a rapidly-spreading abscess is called *sanious* pus. These unhealthy forms of pus are very acrid and give an acid reaction.

A microscopical examination of the connective tissue in suppurative inflammation shows that in the early stages of the process the stellate cells of the tissue lose their prolongations, become rounded, and undergo karyokinesis, and multiply in this way. In the mean time the intercellular substance undergoes a softening process, is transformed into a homogeneous substance, and the proliferated connective-tissue cells are in a state of polynuclear degeneration. This stage is the one immediately preceding that of pus formation. Many of these degenerated cells are therefore of connective-tissue origin, and under some circumstances they may even outnumber the leucocytes. When the polynuclear stage has been reached, it is impossible to tell the origin of these cells.

Suppuration is always to be regarded, as it has been aptly described as a "battle of cells," the bacteria exerting, in all probability, a chemiotaxic attraction which for bacteria is irresistible.

When acute suppuration takes place the symptoms of inflammation all become more marked. There is great increase in redness and swelling, and the part is exceedingly hot and is the seat of a throbbing pain. The formation of pus is often ushered in by a chill or rigor, and a change in the conditions of the part will indicate the locality of the pus. The skin at this spot becomes adherent to the parts beneath, and later presents to the touch the sense of fluctuation. A deeper color is also present at this point, and in the centre of the focus a whiter zone indicates the stage immediately preceding the breaking down of the abscess and the discharge of pus.

The diffused forms of suppuration in connective tissue are called

phlegmonous inflammations. This variety is usually seen after compound fracture when septic infection has occurred, and may involve the greater portion of the limb, as the forearm, the arm, or the leg. An acute swelling, with œdema of the connective tissues, ushers in the process, and areas of bogginess or fluctuation will make themselves manifest later. The constitutional disturbance will usually be great. A sharp rise of temperature, accompanied perhaps with a chill, will mark the beginning of the suppuration, and the pyrexia will remain until free incisions and thorough drainage have arrested the progress of the pus. The route which pus takes under these circumstances depends upon the anatomical structure of the part, upon gravity, and also upon the nature of the organisms. In many cases pus will continue to burrow until the integuments have been freely divided and the margins of the suppurating area have been fully exposed. The improvement following such free incisions is due to the fact that the bacteria growing in the wall of the abscess are thus freely exposed to the air, a condition less favorable for their growth, and are more readily reached by antiseptic agents. Small incisions are of little use in the more rapidly-spreading forms of cellulitis, and incisions from six to twelve inches in length are sometimes required to arrest the progress of the disease. If the treatment adopted fail to arrest suppuration, it may pass into a chronic stage; the pus will then burrow slowly and make its appearance at many different spots. There will also be considerable constitutional disturbance, marked by a progressive emaciation and gradual exhaustion of the patient. The febrile disturbance will be of the remittent type known as hectic fever.

Purulent infiltration of a limb is a still more malignant form of inflammation. Originating in a suppuration perhaps at first trivial, it will spread rapidly, and its involvement of the lymphatics of the limb will be plainly indicated by red lines extending up to the axilla or the groin. The protective influence of the lymphatic glands will be shown by their filtration from the lymph-stream of the cocci and their ptomaïnes. This leads to the formation of an abscess just above the elbow or in the axilla or groin, which temporarily arrests further progress of the suppuration. More rarely the entire limb will be involved in an acute inflammatory swelling with little tendency to suppuration. In this case the whole part is apt to become gangrenous. Free incisions are followed by the escape of a sero-purulent fluid. There is profound constitutional disturbance with perhaps acute septicemia. Probably in these cases there is a mixed infection, and bacilli of putrefaction are mingled with the micrococci.

When infection of a wound takes place the slight swelling which ordinarily accompanies the healing process is much increased at some portion of the wound, and is accompanied by reddening and induration. This will usually occur around one of the stitches which has been the source of infection, or pus may collect in some part of the wound where the surfaces were not accurately brought in apposition and where the wound fluids have accumulated from imperfect drainage. The rise of temperature will give speedy warning of the approach of suppuration in such cases.

The general plan of **treatment** to be adopted in cases of spreading suppuration is the employment of free incisions which expose the extreme limits of the suppurating area. This operation should be accompanied by a thorough curetting of the surface of the pus-cavity to remove the bacteria from the surrounding tissues and by thorough disinfection with appropriate antiseptic drugs. In the case of an extremity this can best be accomplished by immersion of the limb in an antiseptic bath. The agent used should be largely diluted (sublimate 1 to 10,000, or carbolic acid 1 to 500) to prevent poisoning by the drug. Following the bath antiseptic fomentations may be applied.

For this purpose some of the milder drugs containing carbolic acid, as sulphonaphthol, may be used. When other methods fail, irrigation is often successful. Sterilized water may be used for this purpose or extremely weak solutions of disinfectants. If a dry dressing is preferred, iodoform or aristol or boric acid may be dusted freely upon the part, and the wound may then be packed with an antiseptic gauze. The use of stimulants and careful feeding should be the chief feature of the general treatment of the case.

SECTION II.—ABSCESS.

AN ABSCESS is a circumscribed collection of pus, and is caused usually by the presence of the staphylococci in the tissues. When these organisms invade a part, we find even at the end of twenty-four hours an enormous number of leucocytes in the exudation which takes place. The connective-tissue fibers are swollen and the lymph-spaces are distended and filled with cells. As we have already seen, the fixed cells of the tissue undergo changes of an active nature, and form nucleated cells which cannot be distinguished from the leucocytes: they are, however, usually much less numerous than the latter. The small vessels are dilated and distended with blood, and in many cases with leucocytes. The cocci in the mean time increase in number and tend to group in masses. As they exert a peptonizing action upon the intercellular substance and the fibrin of the exudation, liquefaction takes place in the center of the inflamed tissue, and an abscess is formed. The walls of the pus-cavity are formed by a zone of granulation-tissue, the cells and intercellular substance of which have not been broken down by the action of the bacteria, and remain to form a protecting layer between the infected area and the surrounding healthy tissues. This is the mode of development of an abscess in some of the looser tissues like connective tissue. In the denser structures and in the internal organs when a plug of microccocci becomes arrested at some point in the circulaton, as, for instance, in a glomerulus of the kidney or in a lymphatic gland or in the cutis vera, we find that the tissue immediately surrounding it undergoes a chemical change due to the action of the ptomaïnes upon its cells, the result of which is that coagulation-necrosis of the tissue takes place. This ring of dead tissue is readily seen in sections taken for microscopic purposes, as the necrosed area does not take any of the staining fluids which act upon the surrounding tissues. Outside of this area a ring of granulation-tissue forms. Eventually the necrosed area is invaded both by the bacteria and the leucocytes, and becomes liquefied by the action of the cocci. An abscess of this type, when examined microscopically, will show a mass or plug of bacteria in the center, around which is a layer of pus and shreds of tissue enclosed in a zone of granulation-tissue, the miscalled pyogenic membrane of the older pathologists, who thought that the wall of an abscess was a sort of secreting surface from which pus was formed.

The **symptoms** of an acute abscess are usually well marked. The large amount of local swelling, with a varying amount of pain according to the density of the tissues which lie between the cavity of the abscess and the surface, is accompanied frequently by a chill or a gradual rise of temperature as pus begins to form. As the abscess forms a progressive softening of the integuments takes place until the pus reaches the surface. Considerable resistance will be offered by certain tissues, as fasciæ, a joint capsule, or bone, and the pus may take a devious path before the abscess begins to point. Fluctuation will now be distinctly felt, and redness with œdema of the skin and subcutaneous tissue will indicate the near approach of pus. The skin becomes

stretched and thin and its vessels compressed, and over a certain area the blood will not circulate; death of this area occurs, and the abscess then easily breaks through it.

It is not usually difficult to **diagnosticate** the presence of an acute abscess. Acute forms of inflammation may occur, however, in which the sensation of fluctuation is apparently well marked when an incision fails to reveal the presence of pus. No harm is done, the inflammation may be relieved by such an operation, and the impending abscess prevented.

Deeply seated abscesses under a dense fascia, as in the neck, may be overlooked, as no fluctuation can be felt. The local œdema and brawny feel, with other signs of suppuration, are always a sufficient warrant for a deep but careful exploratory incision at an early date to prevent wide and dangerous burrowing of the pus under the fascia. An aneurysm may, however, be mistaken for abscess, particularly when its presence is obscured by the symptoms of inflammation, and the use of the knife in such a case would be a grave error. An aneurysm will declare itself by its less acute history, by the thrill, bruit, and expansile pulsation, and can exist only in connection with a large vessel. Some forms of rapidly-growing malignant tumors may also simulate suppurative processes. In all such cases the use of the aspirator or of the hypodermatic needle is of great value. The heat of the part, the sense of fluctuation, the local œdema, and the rise of temperature, as shown by the thermometer, are all important diagnostic symptoms, and will usually be sufficient to establish the presence of an abscess.

When an acute abscess breaks the pus which is discharged is of a thick cream-like consistency, and is frequently mingled with soft sloughs of connective tissue or fasciæ, or fragments of lymphatic glands which have undergone a necrosis due either to the great tension of the part or to the formation of destructive chemical substances by the pyogenic cocci.

The **treatment** of acute abscess consists in incision as soon as it can be definitely ascertained that pus has formed, and sometimes even earlier. Nothing is to be gained by delay, and extensive injury may be inflicted upon the surrounding tissues if the abscess is not opened early. In some regions the dangers of delay are very great. An abscess in the neighborhood of the appendix vermiformis may produce a fatal peritonitis if allowed to remain unopened. Deep-seated abscesses of the neck may burrow widely, and may seriously interfere with respiration by pressure upon the trachea. An abscess near the rectum should be opened as soon as induration is discovered, in order to prevent a fistula. If no pus has formed the incision may prevent it.

The incision, as a rule, should be a free one, and so made as to favor drainage and to leave the least conspicuous scar. The finger should then be introduced to determine the size and situation of the various pockets. In case of abscesses near large vessels or other important structures Hilton's method may be used to advantage. This consists in making an incision through the skin and deep fascia by the knife. The seat of the pus can be ascertained by pushing in a pair of closed hemostatic forceps or blunt scissors or a sinus dilator, and the opening so made can be easily enlarged by drawing them out open. If necessary, to facilitate the escape of the pus by gravity, a counter-opening can often be made by pushing the hemostatic forceps entirely through the tissues to the opposite skin, and cutting between its partly opened blades. The cavity of the abscess should be thoroughly emptied, curetted, and syringed out with antiseptic solutions. These may consist of corrosive sublimate 1 : 5000 or carbolic acid 1 : 100, or if a milder antiseptic fluid is needed phenyl (sulpho-naphthol) 1 : 250. When the pus and sloughs have been thoroughly removed in this

way, a drainage-tube of a sufficient size should be inserted, and retained either by a safety pin inserted through its extremity or by stitching it to the skin to avoid its falling out of the abscess, or, still worse, of being lost in its cavity. An antiseptic poultice (made of aseptic cotton and cheese-cloth and wrung out of a weak antiseptic solution) may be applied, or a dry absorbent dressing may be used. In freely-discharging abscesses the dressing should be changed at the end of twelve hours or less, and the cavity washed out again. The fountain syringe fitted with a tube ending in a conical glass point is well adapted for this purpose. It gives a continuous stream, and causes but little pain to the patient in its application. In a few days the inner surface of the abscess-wall "cleans off" and healthy granulations make their appearance. The tube can be shortened daily as the cavity shrinks, but the time of its removal will depend entirely upon the length and ramifications of the cavity.

Cold abscess is caused in the great majority of cases by tubercular infection, although occasionally it may be of syphilitic origin. In the ordinary tubercular cold abscess we find a peculiar membranous wall formerly called the "pyogenic membrane" (the "pyophylactic membrane" of Park), which is readily scraped off and is infiltrated with tubercles. In the syphilitic abscess no such condition exists. This membrane, as also the pus of cold abscess, is more fully described in the chapter on Tuberculosis. The organisms found in the contents of the abscesses before they are opened are the bacilli of tuberculosis. Sometimes before, and always after they have opened spontaneously or have been opened without due antiseptic precautions, there is added the infection with pyogenic cocci, or the bacteria of putrefaction. This is an example of what is called *mixed infection.* Clinically, we find few of the symptoms of acute abscess. There is in most cases no redness of the part until the abscess is about to break. Pain and heat are usually wanting. The swelling is frequently quite large and fluctuation is distinct. Such abscesses may exist for months before they burst. During their formation the constitutional disturbance is usually slight. There may be, however, considerable emaciation due to the progress of the tuberculosis. The temperature is usually slightly raised, and in cases of doubtful diagnosis the thermometer will give valuable information. One of the most common seats of cold abscess is the vicinity of the spinal column, and such abscesses are due to tubercular disease of the vertebræ (Pott's disease). The pus burrowing along the psoas muscle (psoas abscess) points above or below Poupart's ligament or on the thigh external to the vessels, or it may point in the lumbar region near the margin of the quadratus lumborum muscle (lumbar abscess).

Treatment.—These abscesses should be opened with every antiseptic precaution, otherwise true suppuration with hectic fever will follow from the mixed infection which inevitably occurs. They must be thoroughly scraped out and the wound stuffed with iodoform gauze. Such treatment is best adapted to those abscesses which have few ramifications, and the walls of which are everywhere accessible to the curette. Treves treats psoas abscess by an opening in the loin which passes external to the latissimus dorsi and erector spinæ muscles and through the quadratus lumborum and psoas muscles. The diseased vertebra is first explored, and fragments of bone are removed, and the abscess-wall is repeatedly scraped and wiped out, and also washed out with a douche of corrosive sublimate, 1 : 5000, at 100° F. The wound is then closed and dressed with an iodoform dressing retained by a bandage. The patient should be kept at rest in the recumbent position for many months. If the abscess-cavity refills, the operation should be repeated.

In many cases of cold abscess it is well to evacuate the contents with the

aspirator and to inject some preparation of iodoform. A large canula is sometimes necessary, owing to the thick plugs of cheesy matter which obstruct the flow of pus. The cavity is now washed out with a 3 per cent. solution of boric acid. Among the preparations of iodoform recommended is a 5 per cent. ethereal solution, but not more than three ounces should be injected for fear of iodoform-poisoning. It causes considerable pain. A 10 per cent. emulsion of iodoform in olive oil can be introduced safely. The following emulsion is also sometimes used, and is considered safe so far as poisoning is concerned: Iodoform 10 parts; glycerin 20; mucilag. gum. Acac. 5; carbolic acid 1; and water 100 parts. From one to three ounces should be injected, and the abscess-cavity should be carefully manipulated so as to introduce the drug into all the pouches. Two or three such injections are made at intervals of three or four weeks. A cure may not be obtained for several months. Equal parts of iodoform and olive oil may be injected freely into tubercular sinuses which have resulted from the bursting of such abscesses. If this treatment fails, recourse may be had to incision, as above described.

The general treatment consists of good food, cod-liver oil and other tonics, and a careful selection of climate. Mechanical contrivances may be needed for the support of joints or bones.

Abscesses of different regions of the body possess characteristic peculiarities. The most common form of abscess in the integuments is the **furuncle** or **boil.** This is caused by a growth of the cocci from the deeper layers of the epidermis downward along the sheaths of the hair-follicles, and a final accumulation near the root of a hair. If the cocci are arrested in their growth at the mouth of the follicle, a pustule is formed, but in many cases the development continues downward and a true furuncle is developed. The boil in its early stages appears as a pustule. The amount of coagulation-necrosis is considerable, and the result is a "core" which is discharged when the abscess breaks. A crucial incision will promptly arrest the growth of a boil in its early stages, or an application of the liquefied crystals of carbolic acid may be used if it is desired to avoid a scar. A **carbuncle** is a suppuration and necrosis of the subcutaneous tissue, and is situated most frequently under the thick skin of the back of the neck. Like the boil, it is at first superficial, but rapidly spreads to the deeper parts. It has erroneously been called a collection of boils, owing to the fact that numerous points of pus appear on the surface, and when opened it presents a honeycombed appearance. This peculiarity of the carbuncle is due to the anatomical structure of the skin and subcutaneous tissues of this part of the body. The pus forms in the dense fibrous reticulum which underlies the thick cutis, and makes its way to the surface through the columnæ adiposæ, in which the fine lanugo hairs are situated, causing disintegration of the parts and sloughing of the tissues and the formation of a central crater (Warren). The carbuncle should be freely incised and all the sloughs removed by the sharp spoon or scissors, and the part disinfected as thoroughly as possible. Complete excision of the carbuncle with thorough disinfection of the parts will often lead to an arrest of the process and a speedy convalescence. Abscess of the *lymphatic glands* may form in the groins, as the result of suppuration complicating venereal disease; in the neck, following inflammation of an adjacent mucous membrane; in the axilla, as the result of suppuration in the fingers or hand; or in the saphenous glands, from suppuration in the toes or foot. **Felons** and **palmar abscesses** are often supposed to be caused by direct local trauma, but are more frequently due to indirect infection by pyogenic cocci which probably follows an injury of some kind. The precise seat of the suppuration will vary

according to the situation of the infection. Nowhere is an early incision of more importance, as the usefulness of the finger or hand is at stake.

When abscesses form in and around the internal organs they usually are designated by special names frequently derived from the organ with which they are associated, as the *perinephritic* and the *perityphlitic* abscesses and abscess of the *space of Retzius*. They should be opened as early as possible and treated as above. Abscesses of the *liver* are rare in America, but are occasionally met with. They are due to infection originating in the digestive tract, and are associated with disturbances of that region more frequently seen in tropical climates. They may sometimes be cured by repeated aspiration, but frequently they must be reached by laparotomy followed by drainage and suturing the edges of the opening of the abscess to the abdominal incision. Pus in the thorax is most frequently found in the pleural cavity, constituting **empyema.** Such an abscess can rarely be cured by aspiration, but should be promptly opened and drained. A cure may be retarded by the mechanical difficulty of bringing the abscess walls together, owing to the contraction of the lung and the rigidity of the chest wall. In these cases resection of several ribs is necessary to allow the thorax wall to come in contact with the lung. (Estlander's operation). Tuberculosis is often a complication of this variety of abscess. Abscesses occur also, but much more rarely, in the lung itself. These can be opened and drained by an incision through or between the ribs. The operation is much simplified if adhesion of the lung to the thorax wall has already taken place.

CHAPTER VI.

ULCERATION AND FISTULA.

SECTION I.—ULCERATION.

An ulcer is a granulating surface, usually of the skin or mucous membrane. There is also a tendency to necrosis or death of the granulations which are formed by the tissues in an effort at repair. If the retrograde changes equal the reparative, the ulcer will remain stationary, but if the former exceed the latter, the ulcer will constantly increase in size.

The **causes** of ulceration are of widely different origin. Some develop during the course of certain infectious diseases, particularly those of a chronic type, as syphilis, tuberculosis, leprosy, and glanders. Another kind of ulcer depends upon widespread disturbances in nutrition. These are known as dyscrasic or constitutional ulcers. To this class belong the scorbutic ulcers, which appear to form as a result of disease of the blood-vessels brought about by the absence of a sufficient variety of nutriment; also the cachectic ulcers, due to exhaustion of the system from starvation, exposure, or disease.

Ulceration may also be favored by certain local conditions. A passive hyperemia due to retardation in the venous circulation may be the cause of the varicose ulcer. *Decubitus*, or *bed-sore*, is due to a feeble circulation, which is easily arrested by continuous pressure from lying in bed, causing death of the part. *Neuro-paralytic ulcers* are caused by diminished innervation. The so-called trophic disturbance belongs in this class. A striking example of this variety is the "mal perforant," or *perforating ulcer of the foot.* We

may also have ulceration as the result of the breaking down of *malignant growths*, as sarcoma and carcinoma, particularly in the epithelial forms of the disease.

Finally, ulcerations occur which are the result of certain *mechanical difficulties* obstructing the healing process. Extensive loss of substance, burns of the skin, or avulsion of the scalp may result in the existence of a permanent granulating surface constantly contracting or enlarging, but never fully healing. Sloughing of the flaps of an amputation-stump may be followed by an adhesion of the integuments to the ends of the bones, which protrude slightly and are covered with granulations. Wounds may be prevented from healing by mechanical irritation, such as chafing or rubbing or the application of irritating ointments or acids.

A section taken from an ulcer and examined microscopically shows generally a thickening of the tissues around the ulcer due to a hypertrophy of the papillæ and an accumulation of the epidermic cells, which sometimes form an overhanging mass, giving the appearance of "callous edges." In the deep layers of the rete mucosum and in the papillary layer of the true skin deposits of blood pigment are often seen. The surface of the ulcer is covered with a layer of granulation-tissue. This tissue may resemble the type seen in healthy granulations, being composed of round cells closely packed together and supplied with a rich capillary network of blood-vessels, or we may find a condition of coagulation-necrosis due to breaking down of portions of the granulations. In old ulcers the cell-growth is much less abundant, and a gelatinous intercellular substance is seen in which clusters of cells are scattered here and there. The granulation layer is quite superficial, and beneath it we see either the nearly normal tissue or a mass of fibrous cicatricial tissue.

Ulcers are classified not only on the basis of their mode of origin, but also according to certain peculiarities which are characteristic. Thus an ulcer may be healthy, fungous, erethistic, callous or atonic, phagedenic, etc.

A *healthy ulcer* is one in which the granulations are small and florid and the edges show a bluish border of cicatrization. If it be small, it may be allowed to scab and cicatrize under the crust. If larger, carbolated oxide-of-zinc ointment, with or without calomel (ʒj @ ℥j), with suitable protection by a bandage, and rest, is all that is needed as a rule. Simple avoidance of irritation by means of a bit of "protective" or gutta-percha tissue under an antiseptic dressing is often better than ointments. If slow in healing, stimulation by the occasional light application of nitrate of silver or a solution of chloral (gr. x @ ℥j) or potassio-tartrate of iron (gr. v @ ℥j) will be useful. Skin-grafting is required in large ulcers, and is now done early in many cases of large loss of tissue which would result in an ulcer at a later period. For the details of its application see the chapter on Plastic Surgery.

The fungous or exuberant ulcer may be caused by an obstruction of the venous circulation due to cicatricial contraction and induration, and may be seen after burns and other injuries followed by undue contraction of the surrounding tissues. The granulations will protrude above the edges of the wound, and are congested and bleed readily. The application of the solid nitrate of silver, a solution of sulphate of copper (gr. i–x @ ℥j), or shaving off the exuberant granulations with a bistoury, followed by compression by Martin's rubber bandage or strapping or skin-grafting, will favor the healing of such ulcers. When the fungous granulations are pale and œdematous, they may be due to tubercular disease, and in this case a thorough curetting of the surface should precede the application of caustic or actual cautery.

The erethistic, irritable, or *painful ulcer* is a name applied to ulcers which

are extremely sensitive. The cause of this sensitiveness is not always clear. They are found in regions liberally supplied with sensitive nerve-fibers, as the anus or matrix of the nail, and are then doubtless due to an exposure of the terminal nerve-branches in the wound. They are found frequently in the lower extremities about the ankle or over the surface of carious bone, as the tibia. *Fissure of the anus* is a good instance of this kind of ulcer, which by inducing constipation and other digestive disturbances often seriously undermines the general health. It is easily overlooked unless carefully sought for in the folds of the anal mucous membrane. It is best treated by forcible dilatation of the sphincter muscle. *Ingrowing nail* or ulceration of the matrix of the nail is due to irritation from a sharp corner of the nail, which should be removed. The local treatment consists of drying and soothing powders, such as iodoform, or, better, the removal of the sensitive granulations with the curette or knife under cocaïne anesthesia, and protection of the raw surface by daily packing a very small bit of absorbent cotton under the edge of the so-called "ingrowing" nail. It is really "overgrowing granulation" rather than "ingrowing nail."

The callous ulcer is sometimes called indolent or atonic, and is due to a diminution to the minimum of the reparative process. The thickened edges are caused by the ineffectual attempts of the surrounding skin to form cicatricial tissue and epidermis. It is found in laboring and ill-nourished people, and is often due to the presence of varicose veins (varicose ulcers) or to eczema of the skin. Occasionally we find, as the result of long-standing disease and neglect in old people, a general hypertrophy of the affected leg, simulating elephantiasis. The treatment of such ulcers consists in rest in bed, elevation of the limb, and the employment of antiseptic or emollient dressings, and later perhaps skin-grafting. These ulcers are likely to recur unless support is given to the part by an elastic stocking or a bandage of flannel cut bias, or Martin's rubber bandage. When circumstances render it impossible for the patient to rest in bed, the ulcer may be treated by strapping with adhesive plaster, and a bandage made of some elastic material to give support to the blood-vessels of the limb. The strips of adhesive plaster should be an inch wide and long enough to encircle two-thirds of the limb, and should overlap each other from below upward like the clapboards of a frame house. Concentric incisions made through the indurated tissues around an indolent ulcer may relieve the cicatricial pressure on the circulation and enable the edges of the ulcer to cicatrize.

The thickened margins, consisting of contracting cicatricial tissue, so interfere with the access of arterial and the egress of venous blood that the formation of healthy granulations is impossible. As much of the healing of all ulcers results from the reduction in size effected by the contraction of their bases, caused by the organization of the deep layers of the granulation-tissue into young connective tissue, rather than by epidermization, the fixation of the margins and base of a chronic ulcer to the subjacent parts must prevent healing. Upon this fact depends the utility of incisions a little distance from the margins of the ulcer. Blisters and the pressure of strapping owe much of their effect to the removal by absorption of the constricting effect of the old cicatricial tissue upon the circulation through the ulcer.

The phagedenic ulcer is due to infection by different forms of microorganisms. When seen on the genitalia it usually follows venereal disease. In other regions of the body it may be caused by constitutional conditions combined with unhealthy surroundings. Intemperance and scurvy are predisposing causes, and when individuals affected in this way are crowded together in barracks or hospitals in time of war, such types of ulceration are not uncommon.

The surface of the ulcer is devoid of granulations, and is covered with a mass of sloughing tissue. Its edges are sharply defined and appear as if eaten out, and it spreads with great rapidity. The treatment consists in curetting by a sharp spoon and removal of the overhanging edges by the knife or scissors, followed by a thorough disinfection of the part by the application of antiseptic agents, such as pure carbolic acid, bromine, sublimate solution 1 : 500, and, if these fail, in the use of the Paquelin cautery. Constitutional treatment by means of tonics and stimulants and favorable hygienic surroundings should be employed. In mild cases pure iodoform or aristol or chloral (gr. x–xx @ ℥j), or the potassio-tartrate of iron (gr. v @ ℥j), will often effect a cure.

Ulcers depending upon *specific origin*, such as the strumous, scorbutic, lupoid, and syphilitic ulcers, will be considered more fully under their appropriate headings. The ulcerations seen in malignant diseases are chiefly carcinomatous. One of the most frequent forms is **rodent ulcer**, which is situated on the nose and cheeks, and often resembles specific or tuberculous ulcerations. It is, however, due to the breaking down of a genuine epithelial growth (Warren). Deep-seated cancers, when they reach the surface, enter upon an ulcerating stage, and may affect large surfaces in this way. Sarcomatous ulcers are comparatively rare.

SECTION II.—FISTULA AND SINUS.

A FISTULA is an abnormal opening into a normal canal or organ—*e. g.* the rectum or the duct of a salivary gland—or a communicating passage between two adjacent mucous cavities—*e. g.* the bladder and vagina, etc. Such a fistula when it communicates with an unhealed wound or old abscess-cavity is usually called a sinus. The terms are often used interchangeably. There is a great variety of fistulæ, each kind being named from the organ with which it communicates. Fistulæ may be due to congenital deformity, as a branchial fistula, which is formed by the non-union of one of the branchial clefts. They may be the result of injury or sloughing, as the salivary or vesico-vaginal fistulæ. Sinuses which result from the failure of an abscess to heal, and which have opened into some canal or cavity, are usually called fistulæ, as the urinary fistula and fistula in ano.

A SINUS is usually a canal opening upon the surface of the skin or a mucous membrane and terminating in the cavity of an old abscess. It may, however, result from the burrowing of pus beneath the skin, and will then form a tortuous series of canals extending in various directions. The failure of such a pus-cavity to heal is usually due to the presence of some secretion which pours into it, or to the presence of a foreign body, as a piece of dead bone, or to the inability of the walls of the cavity to collapse and come in contact with each other, as in empyema or abscess in the spongy end of a bone. Frequently the diseased condition of the walls of the sinus is an obstacle to repair. Many such sinuses are due to the presence of the bacillus of tuberculosis. In such cases they are lined with a membrane resembling that of cold abscesses, which must always be carefully extirpated or cauterized.

The **treatment** consists, first, in the removal of all irritating or diseased substances. It is often necessary to lay the fistula fully open and thoroughly to curette its walls before healthy granulations will spring up and aid in the healing process. Special fistulæ will be considered under their respective regions.

CHAPTER VII.

GANGRENE.

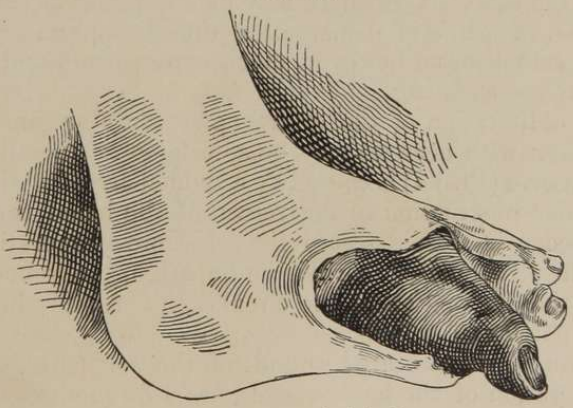
GANGRENE is a term employed to denote death of a part of the body in mass. Necrosis and mortification are terms used in a similar sense, but in surgery necrosis is often limited to death of bone: it is applied also to death of internal organs where, owing to the absence of bacteria, putrefaction does not take place and the dead mass is absorbed, new tissue growing in from the surrounding healthy parts to take its place. Gangrene results either from a cessation of the arterial blood-supply or from an obstruction to the venous outflow, or purely from a stasis of blood in the capillary vessels. It may also take place independently of any disturbance of the circulation by the direct action of destructive agents upon the cells of the tissues.

The most frequent non-traumatic **cause** of deprivation of arterial blood-supply is a diseased condition of the arteries, such as is seen in senile gangrene. It may also be due to arterial spasm, such as is produced by the action of ergot or disturbance in function of the vaso-motor nerves. Obstruction to the flow of venous blood is usually of a purely mechanical origin, as in strangulated hernia, or it may be the result of a venous thrombosis. Many causes act directly upon the tissues of the part, such as pressure, mechanical or chemical injuries, inflammatory swelling, heat or cold, and bacterial infection. The state of the tissue, due to an impaired nutrition of the body, is often favorable to the development of gangrene. This is observed during the progress of fevers or in individuals suffering from grave constitutional conditions, such as diabetes, or in parts deprived of their nerve-supply.

Typical gangrene occurs chiefly in two forms, the *moist* and the *dry*, which present striking contrasts to each other in their physical appearances.

Dry gangrene (Fig. 16), or mummification, is a condition produced by the loss of water from the tissues. The skin becomes black and wrinkled, and is often of a leather-like hardness. The amount of decomposition which occurs in this form is very slight, and the dead part in typical cases causes but slight disturbance to the adjacent living tissues. In this form of gangrene there is a gradual diminution in the supply of arterial blood, while the outflow of venous

FIG. 16.



Dry Gangrene (original).

blood continues unobstructed. In this way, aided by evaporation, water is gradually removed from the part.

The most typical form of this variety is known as **senile gangrene,** due to arterial sclerosis, the result of an obliterating endarteritis or of atheromatous changes in the walls of the vessels, combined with feeble heart-action. The calcareous condition of the arteries can often be easily detected at the wrist. The circulation in the capillaries becomes very feeble, and a slight bruise suffices to produce permanent stasis. Senile gangrene usually occurs in the lower extremities, involving the toes, where the circulation is least vigorous. The tibial arteries are frequently the seat of an endarteritis which materially diminishes their lumen, and a serious lessening of the blood-supply may exist in all the regions supplied by these vessels. The arterial blood may also be cut off by the presence of an embolus derived from valvular growths incidental to cardiac disease. In this case the disturbance in the circulation may occur so rapidly that mummification may not take place and moist gangrene will result. Dry gangrene may, however, be produced by embolism, and a large portion of an upper or lower extremity may occasionally be involved.

Symptoms.—The disease usually originates in some slight injury, as the bruising of a toe or the tearing of a portion of the nail, and is recognized by the change of color in the part, the dark-red congestion which at first appears gradually assuming a purple hue. The surrounding tissues are deeply congested, and the boundary-line between them and the dead tissue is at first imperfectly marked. The gangrene slowly advances beyond the limits of the toe in which it originated, and the adjacent toes may also become involved. When the progress of the disease is arrested, the inflamed parts set up a barrier of granulation-tissue and the **line of demarcation** is formed. The suppuration which follows separates the dead tissue from the living, and a spontaneous cure may be effected in this way. As the line of demarcation forms, the colors of the respective parts stand out in strong contrast. The inflamed tissues assume a brighter tint, while the purple hue of the dead part changes to black. An attempt on the part of the adjacent tissue to form a barrier to the advance of the disease often fails, and the gangrene spreads and may involve the whole foot, and even all the parts supplied by the tibial arteries. In the milder forms of the disease the amount of constitutional disturbance is slight, but when a large portion of a foot or leg is involved there is more or less septic infection, and a rise of temperature will indicate the presence of fever. This type is sometimes called *idiopathic gangrene.* The amount of pain is not great in this variety: during the early stages there may be a stinging or smarting pain, but after the formation of a line of demarcation this disappears. The pain in dry gangrene due to embolism is, however, much more severe, and generally is the cause of much intense suffering.

Occasionally obliteration of the arteries of internal organs may take place also, and infarctions with necrosis may be associated with senile gangrene.

Moist gangrene (Pl. VI) is caused by a sudden arrest of the arterial blood-supply or a similar obstruction to the return of the blood through the veins. It is likely to occur in deeply-seated tissues where evaporation cannot easily take place, as in strangulated hernia. Idiopathic gangrene may be of the moist type when the obstruction of the circulation is rapidly brought about and involves a large portion of a limb.

Severely contused or lacerated wounds of the soft parts, or fractures complicated with laceration of the large vessels, are a frequent cause of moist gangrene, known in this case as **traumatic gangrene.** Acute inflammations may be attended with such intense congestion and swelling that the circulation may be arrested over a considerable area, and death of the part will then occur. The same result will ensue from burns and frost-bites. In this form of gan-

Schultze, pinx.

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GANGRENE FOLLOWING A SHOT LACERATION OF THE FEMORAL ARTERY.

grene—**localized traumatic gangrene**—the tissues become soft and pulpy, the skin is discolored and changes to a deep purple or black or is covered with green and black spots. A thin brownish fluid filters through the skin, and raises the epidermis in the form of blisters or exudes from the open surface of wounds. Decomposition takes place through the agency of the saprogenic bacteria. In most cases a line of demarcation forms around the area affected by the destructive agency.

There is, however, another form of traumatic gangrene—**spreading traumatic gangrene**—in which the disease extends with frightful rapidity, due to an acute infectious process. These are cases in which the main artery or vein has been ruptured and the blood-supply of a portion of an extremity is suddenly cut off, followed by infection. In other cases acute inflammation of severe type, together with the intense septic infection, produces the death of the part. The gangrene spreads rapidly, even hour by hour, up the limb. Acute putrefaction sets in and spreads through the agency of micrococci or bacilli. The changes in color are rapid and striking: a deep bronze hue, like rind of bacon, spreads rapidly along the line of extension of the disease, and is accompanied by streaks of green and black. The part feels dense and brawny. The evolution of gas produced by the changes brought about by the putrefactive bacteria sometimes gives an emphysematous crackling to the subcutaneous tissue—a condition which is often observed somewhat in advance of the gangrenous changes. Constitutional disturbance is by this time very marked, and is due to the absorption of ptomaïnes, which the process of decomposition forces into the lymphatic channels and connective-tissue spaces or beneath fasciæ or along the course of tendon sheaths. As the parts through which the gangrene spreads are beyond the point of injury, no opportunity offers itself for the escape of these chemical poisons, and they spread upward through the circulation. The result is septicemia of a grave type, from which the patient succumbs unless the progress of the gangrene has been arrested by amputation. This type of gangrene is sometimes known as fulminating gangrene or gangrenous emphysema.

Fortunately, such grave results do not always follow death of a part from trauma. The gangrene may be limited to the part the circulation in which has been arrested, and a line of demarcation will soon separate it from the adjacent healthy parts. This form occurs frequently in a stump after amputation for railroad injury when the limb has not been removed at a point sufficiently remote from the seat of injury. A considerable portion of a limb may be destroyed by injury without a tendency of the gangrene to spread. In this case the numerous lacerations permit an escape of blood and serum, and the conditions for the development and spreading of the intense forms of decomposition are less favorable.

Smaller portions of dead tissue, such as the flap of an amputation-stump or masses of connective tissue or skin, are usually called **sloughs.** These are separated from the living parts by the septic inflammation which ensues and which results in suppuration; and, as the wound cleanses itself and the sloughs are thrown off, healthy granulations are found covering its surface.

Gangrene may result occasionally from *pressure*, but unless the latter is excessive this occurs only in parts where the circulation is already feeble and the conditions are favorable for complete stasis. **Decubitus,** or **bed-sore,** is produced in this way from long rest in the recumbent posture in individuals debilitated by fevers or long-standing chronic disease. When the slough has separated the ulcer thus formed may enlarge, and sometimes becomes quite formidable in size, and may be a complication more serious than the original disease. The

parts most frequently attacked are the integuments lying over the sacrum and coccyx, or, more rarely, the shoulder-blades and great trochanters. Sloughs may also be produced by bandages and splints when applied to a fractured limb. A frequent seat of such a "splint-sore" is the posterior aspect of the heel or the skin covering the tendo Achillis.

This form of local gangrene is much more likely to occur if the parts subjected to pressure have been deprived of their accustomed nerve-supply. *Neuropathic gangrene*, as it is sometimes called, is frequently observed after fractures of the spine. Sloughs will form with great rapidity under the heels and sacrum. This predisposition to death of the part has been ascribed to a functional disturbance of the vaso-motor nerves or to an abnormal action of the so-called "trophic nerves" which are supposed to preside over the nutrition of a part.

A type of gangrene more clearly due to abnormal vaso-motor action is the **symmetrical gangrene, or Raynaud's disease.** This appears most frequently upon the tips of the fingers or the toes. It may also be found in various other parts of the body, as the tip of the nose, the cheeks, the knee, and other salient points where the heat of the body is less than in deeper parts. It is due to a spasm of the vaso-constrictors brought about by reflex action. It is extremely rare in America. The "cold finger" often observed in bathers is ascribed to a similar cause. In symmetrical gangrene the parts affected are at first the seat of abnormal pallor and numbness, then of a purplish discoloration, and a small slough finally forms which is thrown off and is followed by healing of the sore thus produced. Several fingers are simultaneously affected on both hands.

A similar spasm of the vaso-motor nerves is produced by the prolonged use of *ergot*, and epidemics of gangrene have been observed in France and elsewhere which were due to the presence of ergot of rye (*Secale cornutum*) in the grain employed as food.

Individuals affected with diabetes are frequently attacked with **diabetic gangrene.** This is often seen in elderly people subjects of the disease, and may be mistaken for senile gangrene. The presence of sugar in the urine should therefore be carefully sought for. Operations upon such persons are supposed to be followed by gangrene or sloughing of the lips of the wound, and it is advised by some authorities to abstain from surgical operations if they can be avoided. A more extended experience with aseptic surgery, however, will probably not bear out this view. In one case known to the writer both legs were successfully amputated for diabetic gangrene. There was an interval of one or two years between the two operations.

Noma, or cancrum oris, is a gangrene of the cheek usually occurring in children as a complication of the eruptive fevers—*e. g.* scarlatina. It is the result of a gangrenous stomatitis, and is of bacterial origin, producing capillary thrombosis. The disease may even attack the bone, and in the majority of cases is fatal. If recovery takes place a large defect usually results which must be restored by a plastic operation.

Gangrene from **frost-bite** may result partly from the intensity of the cold and partly from the enfeebled condition of the individual. The part at first is blanched, but subsequently turns black. It may assume the dry or the moist condition. It may be limited to the toes, which are the most frequent seat of this form of gangrene, or the whole foot may be involved. It is frequently quite superficial, and no attempt at surgical interference should be made until the line of demarcation is clearly established.

Treatment.—The prophylactic treatment of gangrene consists in the removal, as far as possible, of the causes which may favor the development of

gangrene, and in the adoption of such measures as will promote the circulation of blood in the part.

If inflammation threatens to terminate in gangrene, free incisions may relieve the tension sufficiently to avert the impending danger. Division of the constricting ring of a strangulated hernia will remove the obstruction to the circulation in the bowel.

If, however, the obstruction cannot be removed, as in embolism or thrombosis, attention must be given to the establishment of the collateral circulation in the limb by favoring as much as possible the flow of venous blood and preserving the warmth of the part. Moderate elevation of the limb and gentle massage may favor the return of blood through the superficial veins. Slightly flexing the joints will favor the flow of blood through the larger vessels. An equable temperature of the desired degree may be maintained by enveloping the limb in dry cotton-wool, which should be loosely applied.

Minute abrasions or sores about the nails in feeble individuals should receive careful attention, but meddlesome interference should be avoided, as these are frequently the starting-points of senile gangrene. If death of the part is unavoidable, great care should be taken to prevent infection and decomposition. The gangrenous part must be disinfected with the same care as for an operation, and then be kept dry and odorless. Antiseptic dressings containing powders, as iodoform, boric acid, or aristol, should be applied. If the fluid products of decomposition are retained beneath the surface, they should be released by incisions into the gangrenous tissues, or if pus is burrowing, openings should be made into the living tissues to evacuate it.

It was at one time the almost universal custom to wait for the line of demarcation to form in senile gangrene before making any attempt to remove the dead mass, and as a rule it is better to adopt this plan. If the gangrene shows a disposition to localize itself, it would be bad practice to interfere in any way with the processes that are going on in the enfeebled living tissues, as any disturbance of them might cause the gangrene to spread still farther. As soon as the gangrene involves the sole or the dorsum of the foot, the question of amputation will become one of vital importance. In determining the point at which to amputate the pathology of the disease should be kept in mind. If we have to deal with a disease of the tibial arteries, it will be necessary to decide at what point in their course the circulation is of sufficient volume to maintain the life of the stump. Never amputate low down. Heidenhain recommends amputation of the thigh as close above the condyles as possible. An amputation of the leg below the tubercle of the tibia in some cases may be sufficiently high, but generally it is necessary to remove the leg at or above the knee. The latter point is often to be preferred, since the flaps will then be largely nourished by branches of the profunda femoris, which is rarely thrombosed. A considerable number of cases which in former times were allowed to die without surgical interference are now undoubtedly saved by amputation.

In gangrene from embolism amputation should be performed well above the gangrenous area as soon as the extent of the gangrene has been determined by the establishment of a line of demarcation.

In traumatic gangrene involving portions of the integuments it is not necessary to attempt removal of the sloughs until the line of demarcation indicates clearly the extent of the injury. A partial removal of the dead skin may, however, favor drainage of the parts below.

When a portion of a limb is destroyed by injury, the question of an immediate amputation should first be carefully considered. If this is not done and

gangrene sets in, and there are any signs of its spreading, this should prompt the surgeon to urge the necessity of amputation.

If the gangrene is localized, the general condition of the patient will enable one to decide whether it is best to remove the dead portion of a limb immediately or not. The effect of the presence of such a putrescible mass must be weighed against the danger of an operation in a patient suffering from shock and possibly other severe injuries. The conditions of each case will enable one to decide whether it is better to remove the limb at the line of demarcation or to amputate through sound tissue.

In spreading traumatic gangrene it will of course be necessary to amputate instantly and far away; that is, sufficiently high to remove all tissues involved in the septic process. There is perhaps no affection in the whole domain of surgery which demands such prompt interference in order to avert impending death.

The constitutional treatment consists in attention to the condition of shock and in supporting the strength of the patient. Absolute rest, careful nursing, and a diet that will be nutritious without interfering with the digestive functions will best meet these indications. Alcoholic stimulants are also of great value and should be used freely, but with due regard to the patient's powers of assimilation.

The treatment of bed-sores is largely prophylactic by frequent change of posture, and—thanks to the present system of nursing—the attention of the physician or surgeon is now rarely called to this affection. Dry dressings are to be preferred, as moisture favors the enlargement of ulcers produced in this way. Mechanical support to relieve pressure and strict attention to antisepsis will usually arrest the progress of the disease.

The rules for the treatment of diabetic gangrene vary but slightly from those laid down for senile gangrene. The disease is not necessarily a contra-indication to amputation. In any event a most careful attention to the diet will form an important factor in the prognosis of the case.

Little operative interference is necessary in symmetrical gangrene: the main points in the treatment of such cases are attention to the diet and hygienic surroundings and the administration of tonics.

Hospital gangrene is one of the traumatic infective diseases, and is characterized by a septic inflammation of the surface of a wound, causing ulceration and the formation of sloughs, and is accompanied by more or less constitutional disturbance. The disease at the present time has almost completely disappeared, owing to the general employment of aseptic and antiseptic treatment. It formerly occurred when patients were crowded together in small quarters with insufficient attendance and food and under poor hygienic conditions. The principal varieties usually described are the diphtheritic, the ulcerating, and the pulpy forms. The disease has been regarded by some as identical with diphtheria, but, as the latter disease has continued its activity for twenty years after gangrene has disappeared, this assumption does not appear probable. No bacteriological studies of value have been made, but some writers report large numbers of streptococci, and Koch produced in mice a disease resembling hospital gangrene in which the streptococcus was found.

The diphtheritic form is characterized by the occurrence of coagulation-necrosis in the granulations. There is, moreover, less inflammation in the margin of the wound in proportion to the depth to which the tissues are involved. The discharge is at first diminished, but later becomes more watery in character, the sloughs separate, the wound has a crater shape, and its edges are eroded. In the ulcerating form there is a progressive enlargement of the

wound, chiefly on the surface, accompanied by an unhealthy or grayish discoloration of the granulations. The edges break down, recede daily, and have a gnawed look, and the wound may finally become very large. This type is sometimes called phagedena. The pulpy form is more common in epidemics. The granulations swell, become œdematous and necrotic, the surface of the wound is soon enormously swollen, and a fetid discharge wells up in large quantities from its depths. Its margins become swollen, everted, and are exquisitely sensitive. There are great discoloration and swelling of the surrounding parts, with profound constitutional disturbance. The wound increases in size with great rapidity, and secondary hemorrhage often occurs. Joints are laid open and muscles dissected out as the disease spreads, and if the disease is not arrested, the patient finally succumbs to septicemia.

The prophylactic **treatment** consists in the application of the rules of aseptic surgery, and when, as in time of war, these cannot be observed with sufficient care, in avoiding the accumulation of great numbers of patients in confined quarters and their prompt isolation if the disease appears.

The local treatment consists in a thorough disinfection of the surface of the wound and the surrounding infected tissues. This may be accomplished by removing the diseased tissue with the curette or scissors, and by the subsequent application of the cautery, bromine, fuming nitric acid, or acid nitrate of mercury. The operation will require anesthesia, as even the ordinary dressing of such a wound is exceedingly painful. For milder cases a weak solution of nitric acid may be used with advantage, or the wound may be freely dusted with iodoform. Perchloride of iron was used with success by the French in their last war. Whatever the agent employed, it must be applied as directly as possible to the living tissues. The constitutional treatment consists in the free use of stimulants and supporting diet. An entire change of the patient's surroundings may bring about a prompt improvement. Epidemics have been broken up by moving the patients from the wards of a hospital into tents. All clothing and bedding and dressings should be changed at the same time. Amputation may be sometimes called for, and can be successfully done under strict antiseptic precautions. The disease being distinctly contagious, isolation and the non-use of sponges, towels, basins, etc., from patient to patient, are evidently necessary.

CHAPTER VIII

THROMBOSIS AND EMBOLISM.

A THROMBUS is a clot of blood which forms in the blood-vessels during life. An **embolus** is a detached fragment of a thrombus, a fragment of a vegetation on one of the valves of the heart, a globule of fat or of air, etc., which has been transported to some other part of the arterial system and acts as a plug.

Coagulation of blood may take place in one of two ways: When blood is allowed to remain stagnant in a flask, the clot which forms is nearly as large as the whole amount of blood, and is of a deep-red color, which still remains after the serum has been pressed out. It contains chiefly red corpuscles held together by fibrin. It is such a clot that is found in the *red thrombus*.

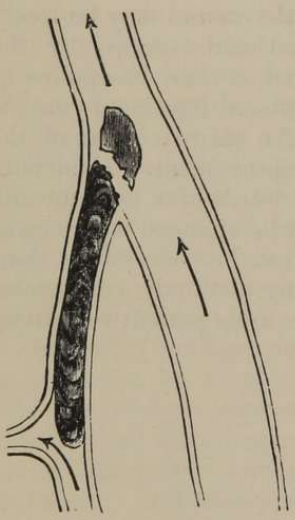
The clot from blood beaten with a stick loses its red color, and is of a yel-

lowish-white tinge, consisting of a tough mass of fibrin containing but few red corpuscles. As has been shown elsewhere, this coagulum contains chiefly broken-down white corpuscles which have yielded up their fibrin-producing material. This is one way in which a *white thrombus* is formed.

The cause of coagulation of blood in the vessels was thought by Virchow to be a slowing of the current, but it has been shown that the blood may be kept stagnant between two ligatures and yet no thrombus form, provided the vessel be kept aseptic and uninjured. Coagulation appears to be due to slowing of the current if these conditions are not fulfilled, and also to roughness of the inner wall of the vessel, to injury to the wall of the vessel, or to septic infection. The blood-plaques or third corpuscles play an important part in the process of coagulation of the circulating blood. When a roughness exists on the vessel-wall and the current is less rapid than usual, the blood-plaques leave the center of the stream and accumulate at the spot in question. Numbers of leucocytes are also arrested and become attached, and form a little hill which projects into the lumen of the vessel (mural implantation). The cells by a process of "conglutination" form a viscous mass in which little cell-structure is seen. This is another process by which a *white thrombus* is formed.

Mixed thrombi are those white thrombi in which an unusually large number of red corpuscles are seen here and there in clusters. The white or mixed thrombus forms from flowing blood, and is the variety usually seen in the blood-vessels. Red thrombi are more rarely seen in the living body: they occur chiefly in vessels subjected to septic infection; they may also be found plugging the mouths of vessels which have been cut and have bled freely.

Fig. 17.



A *Thrombus* in a Vessel. The detached fragment about to be carried away in the direction of the blood-stream is an *embolus* (Billroth).

The white thrombus usually begins as a parietal thrombus, but it may finally grow to sufficient size to obstruct the lumen of the vessel by successive deposits and may extend some distance. It is then called an obstructing thrombus. After a thrombus is formed it may undergo several changes. It may become organized, young tissue growing into it from the vessel-walls and forming a cicatricial tissue; as portions of the clot are disintegrated and absorbed, spaces are left in the newly-formed tissue, which has a spongy consistency. It is then said to be "canalized." Blood flows through the new channels, and the circulation is partially re-established in this way. At other times organization does not take place. The fibrin and leucocytes break up into a fatty mass which forms a slimy fluid in the inner layers of the thrombus, and the thrombus is thus broken up. When septic infection takes place, we have broken-down leucocytes mingled with bacteria and the various ingredients of the clot, and a "puriform softening" or "suppuration" of the thrombus takes place. A thrombus thus disorganized may break up into masses which become detached and are swept off into the circulation as infective emboli; or a thrombus which has developed so as to project into a large vessel may lose a portion of the protruding clot, and so give rise to embolism (Fig. 17).

Thrombi are found in the heart and veins, and also in the arteries. Emboli are found in the arteries, but also in the veins of the liver. When an embolus is lodged in a "terminal" artery, the part supplied by this vessel is

deprived of its circulation and becomes anemic, or occasionally a backward flow of blood takes place from the veins into the emptied vessels and a congestion with extravasation or a "hemorrhagic infarction" occurs. If the embolus is an infected one, suppuration will take place and a **metastatic abscess** forms.

Many of the emboli which are detached from veins become lodged in the capillaries of the lung, but very small emboli may pass through them and enter the general arterial system.

Emboli may be formed from other substances than blood-clot. When tissues containing fat are broken down by injury, drops of fluid fat enter the circulation and are lodged in the pulmonary capillaries. **Fat embolism** thus may follow fracture of a bone, especially at the spongy ends of the long bones. Dyspnea, and even death, may occur from this accident. **Air embolism** may occur through wounds of veins in the neck or axilla and through the uterine venous sinuses. A considerable quantity of air may be introduced without injury. The emboli will then be distributed in the capillaries of various parts of the body and eventually disappear; but if a large quantity is introduced at once, the heart may be distended with air and death will occur.

Emboli may sometimes travel against the current by force of gravity, as in the vena cava and other large veins of the lower part of the body.

The **treatment** of thrombosis or embolism is mainly prophylactic. Care should be taken that the thrombus does not give rise to emboli. The part therefore should be kept at rest until organization or absorption of the thrombus has taken place.

CHAPTER IX.

SEPTICEMIA.

SEPTICEMIA is a disease due to the absorption of the products of putrefaction into the system, or to the introduction into the blood and tissues of bacteria which rapidly multiply there. It is characterized by grave constitutional disturbance, with acute fever, disorders of the nervous system, inflammation of certain viscera, and a local infection of the wound. The nature of the poison which produces the disease is not yet fully understood. Experiments on animals have shown that there are *two varieties* of this form of blood-poisoning. In certain cases symptoms supervene immediately upon the inoculation, and the animals die of a chemical poison, no bacteria being found in the blood or tissues (**sapremia, toxemia,** or **septic intoxication**). In other cases the symptoms come on less rapidly, and death is caused by the presence of bacilli or micrococci in the blood (**septic infection**). Many observers have sought for bacteria in the blood in the septicemia of man, and micrococci have been found occasionally, but not with sufficient regularity to identify them with the disease. Since the existence of ptomaïnes as a product of decomposition has been understood, it is generally recognized that the poisons elaborated by bacteria play a prominent part in the production of the disease.

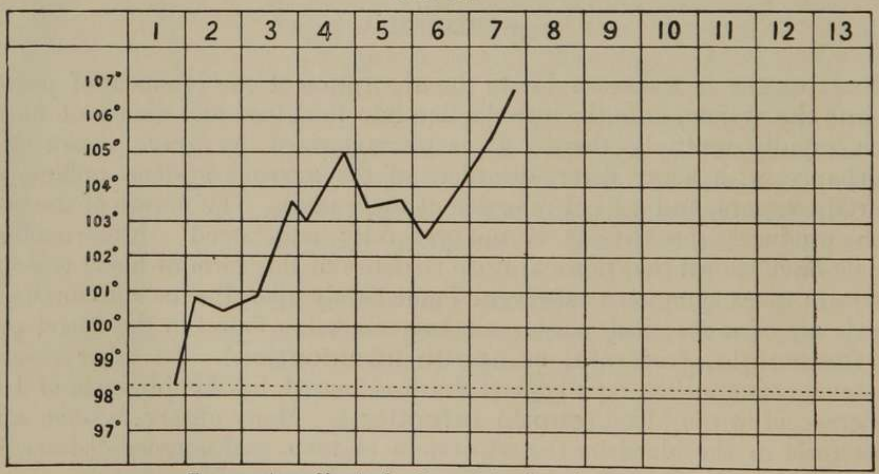
Clinically, we find the same two types of the disease in man. One is due clearly to the absorption of a chemical substance or ptomaïne. The symptoms of this variety cease as soon as further introduction of the chemical substance is prevented by a cleansing of the wound. In the other variety there are progressive changes coming on gradually, as in the bacterial type in animals,

and continuing frequently to a fatal termination in spite of efforts to check them by treatment of the wound. This variety suggests the action of bacteria, and these organisms are found in some cases, those most frequently observed being the streptococci.

The method by which infection of the system takes place is through a wound which is undergoing putrefactive changes owing to decomposition of the tissues (sapremia), or through the diffusion and multiplication of the bacteria from an infected wound, even of a trivial character (septic infection). This is most likely to occur before the wound has become covered by healthy granulations. It may also take place through the intestinal mucous membrane (sepsis intestinalis), as in cases of tyrotoxicon poisoning, and more rarely through the urogenital tract.

Sapremia.—The toxic form of septicemia is frequently seen in obstetrical cases in which putrefaction of retained clots or placenta has taken place within the uterus. The poison may be absorbed through the mucous membrane of the vagina or uterus, or through open wounds in these regions or through the uterine sinuses. The disease is ushered in with a sharp rise of temperature, the chill usually being absent. The temperature continues high, and is accompanied later with delirium. The skin is cold and clammy, and there is more or less tendency to diarrhea. A prompt removal of all decomposing substances from the interior of the uterus will be followed in a few hours by a disappearance of all alarming symptoms. Conditions favorable for such a type of poisoning are rare in general surgery, although a large, ill-drained wound, or decomposition occurring in the contents of a psoas or other abscess, is a not uncommon cause: these conditions also may be found in abdominal wounds where extensive injury of the peritoneum has favored oozing and the accumulation of blood-clot in the peritoneal cavity.

FIG. 18.



Temperature Chart of a Case of Septicemia (original).

Symptoms of Septic Infection.—In true septicemia or septic infection the development of the disease is more gradual. The fever curve is of the continuous type as in sapremia, and as the fatal end approaches the temperature will range higher. In certain cases the temperature is, however, subnormal, as is seen occasionally in strangulated hernia or in gunshot injuries of the abdomen. There is great prostration with headache and anorexia, and a typhoid condition supervenes which renders the patient indifferent to surroundings.

Diarrhea frequently develops, and may at times be accompanied with vomiting, but it is usually not severe. There is a tendency to the enlargement of the lymphatic glands throughout the body, and more particularly of the spleen. The skin is pale and dusky, but an icteric tinge is not so common as in pyemia. The hue is due to the rapid deterioration of the blood caused by the presence of the virus. A scarlet eruption may occur resembling closely that seen in scarlet fever. The skin in the early stages is hot and dry, but later is bathed in perspiration, and finally becomes cold and clammy. The sallow hue becomes more marked. The senses are dulled and the countenance is listless. The tongue is covered with a brownish fur. The pulse is now weak and rapid; diarrhea increases, and the urine is concentrated and scanty. Delirium is followed by coma, and the patient becomes moribund.

The **pathological changes** observed in the internal organs are slight. The blood is thin, of a tarry color, shows no tendency to coagulation, and contains numbers of micro-organisms. Cloudy swelling of the liver or kidneys is usually found. In the alimentary canal there is evidence of a gastro-intestinal catarrh. The mucous membrane is swollen and mottled, and punctiform hemorrhages are found at certain points. Enlargement of the lymphatic glands is noticeable, particularly of the spleen. The wound occasionally is in an extremely septic condition; at other times there is little evidence of any pathological change. When septicemia follows the infliction of a *dissecting wound* or other injury by which material already loaded with the bacteria of putrefaction is inoculated into the tissues, there is a diffused septic inflammation about the wound which develops rapidly and spreads along the line of lymphatics leading from the part, as shown by red streaks running to the adjacent chain of lymphatic glands. In very malignant cases œdema of the adjacent tissues involving a considerable area will be observed.

The original focus from which septicemia is sometimes developed may be a wound involved in gangrene or erysipelas, or some deep-seated infective inflammation around the kidney or appendix or in the medulla of bone, or a tract of connective tissue infiltrated with foul urine.

The principal **diagnostic signs** of septicemia are the continued fever, the absence of chills, the peculiar condition of euphoria or apathy, the intestinal catarrh, and the presence of an increased area of dulness about the region of the spleen. The general appearance of the patient and the condition of the pulse will prove valuable guides in enabling the surgeon to distinguish between this type and the less malignant forms of surgical fever which occur independently of suppuration. The condition of the wound and the presence or absence of pronounced suppuration will also aid in the diagnosis, although it should be remembered that septicemia may develop even during the suppurative process, provided the conditions for putrefaction exist in the wound.

The **prognosis** of the disease is always grave, but its duration may vary greatly according to the intensity of the virus. In sapremia of a pure type the prognosis is much more favorable, as the fever will disappear as soon as the local mass of putrefaction is removed; but inasmuch as it is quite difficult to say in any given case whether there is not also a true septic infection in addition to the toxic poisoning, the opinion expressed by the surgeon must be a guarded one. The weakness and frequency of the pulse, the extremes of temperature, and the mental condition are important symptoms as guides in estimating the gravity of a given case. In the acute type we have to deal with one of the most fatal of diseases. When the disease takes a more chronic course, as it occasionally does, we may have reason to hope for a cure, although a very large proportion of these cases also terminate fatally.

Treatment.—The prophylactic treatment consists in the application of the rules of aseptic and antiseptic surgery, which have greatly diminished the number of cases of septicemia at the present time. When the disease makes its appearance the attention of the surgeon should at once be directed to the condition of the wound, and no time should be lost in carrying out a thorough disinfection of its entire surface. Stitches should be removed and sinuses carefully exposed. All collections of blood-clot or decomposing fluids should be washed out with corrosive sublimate, 1 : 1000, and subsequently the tissues should be disinfected with strong solutions of carbolic acid (1 : 20, or pure crystals) or chloride of zinc (1 : 10). The wound can then be packed with gauze containing a large amount of iodoform powder, or antiseptic poultices can be applied to favor a free discharge (carbolic acid 1 : 1000, or corrosive sublimate 1 : 20,000). When the wound has deep recesses or pockets which cannot easily be reached, irrigation with boiled water, boric acid (4 per cent.), or a saturated solution of acetate of aluminum may be employed. In septicemia following laparotomy the prognosis is so grave that little success can be expected from local treatment. An attempt to save life, however, should be made by reopening the wound and by a thorough hot-water douching of the peritoneal cavity, followed by drainage. In sapremia douching of the wound is generally followed by an immediate, and frequently by a permanent, improvement. In puerperal fever from this cause the antiseptic washing of the uterus is productive of most satisfactory results.

The constitutional treatment consists principally in the fearless use of stimulants. Very large quantities will be assimilated under these conditions without producing alcoholism. The use of drugs taken internally for their antiseptic action has not proved sufficiently successful to encourage a further trial at present. The heart's action should not be hampered by any depressing agents. On the other hand, a free use of digitalis and other heart tonics may prove a valuable aid to stimulation. One of the best is strychnia administered subcutaneously in doses of gr. $\frac{1}{40}$—$\frac{1}{30}$ every two to six hours. Nutritious diet should be administered in such form as not to impede digestion and to favor rapid assimilation.

CHAPTER X.

PYEMIA.

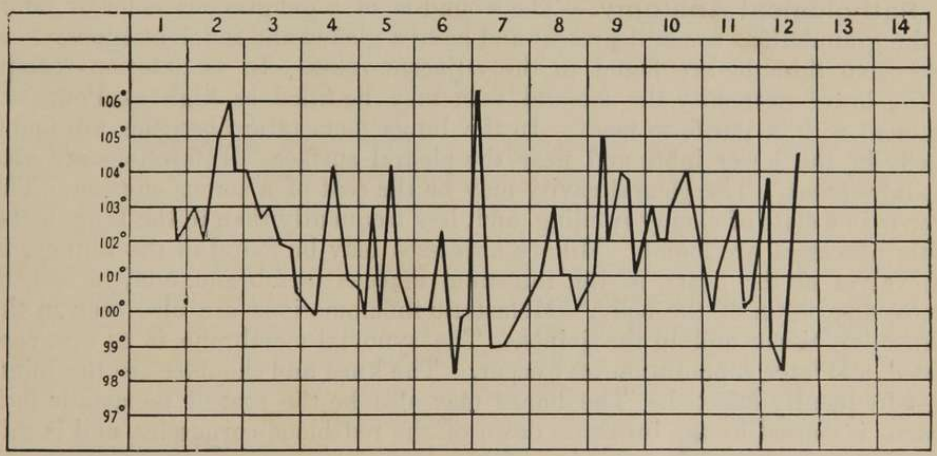
Pyemia is an infective disease developed during the process of suppuration, and is due to the absorption of pyogenic organisms into the circulation. It is characterized by the development of *multiple* or *metastatic abscesses* in different portions of the body, frequent chills, and an intermittent type of fever. The name given to it by Piorry is derived from πύον, pus, and αἷμα, blood. The old view that pus formed in the wound obtained an entrance into the circulation has long since been abandoned, but we now know that certain elements of pus may find their way into the circulation and produce metastatic abscesses.

Etiology.—Reliable investigations on the special forms of bacteria which are found in cases of pyemia have been made only within the last decade. Among the most important are those of Koch, who succeeded in producing the disease in rabbits. He found in the vessels chain-like cocci which caused the blood-corpuscles to adhere and form thrombi. Ogston showed that the pyogenic

cocci were partly anaërobic, and grew more readily in deep sinuses and pockets, and thus readily obtained an entrance into the circulation. The examination of the blood of individuals ill with pyemia has shown that both the staphylococcus and the streptococcus may be the active agents in the formation of metastatic abscesses. When the conditions become favorable for an unusual development of these bacteria, the barrier of granulation-tissue does not prevent their growth into the surrounding tissues. From these they obtain an entrance into the system through the blood-vessels more often than through the lymphatics. Coming in contact with the wall of a vein, an infective inflammation is started which terminates in a thrombo-phlebitis. Rough places are formed on the intima which lead to the formation of parietal thrombi and the subsequent development of an extensive thrombus, which undergoes a puriform softening; or a zoöglea mass of micrococci may accumulate on the inner surface of the wall of the vein and may be swept off into the circulation as an embolus. Minute emboli may pass the pulmonary capillaries, and, entering the arterial system, become lodged in the glomeruli of the kidney or other capillary districts, or even in the valves of the heart.

Larger emboli detached from the softened thrombus may be lodged in the capillaries of the lung. At all these points infective inflammation and suppuration may occur, and **metastatic abscesses** are thus developed. As a rare occurrence pus from an abscess may find its way directly into the circulation by the breaking of the abscess into a vein. The bacterial infection may also occasionally take place through the lymphatic system. The so-called spontaneous pyemias occur by a process of intravascular infection. In individuals in feeble health micrococci are sometimes found circulating in the blood temporarily. If under such conditions a slight internal bruise or wound is received —as, for instance, in the medulla of bone from a fall—the micro-organisms gain an entrance from the blood-vessels into the injured part, and an acute osteomyelitis is developed which may become the starting-point of a pyemia.

FIG. 19.



Temperature Chart of a Case of Pyemia (original).

Symptoms.—The first symptoms of the disease are noticed usually in the second week of the healing process at a period when suppuration has been fully established. These are ushered in with a chill which may be of a widely varying degree of intensity. The occurrence of such a symptom should always put the surgeon upon his guard, and the wound should be carefully inspected.

An increase in the local inflammation may or may not be discovered. A second chill will probably occur on the following day, and frequent repetition of the chill is a characteristic feature of the disease. The fever is of an irregular intermittent type, and varies not only according to the frequency of the chill, but has an almost hourly variation of its own. The undulating character of the daily fever curve is quite characteristic of pyemia, and a fall to the normal point in acute cases is rarely observed (Fig. 19).

The development of metastatic abscess is indicated by a febrile exacerbation and by the symptoms of local inflammation. A sharp pain in the side, with respiratory disturbance and fever, accompanies the formation of an abscess in the lung or a septic effusion into the pleura. The joints are also a frequent seat of inflammation, and this is accompanied with considerable swelling of the adjacent soft parts. The next point attacked may be the parotid gland. The skin is always markedly discolored, and frequently assumes a deep yellow hue. With the development of the icterus there is already marked emaciation, which, in chronic cases, is extreme. Erythematous rashes, which subsequently become pustular, are occasionally noticed. The tongue is furred and coated, but may vary greatly in appearance. The pulse is rapid, and as the disease progresses becomes weaker.

The mental condition of the patient is usually not affected. There is, however, in the later stages great hyperesthesia, and such patients are constantly complaining of pain in various parts of the body, due not only to metastatic inflammations, but to the sensitiveness of the nerves. An examination of the heart-sounds may reveal the presence of an infective endocarditis. Brain symptoms are rarely present, although metastatic inflammations may occur in the brain, and hemiplegia may result from emboli due to the endocarditis. The mind usually remains clear until the development of delirium and coma in the latest stages of the disease.

The duration of the disease will vary according to the acuteness of the attack. Chronic pyemia may be prolonged for weeks or even months. Usually in acute cases a fatal termination will be reached in the course of a week or ten days.

Pathological Anatomy.—The wound is of a gangrenous color or odor, or the granulations are still present and have a glazed and indolent appearance. Extensive thrombi are found in the adjacent veins. In amputation-stumps of the lower extremity the femoral vein may be filled as high as Poupart's ligament with a puriform mass. In the lungs metastatic abscesses are found chiefly in the lower lobes and near the pleural surface. Infarctions are also not infrequent. The pleural cavity may be the seat of a serous effusion. The liver is in a state of cloudy swelling, and, less frequently than in the lung, metastatic abscesses are found. Miliary abscesses may be found in the kidney, in the valves of the heart, in the intestinal mucous membrane, and, in fact, in almost any organ of the body. Metastatic inflammations are also seen in the connective tissue and in the joints. The synovial membrane is at first congested, and later suppuration may occur. The knee and shoulder are the joints most frequently affected. The bones may also be the seat of metastatic foci. Icterus is caused by the breaking down of the red blood-corpuscles, and is said therefore to be hematogenous (*i. e.* of blood origin).

Diagnosis.—In the early stages of traumatic inflammation a chill may be due to the development of some other form of infective disease, as erysipelas, but repeated chills are characteristic only of pyemia. The clearness of the mind, the hyperesthesia, the emaciation and great prostration, are all well marked and significant in this disease. The presence of metastatic abscess and joint inflammations when they finally occur leave no doubt as to the diagnosis.

The prognosis is exceedingly grave. It has been maintained that no case of pyemia ever gets well, but many cases of undoubted recovery have been reported, particularly in the chronic forms of the disease.

Treatment.—The prophylactic treatment consists in the prevention of suppuration. The antiseptic treatment of wounds has almost abolished the disease in hospitals, where it was formerly of frequent occurrence. When the first septic disturbances have developed in the wound and adjacent veins an attempt should be made to arrest the further progress of the disease by a thorough disinfection, not only of the wound, but of the interior of the vein. Such attempts have been successfully carried out in thrombosis of the lateral sinuses and jugular veins following suppuration in the mastoid cells. If the interior of the vein cannot be thoroughly disinfected, a ligature may be placed upon it at a point between the puriform thrombus and the heart. When the infected area is seated in an extremity amputation may be performed, provided the surgeon can be reasonably certain that the thrombus does not extend above the point selected for the operation. When it is possible all metastatic abscesses or suppurating joints should be laid open and thoroughly disinfected. Drugs are of little use in the internal treatment of the disease. Antipyretics depress the heart's action. Carbonate of ammonium and digitalis are more likely to be of service during the stage of prostration. Alcohol should be given freely, and in as large quantities as the patient will bear. Easily-digested food should also be administered unsparingly. If the patient is in a hospital he should be immediately isolated from all other patients, and as strict a quarantine as possible of those in attendance should be preserved. Ventilation should be free, and the patient may be placed in a tent, or even for a portion of the time in the open air, in certain cases.

CHAPTER XI.

ERYSIPELAS.

ERYSIPELAS is an acute infective inflammation spreading along the upper layers of the integuments of the body and mucous membranes through the lymphatic system. It is accompanied by a remittent type of fever and shows a tendency to recur. The name is probably derived from *ἐρυθρός*, red, and *πέλλα*, skin. Erysipelas was known to the ancients, but authentic accounts are of comparatively recent date. Severe epidemics of erysipelas raged in France in 1750, in Great Britain in 1800, and in 1842–43 both Europe and America were visited by an epidemic of a most virulent type. Since then there are no records of epidemics of similar severity. Although much less frequently met with since the introduction of the antiseptic treatment, it is the most common of the traumatic infective diseases seen at the present time.

Etiology.—The organism which is the cause of the disease is the *streptococcus erysipelatis*. This has been abundantly proved by experiments in animals and man. Opinions vary as to the identity of the streptococcus pyogenes with the streptococcus of erysipelas. The cocci grow in serpentine chains; each measures from 0.3 to 0.4 micro-millimeters in diameter. These cocci are said to be somewhat larger than the streptococcus pyogenes, but smaller than the staphylococcus. They are found in the capillary lymphatics of the

skin chiefly, but they may also be seen occasionally in the capillary blood-vessels. They are most active near the margin of the erysipelatous blush, and the lymphatics are crowded with them at this point. They are not found in any numbers in the circulation, but it is probable that the constitutional disturbance is due to their presence or to the presence of ptomaïnes in the blood. The organism usually obtains an entrance through a wound. In idiopathic erysipelas, when no wound is seen, it is probable that small abrasions of the skin are the route through which the virus enters the body. Probably also cases of internal infection occur, the organisms having been previously absorbed through the respiratory or digestive tract.

The *contagiousness of erysipelas* had been abundantly proved clinically before the nature of the poison was understood. The disease has been conveyed to a large number of children through the medium of vaccine virus taken from a child affected with erysipelas. Instances of erysipelas carried from a distance to certain localities where no such disease had existed previously, and producing there an epidemic, abound in literature. The close relationship between erysipelas and puerperal fever has long been recognized, and examples of the transmission of the virus of erysipelas to puerperal women by the medical attendant, and the consequent production of puerperal fever, are far too numerous. Both diseases are produced by the streptococcus, and experiment has shown that this organism can be cultivated from a puerperal case and can then be injected into rabbits, producing erysipelas. It seems probable that the disease is more prevalent at certain seasons of the year, particularly in the early spring months.

Symptoms.—This disease is usually ushered in with a chill which is accompanied with vomiting or more or less gastric disturbance. In children a convulsion not uncommonly takes the place of the chill. An examination of the wound at the time shows no perceptible change, although the nearest lymphatics are apt to be enlarged, and it is not until the end of twenty-four hours or longer that a blush is seen in the skin at this point. There is an increased tension in the part, accompanied by an itching or burning sensation. When the local inflammation has developed the color of the skin is a yellowish red, and there is considerable infiltration of the inflamed part, which has a doughy feel. The area invaded is well defined and its margins are quite irregular, presenting a zigzag outline. During the height of the inflammation vesicles form on the surface and sometimes become quite large. When resolution takes place there is considerable desquamation. The inflammation does not remain long in one spot. It spreads widely, and may involve large areas or even the whole surface of the body. In the mean time, at the end of three or four days the part first attacked begins to improve. During the height of the inflammation the constitutional disturbance is well marked. The temperature ranges from 102° to 104° F. The pulse is rapid and shows a tendency to become weak. The tongue is heavily coated and the urine is charged with urates. With each fresh outbreak of the cutaneous inflammation there is an increased pyrexia and the fever curve presents a most irregular outline. There are marked remissions, but usually no return to normal until the dermatitis has subsided. The duration of the disease is quite uncertain. In favorable cases it will last no longer than a week or ten days, but frequently the attack may last a month. Toward the close of the disease when the case is terminating favorably there is usually a tendency to subnormal temperature, showing the great prostration which the disease has produced. This depression of the vital powers is a feature of the affection which it is always important to bear in mind.

Varieties.—When the virus does not confine itself to the superficial capillary lymphatics, but spreads to the subcutaneous connective tissue, we have the variety known as **phlegmonous** erysipelas. Under these circumstances suppuration, which is extremely rare in ordinary erysipelas, is likely to occur. The foul, acrid, and thin pus infiltrates large areas, and there are sloughs of the connective tissue which are discharged in masses. In some of the severe epidemics of this type the muscles were attacked and the periosteum was destroyed, giving rise to necrosis. Gangrene of the skin may also occasionally occur from deprivation of blood due to death of the underlying connective tissue. The presence of a phlegmonous inflammation is indicated by the increased amount of local swelling and constitutional disturbance. Fluctuation or bogginess is soon felt, and if the pus is not liberated by incision it burrows freely in all directions.

Phlegmonous cellulitis, or inflammation of the subcutaneous cellular tissue, is regarded as identical with phlegmonous erysipelas by many writers. It is probable that the streptococcus rather than the staphylococcus is most frequently found in this form of inflammation, but the question must remain open until the identity or non-identity of the streptococcus pyogenes and the streptococcus erysipelatis is settled. Clinically, the two types are readily distinguished by the absence of cutaneous erysipelas in phlegmonous cellulitis.

There are other forms of rapidly-spreading inflammations of the skin and cellular tissue, particularly those which follow infected wounds of the fingers or hand, which are regarded by some authors as akin to erysipelas. These at times take the form of lymphangitis; at other times they occur as acute swellings of the integuments and connective tissue, extending with great rapidity, showing but slight tendency to suppuration, and frequently terminating fatally with symptoms of acute septicemia. They are probably due occasionally to infection with streptococci or with saprogenic bacilli.

Facial erysipelas, which at one time was regarded as idiopathic erysipelas, is now supposed to be due to infection through some slight wound or abrasion on the face. It usually begins with a blush near the root of the nose or the lachrymal duct and spreads laterally toward the ears. The color is a scarlet red, and the amount of swelling is usually great and is accompanied with œdema about the eyelids, obliterating all facial expression and causing entire closure of the lids. Vesicles and bullæ also form on the cheeks. The inflammation may extend to the scalp or the neck, but the chin is rarely involved. The glands at the back of the neck are enlarged. In some forms the fever runs high, and there is usually considerable delirium. This may be due to reflex irritation of nerves or rarely to a suppurative meningitis, the result of a direct extension of suppuration in the orbit or to the meninges. Ordinarily, the delirium disappears when the fever subsides. There is more or less conjunctivitis, and some œdema in the orbital tissues. If suppuration should occur, blindness may result, a complication which is fortunately rare.

Erysipelas neonatorum occurs usually in epidemic form in hospitals. It begins as a slight inflammation about the umbilicus, but as it spreads to the genitals and thighs the constitutional disturbance is great and the prognosis grave. It may be complicated with phlebitis of the umbilical veins extending to the liver.

Erysipelas may involve the **mucous membranes.** In severe epidemics of erysipelatous angina the tonsils are greatly inflamed and the tongue is often swollen. Diphtheritic or gangrenous inflammation of the fauces may also occur. These epidemics are rarely seen at the present time. Erysipelas may

extend to the glottis, and erysipelatous pneumonia, or pneumonia migrans, is described by some authors. The female genitals and the rectum may also be invaded by the disease.

The **curative influence** of erysipelas is shown not only in the effect produced by it on old ulcers, but even by the wound itself, which, when in the granulating stage, appears to heal more rapidly. Tumors also have sometimes disappeared during an attack. Lympho-sarcoma of the neck has been absorbed, the cells having undergone fatty degeneration. Both lupus and epithelial ulcers of the face have been known to break down, healthy granulations subsequently appearing which healed rapidly. Fehleisen took advantage of this circumstance to inoculate certain ulcers with cultures of the streptococci of erysipelas, and thus demonstrated the identity of the virus of the disease (p. 202).

The **prognosis** of erysipelas is usually favorable, as there is a tendency to self-limitation. The severity of the disease cannot, however, be predicted in any given case, but in small granulating wounds the disease is usually lighter than in large fresh wounds. Danger frequently arises from complications, as œdema of the glottis or secondary hemorrhage.

Treatment.—Attempts to restrain the infective process by antiseptic applications have thus far not been very successful. The apparent success of many drugs may be due to the spontaneous arrest of the process which so often occurs. Hot fomentations, containing corrosive sublimate of the strength of 1 : 10,000 or 1 : 15,000, or carbolic acid may be used; but care must be taken to avoid increased local irritation or poisoning by absorption of the drugs when a large surface is covered. An ointment of carbolic acid and vaseline, 1 to 100, may be brushed on the face with a soft brush or applied to other surfaces and protected with a thin layer of gutta-percha tissue or oiled paper. Zinc ointment is often useful. In phlegmonous erysipelas free incisions are indicated. The sloughs should be removed, and the pus-cavities must be disinfected as thoroughly as possible. Pressure with plasters or bandages in situations where they can be conveniently applied, has been advised to arrest the spread of the disease.

The constitutional treatment should always be supporting, and any depleting measures should be carefully avoided. The presence of delirium does not necessarily contraindicate the use of stimulants. Tincture of the chloride of iron has been recommended in large and frequent doses on account of its action upon the red blood-corpuscles, which are found crenated, and when placed under the microscope run together readily. This method was at one time received with great favor, but is less used at present. Quinine has also enjoyed a great popularity. Antipyretics as a rule have little effect upon the fever, and should be avoided, owing to the depressing influence upon the heart's action which many of them exert. Opium in some form and hypnotics are indispensable to allay the pain and procure sleep. Food should be carefully and frequently administered. When the blush has disappeared a complete change of bedding and clothing, with careful disinfection, may serve to protect the patient from a relapse due to a reinfection of the system.

CHAPTER XII.

TETANUS.

TETANUS is an infective disease, almost always originating from a wound. The central nervous system is the region chiefly affected by the bacterial poison which is the cause of the disease.

The **bacillus of tetanus** (Pl. II, Fig. 5) was discovered in 1885 by Nicolaier. It is a short rod with an enlargement at one end, due to sporulation, which gives it the characteristic drumstick shape. Although it is found in the dust of the street, it rarely finds an opportunity to grow in the living tissues, owing to its anaërobic properties; hence the rarity of the disease. It is found principally in the tissue near the wound, and is rarely, if ever, seen in the internal organs or blood. Several ptomaïnes have been extracted from the cultures of this bacillus, such as tetanine and tetano-toxine, and it is probable that most of the symptoms of irritation of the nervous system are due to the presence of these substances, as but few bacilli are found there.

Punctured wounds naturally offer the best opportunity for the growth of the anaërobic bacillus, and if such wounds are inflicted in dirty parts of the body, as the hands or feet, or foreign bodies covered with dust containing the bacilli are lodged in the tissues, the conditions favorable for infection are obtained. The state of the weather is said to have an influence upon the development of the disease. It has appeared in epidemic form with sudden changes in the weather after battles. It is also said to be much more common in tropical climates.

Tetanus is said to be **traumatic** or **idiopathic.** It is probable, however, that all cases of tetanus are traumatic, but that the wound is so slight in many cases as to escape notice. It has been known to follow such injuries as simple fracture, in which case internal infection probably occurs.

Acute tetanus most frequently makes its appearance at the end of the first week after the infliction of an injury, although this period varies considerably.

The first **symptom** complained of is a stiff neck, which the patient attributes to a slight cold. The muscles of the face and jaw are next involved, and the patient is unable to open his mouth, this symptom giving rise to the popular name **"lock-jaw."** The muscles of the fauces and the pharynx are often in a state of spasm, rendering deglutition difficult. The muscles of the thorax and abdomen are next involved, and the muscles of the back are so painfully contracted that the head is thrown back, the spine is arched, and the body assumes the position known as **opisthotonos.** The lower extremities may also become rigid; the arms are, however, only partially affected. The muscular spasms, which are tonic, permit of little rest, and the sufferings of the patient are excessive and almost continuous. The expression of the face is totally changed by the contraction of the various muscles, which produces the characteristic risus sardonicus. The patient often experiences considerable difficulty in passing urine or in having a movement of the bowels. Any disturbing influence, especially noise, instantly evokes the muscular contractions and adds to the patient's sufferings. These have been known at times to be so severe as to produce rupture of a muscle or fracture of a bone. Such a condition permits of little sleep, and in the acute cases the patient rarely obtains any rest from the moment the disease makes its appearance. The temperature is usually not much elevated, but the skin is bathed in perspira-

tion. The pulse is weak and rapid, and as the disease progresses the exhaustion becomes marked, owing to loss of food and sleep. Sudden death often occurs in a paroxysm of dyspnea. The mind is usually clear to the last. Such an attack will run its course usually in two or three days.

In **chronic tetanus** the disease makes its appearance at a later date. The muscles are extensively involved, but there are periods of comparative relief, and as these intervals become gradually prolonged the patient has an opportunity to sleep. In the chronic form the disease may last several weeks. There is little change to be observed in the wound, although in some cases there are evidences of an infective inflammation.

Trismus is a name given to a milder form of the disease when the contractions are limited to the group of muscles about the neck and face.

Cephalic tetanus or **tetanus hydrophobicus** occurs after injuries in the region of distribution of the twelve cranial nerves. It is accompanied by paralysis of the facial nerve, usually on the side affected, and there is often spasm of the pharyngeal muscles, causing difficulty in swallowing. There is also trismus, and sometimes the muscles of the trunk are affected. It may be either acute or chronic. Many recoveries from the chronic form are reported.

Tetanus neonatorum or **trismus nascentium** is a general affection of the muscles in the newborn infant, beginning with trismus, and is due to an infection through the navel. It occurs occasionally in epidemic form in lying-in hospitals, and is a fatal disease.

Post-mortem examinations of cases of tetanus do not usually show any evident pathological changes. Some observers have found hyperemia of the medulla and cord, but others have detected no change. Brown-Séquard described an ascending neuritis, and Lockhart Clarke observed softening of portions of the gray substance of the cord.

The **diagnosis** of tetanus is usually not difficult in the acute cases, but in the milder forms it may be mistaken for other affections, as rheumatic inflammation of the jaws or hysterical contractions of the masseter muscles and excessive muscular spasm during the dressing of a sensitive wound. In strychnia-poisoning the muscles of the jaw are not rigid at first. Where the dose is small and repeated there will be intervals of rest. There is hyperesthesia of the retina and objects are colored green.

Tetany is a disease characterized by attacks during which tonic spasms of the various groups of muscles occur, principally of the upper extremities. According to Weiss, these attacks are due to an irritable condition of the gray matter of the medulla and spinal cord. It sometimes follows childbed and fevers and some mental shocks. It has also been frequently observed after operations for the removal of goitre. The spasms are tonic and give rise to great rigidity of the muscles. Between the attacks the patient appears well. The majority of cases get well without treatment. It occurs chiefly in young persons. Opisthotonos may occur, but trismus is absent. Pressure upon the nerve-trunk leading to the affected muscles will always bring on an attack. It is a rare disease in America.

Hydrophobia, which is popularly thought to resemble tetanus, is easily distinguished from it. The paroxysm of hydrophobia is not a true muscular spasm, and is limited to the muscles of respiration. The intervals of repose in the early stages and the mania in the later stages are also distinctive. One who has once seen the two affections would not be likely to mistake them a second time.

The **prognosis** of acute tetanus is of the gravest character. The only

hope in such cases is that the acute form may gradually assume a chronic type. According to Yandell's statistics, those patients who live beyond the fifth day are more likely to recover. Every day beyond this period improves the chances for recovery. Cases occurring after injury received in battle are much more fatal.

The prophylactic **treatment** consists in the thorough disinfection of all suspicious wounds. As soon as symptoms appear the patient should be isolated and kept in a darkened room, and extreme care should be taken to disturb him as little as possible. Any method of treatment which involves motion should therefore be avoided. Of all drugs, chloroform appears to have the most soothing effect upon the nervous system, and can be administered in small quantities by inhalation at frequent intervals. Chloral can also be given with the same end in view, and it may be combined with bromide of potassium. Inhalations of nitrite of amyl often act well, the relief persisting for some time after each inhalation. Morphine may be injected subcutaneously. Calabar bean has been used successfully. All of these drugs must be given in unusually large doses and for a considerable time, as a hesitating policy entails great suffering upon the patient. Retention of urine must be relieved by catheterization, and if the muscular spasm of the throat is excessive it may be necessary to administer nutrient enemata. There are few diseases where skilled nursing is of so much importance. Several authors have recently published cases of cure by injections of the tetanus antitoxin of Tizzoni and Cattani.

CHAPTER XIII.

SCURVY.

SCURVY is a constitutional disease traceable to the use of improper diet, defective chiefly in suitable vegetable food, and to imperfect hygienic surroundings. It is characterized by great disturbances of nutrition and a tendency to hemorrhage in the various tissues of the body.

History teems with accounts of diseases strongly resembling scurvy, but no reliable descriptions of any epidemic are to be found before the fifteenth century, when the great extension of navigation exposed the crews of vessels to prolonged privations such as had not before been experienced. During the present century it has been noticed chiefly in Arctic voyages and in many wars. The Allied armies suffered from this disease in the Crimea, and during the late Civil War the troops on both sides were affected. Perhaps the most striking epidemic of any occurred at Andersonville. During the siege of Paris in 1871 many cases of scurvy were discovered and carefully studied. It is rarely seen at the present time, and no opportunity has been obtained for studying it with the care which modern methods of investigation offer.

Scurvy has been supposed to be a contagious disease and also one of miasmatic origin, but it is now conclusively proved that imperfect nutrition is the most important factor in the **causation** of the disease. All are agreed that a deficiency in the variety of the diet is the principal cause of scurvy, but opinions differ widely as to the particular alimentary substance the absence of which brings out the symptoms of the disease. Some have supposed that the disorder was due to the lack of fresh vegetables. Others have thought that the excessive use of salt meats produced conditions favorable for the disease. Garrod's theory that a deficiency of easily assimilated potassium salts in the

food is one of the causes of scurvy has excited a good deal of attention. The most important factor, however, is certainly the absence of variety in diet. In certain instances the use of impure water has caused an outbreak of the disease, as was the case in Ranke's expedition into the interior of Australia. Unhealthy surroundings, as foul quarters in a ship; a bad state of the health, such as might result from great fatigue or dissipation; and mental depression, such as might occur among convicts,—are all predisposing causes.

Symptoms.—The early stages of the disease are marked by a condition of extreme lassitude. On slight exertion the heart's action becomes rapid and the respiration is increased in frequency. The patient complains of muscular pains in various portions of the body and is extremely sensitive to low temperatures. He is drowsy and apathetic and has an appearance of depression. There is no febrile disturbance and the pulse is slow and feeble. The skin is of a pale yellow hue, and is mottled here and there with brownish-colored spots. The epidermis is dry and brittle and there is considerable desquamation. The cutaneous follicles are unusually prominent, giving the appearance of "goose-flesh." This condition will last for several weeks before the symptoms distinctly characteristic of scurvy make their appearance. The gums then begin to be swollen and œdematous, and the mucous membrane of the mouth assumes a bluish tinge. The alveolar membrane is sensitive and bleeds easily, and the breath has a characteristic foul odor.

Petechiæ and numerous small extravasations are seen beneath the surface of the skin. They are at first observed about the roots of the hair, and appear as round bluish-red spots the size of a pin's head, which do not disappear on pressure. Later, some of the extravasations which take place are of considerable size and appear like bruises. Small vesicles form which later grow to large size and become occasionally the starting-points of ulcerations. The latter may, however, result from a septic infection and breaking down of the extravasations themselves. The ulcers vary in size, are covered with a brownish scab, and are surrounded by a violet discoloration of the skin. The granulations are unhealthy and give vent to a foul-smelling discharge. The muscles and the connective tissue are also the seat of hemorrhages, some of which break down and discharge an ichorous fluid. At other times they indicate their presence only by peculiar indurations to be felt in those tissues. Hemorrhages may occur also from the mucous and serous membranes. Inflammatory hemorrhagic effusions may take place in the periosteum. Swellings occur at the epiphyseal line, and the epiphyses may be separated from the shafts of the bones. The joints also may be involved. Even the eyes may be affected, and more or less disturbance of vision result (hemeralopia). The quantity of the urine is decreased, as also the urea and all the solid elements of urine. Fever is present during the height of the disease only when inflammatory complications prevail.

The *post-mortem changes* observed are the hemorrhagic effusions in various parts of the body and such inflammatory complications as may have occurred, especially croupous pneumonia and ulcerative endocarditis. Hemorrhagic infarctions are often found, the result of embolism derived from thrombi which form in the right auricle. Analyses of the blood have not as yet thrown much light upon the hemorrhagic tendency so conspicuous in this disease. Water is found in excess and an increased number of white corpuscles is observed. It is probable that a diminished power of resistance exists in the walls of the capillaries.

Diagnosis.—Scurvy may be distinguished from purpura by the cachexia and the persistent pains and the fetid breath accompanying the peculiar con-

dition of the gums. It may be distinguished in the same way from anemia, hemophilia, and leucocythemia.

The **prognosis** of the disease will depend greatly upon the stage at which the patient comes under treatment. Under favorable conditions improvement soon begins in most cases, but the duration of the convalescence is usually a prolonged one. If the use of the limbs is regained after a few days of treatment, the prospects of ultimate recovery are excellent. The recovery in uncomplicated cases is usually a complete one.

The prophylactic **treatment** consists in strict attention to the hygienic conditions, especially as to dryness and cleanliness on ships and in laying in a supply of live-stock. Among the antiscorbutics of repute at the present time may be enumerated eggs, milk, potatoes, beets, carrots, cabbages, onions, fruits, cocoanuts, pickles, cranberries, cider, lemonade, and lime-juice. The various meat extracts are also valuable and portable articles of food. Good drinking-water is also of the greatest importance as a prophylactic.

The curative treatment of the disease is almost exclusively dietetic. Nitrate of potassium is said to be of especial value. It may be used alone or mixed with vinegar (Wales). Antiseptic mouth-washes and lotions for the ulcers are also indicated. Any medication contemplated should be of a distinctly tonic character.

CHAPTER XIV.

TUBERCULOSIS AND SCROFULA.

SECTION I.—TUBERCULOSIS.

THE INOCULABILITY of tuberculous material was regarded as a possibility by Laennec and others, but Villemin in 1865 was the first to demonstrate the fact that the disease could be transmitted by inoculation to animals, and was therefore infectious like small-pox or syphilis. These views were confirmed in 1877 by Cohnheim, who successfully inoculated the anterior chamber of the eye in animals, and was able to observe through the transparent cornea, after a period of incubation, a development of numerous miliary tubercles in the iris.

The search for the bacillus was from this time pursued with energy, but the observations of Baumgarten gave the only reliable results. His discovery of the bacillus was almost simultaneous with that of Koch, who, however, in 1882 was the first to establish fully the identity of the organism and to cultivate it successfully.

The length of the **bacillus tuberculosis** is about one-half the diameter of a red blood-corpuscle. It is a thin rod, found single, in pairs, or in clusters. In tubercle in the human subject it is seen usually either single or in small numbers, and at times is quite difficult to demonstrate. It is found, however, in large numbers in experimental tuberculosis in certain stages of development, and therefore when it is not possible to discover bacilli with the microscope a diagnosis can be made by inoculation of a suspected tubercle into animals.

The **miliary tubercle** consists of a minute gray non-vascular nodule about the size of a mustard-seed. Under the microscope it is seen to contain a mass of leucocytes, near the centre of which are to be found a number of larger cells with one or more nuclei known as epithelioid cells and one or more

giant-cells. The appearance of such a cluster of cells is so characteristic that a tubercle can usually be recognized by the presence of the giant-cells without a demonstration of the bacilli, although these cells are also found in other growths besides tubercle (Pl. IV, Fig. 9). The structure of these giant-cells is peculiar, the nuclei being arranged in a somewhat radiating manner around the periphery of the cell, the center of which is made up of a granular protoplasm in a more or less advanced stage of degeneration. In studying experimentally the development of a tubercle it has been found that the first change consists in a division of the fixed cells of the part involved (by karyokinesis), by means of which process the epithelioid cells are formed. The giant-cell formation is due to the fact that the epithelioid cells do not show a tendency in the less active forms of tuberculosis to proliferate, but the division of the nuclei of certain cells continues, and the unusual cell-growth is thus produced. In acute miliary tuberculosis the cell-division is more active and giant-cells are less frequently found.

As the growth of tissue-cells begins to subside, the number of leucocytes which have wandered in from without begins to increase. The fine reticulum or network of fibers which supports the cells of the tubercle does not appear to be a new formation, but is merely the remains of the intercellular substance of the pre-existing tissue.

The bacilli are found either in the larger cells or between them; at times but one or two bacilli are found in the giant-cells. They are seen usually near the nuclei at the border of the cell. More rarely they are found in large numbers in the human subject. How they are brought to the part affected is not clear: it is thought by some that, not possessing any movements of their own, they are transported by the leucocytes, but this view would not accord with that first expressed (Baumgarten)—namely, that the leucocytes appear only at a later stage in the process of development. The bacilli are rarely found in the circulating blood.

Sections of tubercle are well shown by the double staining process, the fibers of the tissue being colored red by eosine, and the giant-cells being well brought out by the hematoxylin. In order to show the tubercle bacilli a special staining method is necessary. The staining fluid consists of the following ingredients: Saturated alcoholic solution of fuchsin, 10 parts; 5 per cent. aqueous solution of carbolic acid, 90 parts.

The section should be placed in a small quantity of this fluid in a watch-glass, and allowed to remain from one to twenty-four hours according to the degree of staining required. The section should then be decolorized with a 5 per cent. solution of sulphuric acid for a few seconds. If, when the specimen has been washed in alcohol 60 per cent., it is found not to be sufficiently decolorized, it should be replaced in the sulphuric acid. It should finally be dehydrated in absolute alcohol, cleared in oil of cloves, and mounted in Canada balsam.

Tubercle shows a tendency at an early period of its existence to undergo a **caseous degeneration.** This tendency is favored by the absence of blood-vessels, and the part which first succumbs to this process is the center of the tubercle, the portion farthest removed from the supply of nutriment. The change is principally due to a coagulation-necrosis, presumably caused by the action of the bacilli upon the cells. As a result of this change the mass presently assumes the appearance of a caseous nodule. If the progress of the disease is arrested at this point, the tubercle becomes enclosed in a fibrous layer the result of a reactive inflammation, and is said to be encapsuled, and the cells, having all undergone cheesy degeneration, are finally absorbed or the caseous

product is calcified. If, however, the process extends, the caseous nodule becomes larger, the necrosed material breaks up into a granular débris, and a fluid is produced which in appearance resembles true pus. These products of degeneration frequently contain the bacilli, and when inoculated into animals may reproduce the disease.

This *tuberculous pus* or puruloid material contains the broken-down masses of cells and a certain number of leucocytes and fragments of the coagulation-necrosis. The contents of cold abscesses arising from tuberculous processes are usually of this character, but occasionally the pyogenic organisms are found in this fluid, in which case true suppuration occurs. The tubercular pus is thin and of a peculiar white or chalk-like color: it contains lumps of cheesy matter the product of tubercular softening, and fragments of sloughs of the connective tissue. Crumbs of bone may occasionally be felt in it. If the tubercular nodule is on the surface of the skin or a membrane, such degenerative changes will lead to ulceration.

The local spreading of tubercular inflammation is caused by the growth of the bacilli, which involve new areas of tissue. Adjacent cavities or organs may thus be invaded. By the breaking down of bone-tissue the bacilli may gain an entrance into a joint, or the peritoneum may become infected from a tuberculosis of the intestine. When the bacilli enter the blood-vessels or lymphatics, they may be transported alone, or in the interior of small emboli, to a distant organ, and a general miliary tuberculosis may be thus produced.

Tuberculosis is probably the most common of all diseases, for it is estimated that 18 per cent. of all cases of death occur from this cause. According to Baumgarten, it arises more frequently by inheritance than in any other way; but, although the bacillus may undoubtedly be transmitted from parent to offspring, it is probable that only a predisposition to the disease is the more frequent result of heredity. The disease easily arises then in such predisposed persons when the bacillus gains an entrance to the body through the respiratory organs, whether inhaled with the air as dust arising from dried sputa and other excretions, or taken into the alimentary canal with food and penetrating the intestinal mucous membrane. It may also be introduced through wounds of the skin, chiefly of a trifling character, such as bruises or scratches. It is undoubtedly an infectious disease, and may be contracted by persons of healthy ancestry by continued exposure to its germs.

Tuberculosis of the skin includes a number of diseases which until recently have been regarded as different affections. The most frequent form is that known as **lupus.** This disease is now recognized as a lesion due to the presence of the bacillus of tuberculosis, although it is often extremely difficult to find the organism. The tendency of the disease is to remain local, but it may occasionally lead to a general tuberculosis. *Lupus vulgaris* is most frequently seen on the face, but other portions of the body may be the seat of the affection, particularly the extremities. It is characterized by a chronic inflammatory process, forming brown-red nodules with a tendency to ulceration and subsequent cicatrization. In this way a considerable area gradually may be involved. When the tendency to ulceration is excessive we have the form known as *lupus exedens*, although this name is often given erroneously to ulcerating forms of cancer of the face.

In other cases the amount of granulation-tissue may be a prominent feature, and then we have the form known as *lupus hypertrophicus.* When there is a tendency to the formation of cicatricial tissue the disease may produce extensive superficial alterations in the skin, and give rise to great deformity, the

whole surface of the face being occasionally involved. Patients with lupus not infrequently die of pulmonary tuberculosis.

The affection known to surgeons as *anatomical tubercle*, and frequently found on the fingers and hands of assistants in the autopsy and dissecting rooms, is now recognized as tubercular, and is regarded as almost identical with the variety known chiefly as *tuberculosis verrucosa cutis* or *verruca necrogenica*. It is characterized by plaques situated chiefly on the backs of the hands, arms, and fingers, looking at first sight like a cluster of inflamed warts. There are also erythematous patches and pustules.

Scrofuloderma is a name applied to certain tuberculous affections of the skin which formerly were not regarded as allied to lupus. It occurs as a more or less deep-seated, chronic inflammatory process in any part of the skin, preferably on the neck, body, or extremities, and shows a tendency to the formation of granulation-tissue, which breaks down and gives rise to sinuses or minute ulcerations. It is occasionally associated with disease of the lymphatic glands and bones. It is sometimes called scrofulous gumma, owing to its resemblance to syphilis.

Primary *tuberculosis of the panniculus adiposus* is observed, particularly in children, in the form of flat subcutaneous nodules which gradually soften and break down and discharge. In some cases they may burrow extensively without coming to the surface. Tubercular abscesses of the deeper connective tissue are, however, usually secondary to some affection of the bones or joints or lymphatic glands. The larger abscesses, generally known as **cold abscesses**, originate most frequently from tuberculous disease of the bones. Such cavities, when opened, present a characteristic appearance. The walls are covered with a membrane of a grayish-yellow or grayish-red color, which is loosely attached, and can readily be removed with the finger or sharp spoon in large fragments. It consists of a very soft and slimy material, which contains great numbers of miliary tubercles closely packed together and imbedded in masses of fibrin. When scraped away healthy tissue is exposed. At one spot the persistence of a small islet of granulations indicates the opening of a fistulous track which leads to diseased bone. Occasionally no such fistula can be found. This is the case in the so-called peri- or para-articular abscess when the septic infection of the connective tissue is transmitted from a diseased bone or joint through the lymphatics. Such abscesses, although at first not communicating with the affected joint, may later establish an opening into it. Fistulæ leading to tubercular abscesses are also lined with a tuberculous membrane. The pus of these abscesses may contain a few leucocytes, but consists chiefly of the products of caseous degeneration. The presence of the bacilli of tuberculosis, although not easily determined with the microscope, is often demonstrated by experimental inoculation in guinea-pigs. In the typical cold abscess pyogenic cocci are not usually found under the microscope, nor can they be obtained from cultures of this pus. The absence of fever in cases where these large abscesses are found is thus explained, and the constitutional disturbance which frequently follows the opening of a cold abscess is undoubtedly due to a subsequent additional infection with the pyogenic cocci.

Adjacent *muscles* are rarely infected by tubercular abscess: it is now well understood that striped muscular fiber is not liable to tuberculous disease.

Tuberculosis of the *mucous membranes* may follow or accompany lupus of the skin. A direct extension may take place from the alæ of the nose or from the lips to the nostrils, gums, or pharynx.

Tuberculosis of the *tongue* is a comparatively rare affection, and is liable to be mistaken for cancer or syphilis. It appears as a chronic inflammatory pro-

cess which produces an infiltration extending to the deeper muscular tissue. On the surface ulceration may take place. It may be associated with tuberculosis elsewhere, and the presence of pulmonary signs or fistula in ano would serve as aids to diagnosis. The prognosis will depend largely upon the general condition of the patient.

Lupus of the *velum*, *tonsils*, and *pharynx* is often found associated with lupus of the skin, and, according to Lennox Browne, is more likely to be seen in skin than in throat clinics. It appears in the form of numerous superficial ulcerations surrounded by inflamed and thickened borders, which show a tendency to become confluent. There is less loss of substance than in syphilitic lesions of these parts, as the ulcer tends to cicatrize. The adjacent mucous membrane is often found studded with miliary nodules, which run together, break down, and form new ulcerations. The miliary tubercles are situated immediately beneath the epithelial layer, and may also involve the intermuscular and connective tissue. The giant-cells are numerous and well developed; the number of bacilli is, however, usually small. Many of the patients who are the subjects of these affections succumb to pulmonary tuberculosis.

Tuberculosis of the throat or lungs may give rise to *tubercular disease of the intestinal canal.* As a result of such infection ulcers may form in the neighborhood of the cæcum and appendix, and may perforate the bowel and give rise to a tubercular abscess. Tubercular inflammation of the large intestine has been known to give rise to so much obstruction as to necessitate laparotomy, which has been successfully performed. The development of tubercular peritonitis from this source is supposed to be much less common than from the Fallopian tubes.

Most cases of *fistula in ano* are tuberculous. They are characterized by the formation of fungous granulations and a tendency to burrow beneath the skin and mucous membrane. In many of these cases symptoms of pulmonary disease are also present, and the prognosis is then exceedingly unfavorable.

All portions of the *genito-urinary tract* appear to be affected by tuberculosis. Lupus is found occasionally on the labia majora. Cornil has found the bacilli in ulcerations of the vagina adjoining a vesico-vaginal fistula. In six autopsies of cases of tuberculosis of the uterus he found in three a number of bacilli. Tubercular infection of the Fallopian tubes often supervenes upon a chronic catarrhal salpingitis in cases of tubercular disease of other portions of the genital mucous membrane. It is possible that infection of the female genital organs may result from coitus, as the bacilli of tuberculosis have been found in the semen of tuberculous men even in cases where the genital organs are not the seat of tuberculous disease. Tuberculous peritonitis not infrequently accompanies tuberculous pyosalpinx.

Tuberculosis of the *mamma* is rare. Tuberculous ulcerations or sinuses may occasionally be seen about the nipple, and yield readily to treatment. Several cases are reported by Cornil where miliary tubercles containing giant-cells and bacilli were found in the ducts of the gland. Tillmans recommends, in every case of tuberculosis of the mamma, extirpation of the breast and the lymphatic glands.

Tuberculosis of the *male genital organs* has usually an unfavorable prognosis. Tuberculosis of the *testicle* occurs most frequently in early adult life. Many cases of cure occur without operative interference, although there is danger that the disease may propagate itself along the course of the vas deferens to the vesiculæ seminales, the prostate, and the bladder if the testicle

is not removed. Tubercles are found in the urethra, in the membranous portion chiefly, but the disease is more frequently described as existing in the bladder. It may at times be quite extensive and involve the kidneys. It is one of the most difficult forms of the affection to deal with, and early diagnosis by detection of bacilli in the urine is therefore important.

The tubercular affections of *bones* are found most frequently in the vascular spongy tissue of the epiphyseal ends of the long bones. Tuberculosis of the shaft of the long bones is comparatively rare. The disease is found in the short spongy bones, as the bodies of the vertebræ and the bones of the tarsus and carpus. It is also seen occasionally in the flat bones, as those of the skull and the pelvis, the orbital portion of the superior maxilla, and the ribs. In the epiphysis the tuberculous nodule is usually formed some little distance from the cartilage. On section of the bone one sees, in the beginning of the disease, a yellowish-white or pure yellow well-defined mass lying in the spongy tissue, which even with low powers can be seen to be made up of miliary tubercles, some of them already in a state of cheesy degeneration. As this nodule grows in size it becomes softened, and finally forms a cavity containing a more or less softened material mingled with minute fragments of bone; or the degenerated bone becomes necrosed in a mass and forms a sequestrum. This is generally of a roundish form and frequently as large as a walnut, and is surrounded by a layer of granulation-tissue which is also infected with tubercle bacilli. More rarely the tuberculous nodule may break down and form a small abscess. Such pus-cavities are most often seen in the extremities of the tibiæ. Occasionally the nodule may remain for a long time unaltered, and is then surrounded by a dense capsule. Sclerosis or eburnation of the surrounding bone may occur under these circumstances. The bacilli reach the epiphysis usually through the circulation. They are most frequently conveyed there as single organisms floating in the blood, but they may be transmitted in emboli, possibly from a tubercular mass in the bronchial glands. If such an embolus should plug a terminal arteriole, an infarction of the bony tissue may result, forming a wedge-shaped sequestrum with its base directed toward the joint and the apex pointing toward the diaphysis. These wedge-shaped tubercular infarctions have been produced experimentally in animals by injecting tuberculous pus into the tibial artery. It is possible that a growth of granulations may invade the tubercular mass, and that complete absorption may take place; and the part may be thus restored to its normal condition. Even a tubercular sequestrum may be disposed of in this way under favorable conditions. Usually, however, the nodule softens and the tubercular pus breaks into the joint or into the adjacent connective tissue. When the joint is involved, tubercular infection of its surface will occur and disorganization will probably take place. When the pus discharges through the periosteum, a cold abscess will form which may burrow extensively and finally break externally.

Tuberculous *osteomyelitis* of the shaft of the long bones occurs chiefly in the phalanges of the hands and feet. The disease appears first in the marrow, which with the cortical bone is changed into granulation-tissue: at the same time the periosteum is stimulated into a new bone-formation, which in its turn becomes involved. In consequence of these progressive changes the bone is much distended in the middle of its shaft, the so-called *spina ventosa*. The disease may undergo spontaneous cure or suppuration may take place. Considerable deformity may be caused by atrophy of the affected bones in early life.

Tuberculosis is also frequently observed in the short spongy bones, particularly in the bodies of the *vertebræ*, giving rise to *Pott's disease*, and in the bones of the carpus and tarsus. The changes produced in bone-tissue by

the bacillus of tuberculosis is that known hitherto as caries; that is, an absorption of the bony tissue, giving it a worm-eaten appearance. Necrosis is more frequently the result of acute inflammation produced by the presence of the pyogenic cocci, but, as we have seen, it may occasionally be due to the action of the bacilli of tuberculosis.

Tuberculosis of the *joints* (known often as white swelling, tumor albus, hip disease, ankle disease, etc.) usually results from infection by the opening of a primary nodule from the bone into the joint. A primary tuberculosis of the synovial membrane, however, may also occur. As the consequence of infiltration with miliary tubercles we find a thickening of the membrane with formation of granulation-tissue which may not be accompanied by any collection of fluid in the joint. At other times there is considerable turbid or bloody fluid, or suppuration may take place and the joint contain the characteristic thin and pale tubercular pus. When the tendency to the formation of granulation-tissue is excessive, the condition known as *caries sicca* exists. Little or no pus is formed, but there is extensive loss of bone as the result of caries. Occasionally circumscribed tubercular nodules form on the synovial membrane and project into the joints as small pedunculated tumors, consisting of fibrous tissue, but containing a softened tuberculous mass in the interior. In the serous form of tuberculous synovitis numerous "*rice bodies*" or "*melon-seed*" bodies are seen in some cases, either free in the joint or attached to the capsule by a pedicle. They are composed of concentric layers of fibrin, a substance which is so often associated with the formation of tubercles.

As the disease progresses the articular cartilage is attacked by the granulation-tissue in the joint, and ulceration takes place, or granulation-tissue may form in the epiphyses and perforate the cartilage from beneath. In cases of long standing the disease spreads from the capsule to the surrounding tissues, and the connective tissue, the tendons, and even the muscles, become involved in a gelatinous degeneration. This peculiar change is supposed by some to be a saturation of the diseased tissue with a fluid of a mucous or synovial character. Under favorable conditions a more or less complete restoration of the joint-cavity may take place, but when the disease is once well developed the best that can be hoped for is a fibrous or bony ankylosis. If suppuration takes place, the abscess may open externally, and fistulæ communicating with the joint may be established. In long-standing cases of joint-suppuration amyloid changes are found in the internal organs.

Tuberculosis of the *tendon sheaths* is usually secondary to bone or joint disease, but it occurs occasionally as a primary affection. A thickening of the tendon sheaths takes place and develops into a cylindrical doughy swelling, which is usually not painful. Rice or melon-seed bodies often form. A portion of the new tissue softens down and fistulous openings occur. If the sheath is laid open by a longitudinal incision, a mass of gelatinous tissue is found which can easily be stripped off. Such an operation may result in cure.

Tuberculosis of the *lymphatic glands* is a very common affection. Enlarged glands may be found at the autopsies of children dying of almost any disease, and on examination prove to be the seat of tubercle. The disease may occur in the glands secondarily to the involvement of some adjacent organ, as in the bronchial or mesenteric glands from pulmonary or intestinal tuberculosis. In the glands of the neck, which are by far most frequently affected, the disease often appears to occur primarily, but is in reality usually secondary to a catarrh of a mucous membrane or to a cutaneous eczema. The bacilli are few in number except in the glands nearest to the primary focus, and in many glands they cannot be found. In abscesses of lymphatic glands they may be found in the

tuberculous membrane which lines their walls. In the bronchial glands the bacilli are often seen in the capsule and the periglandular tissue. As a result of caseous degeneration and infection with pus cocci abscesses may form, and a spontaneous cure may be rarely effected. Where an extensive invasion of the lymphatic system takes place the bacilli eventually reach the circulation, and acute miliary tuberculosis may result; but this is brought about more frequently by the entrance of the bacilli into the veins and their dispersion in emboli to different parts of the body.

The **diagnosis** of tuberculosis can usually be established by the clinical symptoms and history of the case, but in doubtful cases a microscopic examination may reveal the presence of the bacilli. This can be done by an examination of the sputa or urine. (See Surgical Bacteriology.) If the case is one of doubtful lupus, a fragment can be punched out with the Mixter exploring canula, and sections can thus be obtained for microscopical study. In those cases in which the bacilli cannot be found recourse must be had to experimental inoculation. A fragment of the suspected tissue can be implanted into the subcutaneous connective tissue of the groin of a guinea-pig, and if the specimen is tuberculous a miliary tuberculosis will be produced in from five to six weeks.

The **prognosis** of the disease depends greatly upon its locality. In tuberculosis of the skin and superficial tissues it is more favorable than that of internal organs. In children the prognosis is generally more favorable than in adults. Any tuberculous nodule is always a source of danger, and should not be allowed to remain if it can be removed. There is always the possibility of recurrence even after operation.

The operative **treatment** consists either in complete removal of the diseased tissue by incisions carried through the surrounding healthy tissue or in a thorough curetting, followed by free irrigation with iodine-water, packing with iodoform, or occasionally by the actual cautery. In laying open healthy tissues the possibility of an infection of the system with bacilli should not be forgotten; hence thorough removal or no operation is the rule. The special methods of dealing with the local conditions will be considered in their appropriate places. The general treatment of the disease is of the greatest importance. This consists chiefly in the selection of a suitable nourishing diet and an appropriate climate. When change of residence cannot be effected the patient should be kept as much as possible in the open air. Among the most valuable of internal remedies are cod-liver oil, the hypophosphites, and alcohol. Koch's remedy, which is at present attracting so much attention, is prepared as follows:

Tuberculin, or *paratoloid*, is obtained from a pure culture in nutrient bouillon of the bacillus of tuberculosis by extraction with 50 to 60 per cent. of pure glycerin. As dispensed for use, it is put up in small vials holding about five cubic centimeters, and consists of a viscid dark-brown fluid of an alkaline reaction and somewhat bitter taste. The fluid as at present prepared does not consist entirely of the active principle, of which there is estimated to be but about 1 per cent. This is not one of the ordinary ptomaïnes, for the reason that it is not decomposed by any ordinary degree of heat, as are these latter. The material may be subjected to a sufficient temperature for complete sterilization without affecting its potency. The activity is supposed to be due to a compound belonging to the class of toxalbumins which have come into prominence and which are not changed by heat. It is precipitated by alcohol as a heavy flocculent white precipitate, which disappears at once upon the dilution of the alcohol.

The original material is prepared for use by the addition either of water or, if one desires to keep the dilution for some time, of a 0.5 per cent. of carbolic acid. The dilution should be made with the greatest care and with thoroughly sterilized pipettes, solutions, etc. The usual proportion is 1 per cent., so that in a syringe divided into tenths of a cubic centimeter each division will contain one milligram of the original material, this being the average dose at the beginning of the treatment. After the dilutions have been opened and their use is over for the day, they may be sufficiently sterilized by placing them in a sterilizer for five minutes after the steam has begun to pass. With this precaution they may be used for a period of at least ten days.

Human beings are much more susceptible to the action of the material than are the lower animals, especially guinea-pigs. In the latter there has been injected as much as four centigrams of the original material with no apparent effect.

The syringe used for the subcutaneous injections is pistonless, and its contents are expelled by a rubber ball. It was designed by Koch for the purpose of obtaining an instrument that could be easily sterilized. The point usually selected for injection is the skin of the back beneath the scapula.

The mode of action of this remedy is to produce an inflammation of varying degrees of severity in the tissues which are the seat of the tubercle. It is analogous to the effect produced by an acute inflammation upon a chronic one. The surrounding connective tissue is inflamed, but the miliary tubercles remain unchanged beyond a certain diminution in size. In ulcerating forms of the disease the tuberculous tissues are more readily separated and thrown off. The material is injected subcutaneously, either with the Koch syringe or the ordinary hypodermatic syringe. The smallest dose is one milligram, but ten milligrams are often given after the treatment has been continued for some time; and this is occasionally increased later to five hundred milligrams. At the conclusion of the treatment as large a dose as one gram has been given by Bergmann.

Thus far, a primary improvement has been noticed, but the disease usually returns after a cessation of the treatment. It has been found by Bergmann in cases of lupus that a preliminary curetting and cauterization of the nodules, followed by a course of injections of tuberculin, offers the most favorable prospects of success. But very few cases of permanent cure by this method have as yet been reported.

Cheyne has obtained more satisfactory results by substituting for the intermittent dosage of Koch a continuous dosage, which consists in giving the injections two or three times a day, and increasing the dose, sometimes slowly, sometimes rapidly, until occasionally as much as three decigrams were given three times a day. Of 9 cases so treated, 6 improved to such an extent that no evidence of disease was seen some weeks after treatment. Treatment should be continued for a long period. In conjunction with other treatment, he found it useful in lupus and in cases of bone and joint disease after operation when healing had not taken place. He found by experiment that tuberculin predisposes the tissues to fresh infections. In guinea-pigs which had been previously treated with tuberculin the disease appeared earlier and progressed more rapidly than in others.

He also treated a number of patients with the *derivatives of tuberculin* obtained by Dr. William Hunter. According to the latter observer, tuberculin owes its activity not to one principle, but to at least three, and probably more, different substances. By taking advantage of the action of absolute alcohol on tuberculin he obtained by precipitation a fluid consisting of proteid materials and a small quantity of salts. This caused no pyrexia when injected, but pro-

duced the depressing effects of tuberculin and the local inflammatory reaction. The residue from the filtrate contained the salts in excess and a small quantity of proteid materials. This fluid when injected caused fever, but produced no local inflammation. The local disease, however, appeared to improve under its use. He also obtained from the residue of the filtrate, by a process of dialysis, a substance which produced very distinct local improvement, but was unaccompanied by fever or local inflammatory reaction. Still a fourth material was obtained by precipitating more thoroughly the proteid substances of tuberculin ammonium sulphate being employed instead of alcohol. The action of the substance thus obtained was very much like the one last mentioned, but a little more rapid.

A somewhat limited experience with the last two substances in cases of human tuberculosis showed that the disagreeable features were avoided, but that the remedial effects were nevertheless obtained.

SECTION II.—SCROFULA.

Scrofula (from *scrofa sus*, a swine) is a name formerly applied to all tuberculous affections except those of the lungs. At the present time the term is synonymous with tuberculosis of the glands, joints, or bones. It is still, however, an open question in the minds of some pathologists whether the name should not be reserved for a certain class of cases clinically resembling tuberculosis, but which are caused by the presence of some other form of microorganism than the bacillus of tuberculosis. By others there is supposed to be a certain type of constitution which is peculiarly susceptible to external irritants of various kinds which may produce inflammation of the skin, mucous membranes, or lymphatic glands. Such individuals are considered equally susceptible to tuberculosis.

The observations of several observers have given some support to this theory. Charrin and Roger examined a guinea-pig which had died of a disease which resembled tuberculosis, but were unable to find the characteristic bacilli. Cultures, however, were obtained which were found to consist of bacilli much smaller than those of tuberculosis. When other animals were inoculated from these cultures a similar disease was produced. Similar observations have been made by Eberth and Pfeiffer. Babes describes a case of acute bronchitis with miliary tubercles of the lungs in which oval and fusiform bacteria 0.8 micromillimeters in length were found in the tubercles. Observations of this kind have given rise to the name "pseudo-tuberculosis," and it does not seem improbable that certain affections of this class may be due to other organisms than the bacilli of tuberculosis.

Two types of the affection are usually described—the torpid and the erethistic. The *torpid* form is the most characteristic. Such children have light or reddish hair, a sallow and pasty complexion, puffy cheeks, and protruding lips. The eyelids and conjunctivæ are often the seat of a chronic inflammation. Catarrhal affections of the nose and ear often exist, the skin is eczematous, and the cervical glands are enlarged. The general appearance of such a patient suggests the origin of the name "scrofula." In the *erethistic* form there is less tendency to glandular enlargement. The individuals are dark-colored, of a nervous temperament, and are subject to catarrhal affections. Undoubtedly there are certain types of children of delicate constitutions who need an unusual amount of care; and, although the above description savors somewhat of an antiquated pathology, it is well to remember that not all enlarged glands or swollen joints or inflamed bones are tuberculous. Such children should be

placed under the most favorable hygienic conditions, and exposures and fatigues of all kinds should be avoided. They should not be subjected to too rigorous a school discipline. Adults should seek the most favoring climates. Cod-liver oil and iron are the most useful tonics for these cases when medical treatment is indicated.

CHAPTER XV.

RHACHITIS.

THE term **rhachitis** is derived from *ῥάχις*, the spine. The English name **rickets** is, however, more commonly used. It is a general disturbance of the nutrition of the body in infancy and childhood, and consists principally in an insufficient deposit of lime-salts and in absorption of already-formed bone.

Etiology.—It is a disease seen chiefly among the poor in large cities, less frequently in the country. It is much more common and severe in Europe than in America. In America the disease is neither very prevalent nor very severe, and except in colored children or in Italians and Portuguese very great deformity is rare (Bradford). Bad hygienic influences, such as poor ventilation, damp dwellings, and crowded rooms, are frequent causes of the disease, but the most important cause of all is improper feeding. The substitution of patent foods for the mother's breast-milk is said to favor its development In menageries, where animals live under highly artificial conditions, the disease is frequently observed. In congenital syphilis changes in the bones closely resembling those of rickets are occasionally seen. The disease begins in the first or second year of life, exceptionally after the fifth or sixth. It is not often seen in newborn infants, but rhachitic changes are occasionally found in the bones during fetal life.

The **pathological changes** are due to the formation of incompletely calcified bone. "Osteoid tissue" persists, therefore, much longer than usual. At the epiphyses there is an absence of the line of calcification; there is a great increase in size of the zone of cartilage-growth, and the medullary tissue grows into the cartilage area in the most irregular manner. The cortical portion of the bone becomes porous, and the trabeculæ of the spongy bone become thinner or disappear entirely. After the disease has run its course calcification may take place on an increased scale, and sclerosis of the bone may occur. Rhachitic bones are frequently so soft that they can be cut with the knife, and as a result of this change great deformity often occurs. In older children such changes are seen in the bones of the thorax, spine, and extremities; less frequently in the skull. The ligaments are relaxed and movements of the joints are often painful. The promontory of the sacrum is depressed, and the pelvis thus greatly narrowed. Curvatures of the spine, as *scoliosis* or lateral deviation, *kyphosis* or curvature with convexity backward, and *lordosis* or curvature with convexity forward, are also observed. In the skull the bones are often unnaturally thin and crackle under pressure like parchment. This condition is known as *craniotabes*. Dentition is often delayed, and during convalescence progresses with great rapidity. It is always irregular.

The brain may be hypertrophied, and sometimes is sclerosed; hydrocephalus may also occur. The bronchial tubes are filled with mucus, and emphysema of the lungs is occasionally found. Evidences of intestinal catarrh are seen. The spleen is often enlarged.

Among the early **symptoms** is restlessness at night, with a tendency to profuse perspiration especially about the head; the bowels are constipated and the belly becomes distended. The urine is large in amount and loaded with phosphates. In the bones the earliest changes are seen at the epiphyses, which become thickened chiefly at the end of the radius, and in the ribs, where the row of beaded enlargements is quite characteristic. With the softening of the bones deformities of the spine and extremities begin. The head is increased in size, particularly the forehead and the frontal eminences. The distortion of the ribs gives rise to the characteristic pigeon-breasted deformity. Catarrhal affections, as bronchitis, and even pneumonia, may occur as complications, as also laryngismus stridulus. Among important diagnostic symptoms are delayed dentition and delayed closure of the anterior fontanel. A search for the epiphyseal enlargements will usually settle the diagnosis. Rickety children are often stunted in stature.

The **prognosis** is usually favorable. Deformity disappears in 90 per cent. of the cases. A few cases terminate fatally from complications, such as broncho-pneumonia.

In the **treatment** of rickets careful regulation of the diet is of the utmost importance. Fresh food should be given in preference to prepared foods; fresh milk properly diluted for infants, and meat-juice or raw beef for older children. Fresh air and light in the nursery should be obtained if possible. Salt-water bathing is highly recommended. Cod-liver oil is considered the most valuable of drugs. Phosphorus is also a favorite remedy; syrup of the iodide of iron is perhaps to be preferred. Lacto-phosphate of lime is given on theoretical grounds chiefly, but is a good tonic for children. Those modern inventions, "sea-shore homes" and "day nurseries," are particularly adapted for the treatment of this disease. The surgical operations for deformities of bones are described elsewhere.

CHAPTER XVI.

CONTUSIONS AND WOUNDS.

SECTION I.—CONTUSIONS.

An injury produced by a blunt body in which tissue-elements are more or less rent asunder, but in which there is no gross or manifest external breach of tissue, constitutes a contusion. In a simple contusion or bruise the area of damage is limited by the area of impact of the bruising body, but the amount of damage may be of any grade, from the imperceptible molecular division of a slight bruise to the pulpification of large masses of tissue. The element of contusion is present as a complication of most wounds, and in many constitutes a grave and most important factor. The distinction between a contusion and wound is therefore one of degree and not of kind. A contusion should be defined more properly as a hidden wound, the firmer tissues of the skin being able to resist the rending effect of the blow, which produces its greater effect upon softer tissues underneath. Whether an injury shall be defined as a contusion or a wound depends also upon the character of the injured structures and the nature of the tissues which lie underneath the surface. Thus a hard, bony surface, so related to the tissues on which a blow is struck that they are forced against it by the bruising body, will necessarily aggravate an injury, and much

more readily cause an absolute destruction of all the tissues, including the skin, and so produce a wound, than if a thick cushion of soft tissue alone is involved. The results of blows over the shin are examples of the first, while those upon the surface of the abdomen or upon the fleshy masses of the nates or the thighs are examples of the second.

Pathology.—The pathology of a contusion is that of a subcutaneous wound. The more delicate and easily-torn tissues suffer first and most extensively; ruptured blood-vessels give rise to more or less hemorrhage; injured nerve-fibrils are the sources of pain; functional disability follows according to the extent and character of the tissues injured; local swelling, both from hemorrhage and from serous effusion, quickly ensues. When the effused blood shows itself as a somewhat diffused subcutaneous discoloration, an *ecchymosis* is said to be present; when, however, it is collected in a more or less well-defined cavity, so as to constitute a blood-tumor, it is known as a *hematoma*. When blood-vessels of some size are involved in a contusion, special conditions of hemorrhage may arise; thus they may be either ruptured outright or their walls so bruised that they subsequently slough, and so occasion a later hemorrhage. The hemorrhage from the smaller vessels is usually soon controlled after moderate escape of blood by the reactive pressure of the surrounding engorged tissues. The force of the blood-current in large veins and in most arteries is likely to be such as to cause a considerable loss of blood, especially when it escapes into any of the great cavities of the body or when the locality involved is one in which there is present much loose connective tissue. Contusions of nerves may produce more or less paralysis of the regions supplied by them. A progressive degeneration of a nerve may result from the changes produced in it by a violent contusion. The effects of contusions of muscles depend upon the extent of the damage done; local soreness and pain upon movement attend less severe injuries; rapid recovery under rest and proper treatment is to be expected in such instances; from even quite extensive lacerations ultimate recovery with full functional power often takes place. In less favorable cases, however, atrophy, contracture, and permanent loss of power may result. The contusions of bone when short of absolute fracture are usually rapidly recovered from, but may develop into acute or chronic inflammatory conditions or determine caries or necrosis, or even the development of malignant changes.

Diagnosis.—The symptoms which indicate the occurrence of a contusion are easily recognized. The part is tender and quickly becomes somewhat swollen, with some elevation of temperature. In simple and superficial contusions discoloration of the skin soon declares itself as the result of the subcutaneous hemorrhage. In cases where deeper structures are especially contused the appearance of the external discoloration may be delayed for some days, owing to the slowness with which the effused blood finds its way to the surface. Loss of function may be present, dependent upon the character of the tissues injured and the extent of the injury inflicted. The amount of pain in the part may vary. At first there is numbness, followed quickly by severe acute pain, which gradually subsides with the lapse of time. Shock is almost always present to some extent. Contusions of moderate severity produce a degree of shock characterized by momentary stunning; others of greater severity may produce faintness or total loss of consciousness for a variable period; while in the more severe cases, as in contusions of the abdomen, immediate death may ensue.

Treatment.—For the general shock and the local pain the treatment required for such conditions accompanying any injury is indicated. For the contusion itself the first thing to be secured is rest to the injured part.

This is especially important when the contusion is severe and the injuries to deeper structures are extensive. For securing rest, if voluntary immobilization is not sufficient, the use of apparatus of some kind may be required. Bandages, slings, splints, a recumbent position in bed, all may have their use. By rest local irritation is diminished, hemorrhage and inflammatory effusions are restricted, the absorption of effused fluids and of necrotic tissue is favored, and the normal repair of the injured tissue is fostered. Of all means for treating these injuries, rest is the one of primary and greatest importance.

Next, hemorrhage and serous effusion may require attention. Equable, elastic, and firm compression is to be recommended for their control. Compresses of cotton wool secured by proper bandages are especially serviceable for this purpose. A simple flannel bandage alone will often be of great service. When, for any cause, the use of compresses and bandages is inconvenient or undesirable, some advantage may be obtained from the application of cold, by ice-bags, evaporating lotions, or affusions of cold water. In the more severe forms of contusion cold is to be used with caution, since by its continued use the vitality of the parts is depressed, and tissues which under more stimulating treatment might be preserved from necrosis and regain their normal condition may be precipitated into absolute death. In the slighter and more superficial forms of contusions evaporating lotions are frequently both convenient and efficient. As an example of such a lotion a solution of chloride of ammonium and alcohol (gr. v @ f℥j) is to be recommended. Tincture of camphor, tincture of arnica, tincture of witch-hazel, all favorite popular applications for contusions, are of use, but depend for their efficiency chiefly upon the alcohol which they contain.

In cases in which much bruising and disorganization of tissues are present great care must be taken to avoid everything which may still further depress the vitality of the part. The indications are, then, to support and stimulate. In addition to the rest already recommended, a moderate amount of heat will be of use; hot-water bags, the hot-water coil, masses of cotton wool, or flannel previously heated, may be found useful. In the later history of many contusions massage and stimulating liniments are of value. They promote the activity of circulation in the part, break up and diffuse among the tissues blood-clots and serous accumulations, and hasten their absorption; they promote the nutrition of the injured tissues, break up adhesions, and expedite the return of the normal functional activity of the contused parts. Blood-extravasations as a rule should be left to the natural processes of absorption for their removal.

Blood-effusions widely dispersed along connective-tissue planes, infiltrating tissues already lowered in their vitality by a contusion, present conditions eminently favorable for the development of widespread and disastrous septic infection, for which reason an attempt to evacuate a hematoma by incision under ordinary circumstances is always to be deprecated. When, however, continuous subcutaneous hemorrhage is present, showing the existence of a wound of a vessel of importance, it is imperative to make a free incision, so as fully to expose the wounded vessel, and to apply a ligature to it. In such cases the incisions through the external parts should be very free, and all recesses into which the effused blood has found its way should if possible be opened up. All clots should be turned out, and the most perfect disinfection and drainage of the infiltrated areas provided for. Circumscribed blood-tumors may sometimes be relieved by aspiration. After the lapse of two or three weeks from the time of the original injury any persisting blood-tumor may be more freely laid open and its contents evacuated; by this time it will

be surrounded by a layer of condensed connective tissue reinforced by inflammatory exudation; the surrounding tissues will have recovered from the state of depression immediately following the injury; and as the result of these conditions the danger of septic infection will have greatly diminished.

Severe inflammatory reaction following contusion must be treated upon general surgical principles, including rest, elevation of the parts, evaporating lotions, together with such constitutional measures as may be required for relieving pain, reducing temperature, and lessening the intensity of the general febrile reaction. If suppuration occurs, adequate incisions must be made for the evacuation of the pus; if local gangrene threatens, stimulating applications are first required, as dry heat or stimulating liniments, until the line of demarcation of the slough is distinctly formed. Fomentations should now be used, composed of compresses wet with some antiseptic solution and covered with rubber dam or oil silk, to hasten the separation of the slough. If phlegmonous inflammation advances into adjacent parts, free incision into the inflamed tissues, with abundant antiseptic irrigation and iodoform tampons, should be used.

SECTION II.—WOUNDS.

A WOUND is a solution of continuity of any tissue, produced either directly or indirectly by sudden mechanical force. The occurrence of a solution of continuity in any of the solid tissues of the body may be due to slowly-acting causes, as the gradual waste of atrophy, or the more active disintegration of ulceration; but a breach of tissue thus affected would not be a wound. There is involved in the idea of a wound the action of a force outside of the tissue itself, which by mechanical violence has rent or divided its substance. The term "wound," therefore, is susceptible of a very wide range of application. Contusions, sprains, fractures, subcutaneous as well as cutaneous breaches of tissue, are included in the term. In all essential particulars they are identical accidents, involving the same methods of repair and subject to the same principles of treatment, the apparent differences depending upon accidental differences of structure, function, nutrition, relation to other parts, extent of traumatism suffered and of exposure to influences from without. In the present chapter the wounds of bones will not be considered.

Classification.—Wounds may be divided primarily into the two great classes of *subcutaneous* and *open* wounds. Subcutaneous wounds include all which are unaccompanied by breach of the skin. Protected by the unbroken skin from external irritation and infection, their repair is usually rapid and undisturbed by untoward irritations. The preceding paragraphs devoted to the consideration of contusions are descriptive of the greater number of subcutaneous wounds. Open wounds, as a class, include all in which there has been a breach of the skin or mucous membrane.

Open wounds are subdivided, according to the manner in which they are produced, into *incised*, *punctured*, *contused*, *lacerated*, *gunshot*, or *poisoned* wounds, according as the wounding agent has been a sharp cutting edge, a penetrating point, a dull and bruising body, a tearing force, a projectile impelled by the force of an explosive, or one which carries with it into the wound a poison. *Penetrating* wounds are those in which the vulnerating body enters a cavity without emerging; *perforating* wounds, those in which the vulnerating body both enters and emerges from the cavity.

All wounds are accompanied by death of tissue in their track; even the path of the keenest knife-edge through a tissue is lined by disorganized particles that have been killed by its impact. Between a slight and clean incised wound, in which the destruction of tissue is limited to the molecules traversed by the

cutting instrument, and an extensive lacerated wound, with roughly torn and contused edges, or between a slight bruise and a contusion producing the death and disorganization of large masses of tissue, the difference is one of degree and not of kind. The important practical difference which has always been recognized in the healing of these different classes of wounds depends simply upon the difference between the facility with which the devitalized tissue is prevented from becoming a source of disturbance to the healing of the wound in the several instances.

Wounds may be again classed as *aseptic* and *septic*. *Aseptic wounds* include all which are preserved from contamination by poisonous bacterial products, whether such poison come in contact with the wound directly or be generated in it by the action of germs that gain access to it. An aseptic condition in a wound may be obtained either by the protection which the wound received from the first against the access of any septic agent, or by the power of tissues to resist and destroy septic agents, or by the application to the wound of substances which destroy them. Subcutaneous wounds, as a rule, remain aseptic in consequence of the protecting covering which the skin affords; operative wounds inflicted under certain precautions may be aseptic; all open wounds in which union by first intention is secured without special and adequate aseptic precautions are examples of the power of living tissues to resist septic infection. *Septic wounds* include all those in which any agent capable of exciting fermentation or putrefaction lodges and grows. In all cases they are attended with some degree of inflammation and suppuration and with sloughing of dead tissue.

Symptoms.—The symptoms indicative of a wound are *local*, dependent upon the effects produced at the point at which the wound is inflicted, and *constitutional*, dependent upon the effects on the body at large.

Local Symptoms. — First, IMPAIRMENT OF FUNCTION. — A certain amount of disability is the inevitable result of a division of tissue. Its extent and nature will depend upon the amount of injury and the tissue injured. The duration of the disability will depend upon the promptness of healing and the susceptibility of the wounded tissue for perfect repair.

Divided tissues tend to retract from each other, and thus a greater or less amount of GAPING becomes a wound-symptom.

PAIN is a usual accompaniment of a wound. It is due to the irritation sustained by the sensory nerves. The amount of pain is of variable quantity. At the moment of the infliction of a wound no pain at all may be experienced, owing to mental preoccupation or excitement or to the rapidity with which the wound was inflicted. The temperament of the individual may modify the amount of pain. Some individuals experience great pain from causes which in others produce but little suffering. The sharp pain usually felt at the moment of the infliction of a wound soon gives way to a dull aching or smarting pain, which may last for some hours, but will finally subside and disappear, provided the wounded parts are kept at rest and their repair progresses without disturbance. Attempts at motion in a wounded part, which tend to pull apart the divided tissues, or the occurrence of a high grade of inflammation, causing tension and excessive congestion, awakens pain anew. When large sensory nerve-trunks have been involved in wounds, later and continuous pain may be due to slight inflammatory conditions extending from the wound upward along these nerves; hence the pain often complained of in the stumps of amputated limbs during the first few days following operation.

HEMORRHAGE.—Some amount of bleeding is the immediate effect of every wound. It is always the invariable and most manifest symptom that a wound has been inflicted, but the amount of the blood lost may vary greatly according

to the constitutional condition of the wounded person, to the character of the tissue wounded, and to the size of the blood-vessels implicated. In scorbutic conditions of the system, and in those occasional instances where a hemorrhagic diathesis exists, prolonged and even dangerous loss of blood may result from a trifling wound. Ordinarily, when merely capillaries or small arterioles or venules are divided, spontaneous cessation of hemorrhage quickly occurs, especially if the tissues wounded are retractile, so that the wounded vessels become withdrawn among and embraced by them. Whatever favors the production and retention of a clot about a wounded vessel favors the arrest of hemorrhage; hence lacerated wounds, where the wound-edges are ragged and the openings of the vessels themselves irregular, the coats of the larger vessels, being unevenly divided, are not likely to bleed much, on account of the entanglement of the blood-fibrin in the irregularities of the wound-surfaces and the speedy production of blood-clot. When large blood-vessels are opened profuse and speedily fatal hemorrhage may occur.

SHOCK.—The primary constitutional symptom of a wound is "shock." Shock is that condition of general vital depression which marks the immediate effect upon the individual as a whole produced by the local wound. It may be of any grade of intensity, from a slight, evanescent, and hardly appreciable disturbance of mental force to the most profound general depression and speedy death. Its manifestations are through the nervous system, and are exhibited most markedly by depressed action of the circulatory organs—vaso-motor paralysis. Shock is to be distinguished from the effects of hemorrhage; and in cases of surgical operations from the effects of anesthetics, although in many instances it may be aggravated by either or both. Martin and Hare have recently proposed to use the hemoglobinometer as a means of distinguishing hemorrhage, especially intra-abdominal, from shock. In shock the hemoglobin would be unaltered; in hemorrhage the hemoglobin would be greatly diminished. The pathology of shock cannot be determined by the ordinary methods of research. In such cases death leaves no change which can be detected in any of the tissues. The effects manifest themselves chiefly through the agency of the nervous system in the same way as all the phenomena of life which are controlled by that system. Sometimes, however, as seems to have been shown by Goltz, a marked distention of the intra-abdominal veins exists. The phenomena of shock must be accepted as the measure of the ability of an individual to resist hurtful influences from without. The same injury will produce different degrees of shock in different individuals, and different degrees likewise in the same individual at different times. Women, as a class, are less susceptible to shock than men. Persons who are inured to suffering, or who by long confinement to bed or by the influence of drugs have acquired a certain torpidity of the nervous energies, are less susceptible to shock than individuals whose nervous forces are in a high degree of activity. Temperament modifies the manifestations of shock. The phlegmatic and lymphatic temperaments resist shock; the sanguine and mobile temperaments favor it in the highest degree. Mental conditions modify shock; fear, despair, despondency, disappointment, depressed mental states of any kind, aggravate shock; on the contrary, hope, joy, cheerfulness, glad expectation, success, diminish shock. Age modifies shock. The young bear injuries well, and rally quickly from shock when unaccompanied with much loss of blood; in the aged the frequent presence of organic disease often renders shock more severe and prolonged. In the absence of organic derangements the dulled nervous susceptibility of the aged diminishes their liability to shock.

Symptoms of Shock.—The symptoms of shock are those of general depres-

sion: the skin is pale and cool; the pulse is feeble and rapid, the respiration is shallow and irregular; the body-temperature is lowered; a sense of faintness is experienced by the individual, and in the more severe forms total loss of consciousness ensues; the functional activity of all the organs of the body is retarded; muscular tone is diminished, with a sense of general muscular powerlessness; the sphincters may fail to act, causing involuntary evacuations; nausea and vomiting often occur. Every degree of intensity in these symptoms of depression which have been enumerated may exist in different cases, from a transient feeling of weakness and momentary mental confusion to absolute death. The symptoms of shock are the immediate consequence of the injury sustained. The assumption of the possibility of a condition of delayed shock is not consistent with what has been said as to the nature of shock itself. Whenever a condition of sudden and marked depression declares itself some time after the reception of an injury, it is always due to some distinct cause other than the original injury, and when recovery from shock is delayed and manifests oscillations of improvement and retrogression, distinct diseased conditions, possibly directly resulting from the injury, are always its cause. For this reason the terms which are found in older text-books, and which are still often used in ordinary surgical parlance—namely, delayed shock, secondary shock, and imperfect reaction from shock—may be misleading, as they tend to divert the attention from real conditions. The conditions which most frequently cause these symptoms of later depression are concealed hemorrhage, septic infection, and fat embolism. Pulmonary œdema and renal congestion are also possible conditions always to be inquired after when a sudden unfavorable turn occurs in the condition of a patient soon after an injury has been sustained, especially when ether has been used as an anesthetic. The occurrence of any of these conditions may, of course, produce its own shock, but this shock arises *de novo*.

Prognosis of Shock.—Very quick and complete recovery from a state of most profound shock may occur. The chief elements upon which recovery from shock depend are these: First, whether the injury has to do with a vital part; and second, whether it entails a continued source of irritation and depression. Thus in injuries to the head the immediate shock may be overwhelming in consequence of the vital relations of the injured part, or when not at once fatal may be continued and masked by inflammatory conditions arising in the cerebral tissues as a consequence of the injury. So in crushing injuries of the extremities: the immediate shock of the injury may be prolonged and intensified by the pain and irritation arising in the mangled tissues, so that the surgeon is often called upon, even in the presence of much general shock, to run the risks of subjecting his patient to the additional brief shock of an amputation, rather than to leave him exposed to the continued irritation of his mangled limb, with possible added septic infection, while waiting for reaction to be established. In general it may be said that when an injury is not primarily fatal through shock, and continually renewed shock can be prevented, speedy recovery therefrom may be confidently looked for under proper treatment. Severe shock is so often complicated with the acute anemia caused by loss of blood that it is difficult to separate its prognosis and its treatment from those of the latter condition; nor in practice is it essential to do so.

Reaction.—The symptoms which indicate the passing away of the effects of shock are a gradual increase of the strength and volume of the pulse, a diminution in its frequency, a more natural color and heat of the skin, return of consciousness, and the manifestation of muscular power, as the shifting of his position by the patient. The appearance of such favorable symptoms constitutes what

is termed a state of *reaction*. In the most favorable cases reaction is gradual and progressive, though it may occupy many hours or even days in its course. Returning color to the face and an increased power in the heart's action are unmistakable signs of its occurrence. In certain cases fluctations in the reaction occur, relapse alternating with improvement for a variable time. The real significance of such fluctuations has already been dwelt upon. In other cases, before perfect reaction has been accomplished, there supervenes a condition characterized by a rapid and weak heart's action, cerebral excitement and delirium, muscular tremor, and high body-temperature. These are the signs of septic infection. Reaction from shock is commonly attended by some elevation of the body-temperature, quickening of the pulse, thirst, derangement of the secretions, restlessness, and headache. This fever attending reaction may be so trifling and evanescent as to escape notice. Its grade of severity depends chiefly upon the nervous activity of the patient, his previous constitutional condition, and the amount of local irritation produced by the injury. Children manifest it most readily. It makes its appearance usually within a few hours after the reception of an injury, and may be expected to decline on or after the second day. This aseptic fever is to be distinguished from the traumatic or surgical fever which sometimes complicates the repair of injuries, which does not develop until two or three days after an injury, and which is dependent upon general blood-infection by absorption of septic matter from the injured part.

Prophylaxis of Shock.—In cases of surgical operations it is possible for the surgeon to diminish to some extent the shock resulting from the wounds inflicted. These means include moral, physical, and medicinal measures. The patient should be inspired to believe that success will crown the surgeon's efforts, and to place implicit reliance upon his skill. However plainly the surgeon should state the possibilities of mischance to the friends of the patient, nothing but hope and happy expectation should usually be expressed to the patient himself. Among physical means are included all measures of a general character which tend to diminish nervous irritability and promote the general resisting power of the individual. Confinement to the bed for some days is of value as a nervous sedative. The regulation of all the secretions of the body so as to secure as nearly a perfect condition of well-being as possible is not to be overlooked. The choice of the period of the day for operating when the vital powers are at their best is likewise to be considered. As a rule, this is during the morning hours. All unnecessary exposure of the body occasioning loss of body-heat is to be avoided; if the operation is to be long, artificial heat by hot-water bags and bottles should be applied during the operation. Hemorrhage is to be carefully guarded against and restrained.

Medicinal measures include the use of narcotics, as opiates, the bromides, and the free administration of alcohol. These may be of benefit when a state of excessive nervous irritability has to be antagonized. They are of special value in preparing alcoholic subjects for operation. In patients the subjects of malarial cachexia the free preliminary use of quinine should be resorted to. The administration of an anesthetic should be conducted with great care, lest the depressing effect of excessive anesthesia should be added to that of the surgical procedure, but at the same time complete anesthesia should be secured. For the same reason, while avoiding undue haste, operations should be done as quickly as possible. Strychnia may be used hypodermatically in full medicinal dose, $\frac{1}{20}$ to $\frac{1}{10}$ of a grain, after anesthesia has been induced, at the beginning of serious surgical procedures, as a prophylactic against shock through its stimulating action upon the cerebro-spinal centers.

Treatment of Shock.—Shock, having once become established in a severe degree, requires prompt treatment. If it occurs in the course of a surgical operation, the operation must be brought to a conclusion as speedily as possible, or may even have to be suspended. The head should be lowered and the body placed in the recumbent position, if it is not already so. Respiration should be kept free from impediment, and when practicable the stimulating effect of inhalations of oxygen should be resorted to. Heat should be applied not only to the extremities, but to the whole surface of the body as far as practicable. Hot-water bottles and hot blankets should have been provided for this purpose. In cases of severe shock an efficient and speedy method of applying heat is to wrap the whole body in blankets wrung out of hot water. Injections of a pint of warm normal salt-solution (℥j to Oj) may be made under the skin or into a vein. Diffusible stimulants should be instantly and freely administered. Hypodermatic injections of whiskey or brandy in doses of one-half to one dram should be given every five or ten minutes until a distinct effect from them can be discerned by a more full, slow, and regular pulse. A rectal enema of turpentine (f℥ss–j), rubbed up to an emulsion with a raw egg in warm water (f℥iv), acts as a powerful stimulant. A warm strong infusion of coffee will be of much use. In digitalis and atropine two most valuable remedies for sustaining a flagging heart are found. They should be administered hypodermatically, the tincture of digitalis in fifteen-minim doses every fifteen minutes till the pulse is affected; not more, however, than four such doses should be administered consecutively. If any benefit is to be obtained from the remedy, it will have been developed by that time. The first dose of digitalis may be combined with one one-hundredth of a grain of atropia. When the pulsations of the heart become more slow and regular, and the superficial capillaries show that the blood-stream is again filling them, and an increasing muscular power and general well-being is beginning to be established, a gradual withdrawal of these stimulating measures is to be practised; the pulse is to be watched, and according to its indications of recurring weakness or progressive strength the stimulants and cardiac tonics are to be resorted to anew or entirely withdrawn. When the patient begins to complain of the temperature of the hot appliances by which he has been surrounded, they may be removed. Where there has been much hemorrhage the copious administration of hot liquids by the stomach and by the rectum should be resorted to to the full amount which these organs are able to dispose of. Recovery from shock under proper treatment, if it occurs at all, is usually quite speedy; delay in recovery or alternations of improvements and relapse, as has already been stated in a preceding page, are due to the nature of the injury itself or to new complications introduced, and are not to be attributed to or classed as shock.

Death from shock may be immediate or gradual. When instantaneous death takes place the nerve-centers must be considered as having been overwhelmed beyond the power of resistance. In some such cases the heart has been found contracted and empty. More commonly the fatal issue occurs only after some minutes or hours of struggle against the inevitable. The fatal approach is then more gradual; the action of the heart becomes more and more feeble; the pulse, weak and thready and counted with difficulty on account of its rapidity, becomes finally lost; the extremities become cool, the face pinched and haggard; the mind, apathetic, gradually sinking into unconsciousness; the temperature continues to fall until it becomes a degree or more subnormal; the respiration is feeble and shallow, until finally, by combined respiratory and cardiac failure, death closes the scene.

Fat Embolism.—Injuries, especially those of bones and of soft parts involving much adipose tissue, when there is much crushing of the parts, through the fact that many fat-cells are broken down and minute fat-globules set free, mingling with the effused fluids and wound-secretions, may exhibit a train of symptoms which are due to the entrance into the circulation of this fluid fat. The condition is known as fat embolism. In extensive compound and multiple fractures its most severe forms are likely to be developed, causing symptoms complicating and succeeding those of shock, and often resulting in death. These deaths have commonly been attributed to shock; their real cause has only been appreciated within a few years, and even now is frequently overlooked. Fat embolism is rare in children, because their skeletons contain relatively little fat. The severity of the symptoms depends on the quantity of fat which has gained entrance to the circulation, on the rapidity with which it has entered, and on the proximity of its source to the heart. Having once gained access to the general venous current, the fatty globules are carried to the right heart, and thence are driven with the blood-stream into the pulmonary capillaries, which they plug up to a greater or less degree, and by their presence here determine the first symptoms of fat embolism. When the amount of fatty material which is poured into the capillaries of the lungs is not very great or when it arrives but slowly, the disturbance which it causes may be but slight; gradually the oil-molecules are forced through and pass on into the general circulation. They may now again be arrested in the capillaries of the brain or spinal cord, and here excite the special disturbances incident to lesions of these organs. More frequently they are arrested and disposed of in the liver and in the kidneys. The urine secreted by kidneys thus blocked up by fat will present oil-globules floating on its surface.

The *symptoms of fat embolism* as a rule develop within from thirty-six to seventy-two hours after an injury, though fatal cases are recorded in which the symptoms developed and ran their entire course in less than twelve hours. The symptoms indicative of the lesser degrees of fat embolism are restlessness, anxiety, slight dyspnea, and accelerated breathing, with quickening of the pulse. In the more severe degrees these conditions become aggravated, general prostration rapidly increases, the countenance becomes pallid and anxious, and later cyanosis, mental excitement, delirium, somnolence, and coma succeed in turn. The dyspnea becomes intense, the respiration very rapid, and finally stertorous. Œdema pulmonum develops; hemoptysis may occur; the pulse is weak, frequent, irregular, and finally imperceptible. The temperature at first is subnormal, and may remain so, or may rise later, according to the development of secondary complications. The urine will display oil-globules floating on its surface.

Diagnosis of Fat Embolism.—Fat embolism is to be distinguished from shock, the effects of anesthetics, acute septicemia, acute congestions of the lungs and of the kidneys, and cerebral hemorrhage or embolism. It is to be distinguished from shock by the fact that its symptoms make their appearance at a time when the symptoms of shock should have greatly subsided, and in many cases where in the first place the amount of shock has never been very great. The remote effects of ether are not so easily to be distinguished from the effects of fat embolism. The irritative effects upon the lungs and the kidneys of the prolonged administration of ether to persons predisposed to pulmonary or renal congestion often declare themselves in severe congestion, which determines symptoms not unlike those of fat embolism. In cases, therefore, in which such administration of ether has been resorted to the diagnosis may be

made obscure. The appearance of oil-globules floating on the urine would be sufficient to determine the presence of fat embolism. The symptoms of acute septicemia are later in their development than those of embolism. They are accompanied by marked elevation of temperature. They are more gradual in their onset, however active their course may be, and not infrequently are engrafted upon those of fat embolism. The sequence of the conditions of shock, fat embolism, and acute septicemia is not infrequent, and, when its possibility is borne in mind by the surgeon, will readily explain the course of many otherwise anomalous cases. Acute inflammatory states of the lungs arising from conditions entirely independent of fat embolism may develop rapidly after operations or injuries, and are to be distinguished from the effects of fat embolism, which may also be present and which may be masked by them. The symptoms indicative of such acute inflammatory lung congestion are sufficiently clear for diagnostic purposes if attention is only directed to them. The danger is rather that the symptoms of fat embolism will be confounded with them than that they should be mistaken for fat embolism. The not infrequent occurrence of acute renal congestion, with total arrest of the urinary secretions, after a severe operation, is to be borne in mind by the surgeon in making his diagnosis as to the cause of threatening symptoms which complicate or supervene upon the shock of the original operation or injury. The disturbance of cerebral conditions likewise, through embolism or cerebral hemorrhage, is to be borne in mind as a possible occurrence.

Prognosis of Fat Embolism.—When the symptoms indicating the presence of fat embolism are severe the probabilities of recovery are very slight. In its lesser degrees the disturbances caused by it are transient and are speedily and spontaneously recovered from. The prognosis depends upon two factors especially—the amount of fat that has gained access to the circulation, and the ability of the heart to force the oil-globules through the capillaries of the lungs. Should this first danger have been overcome, possibilities of renewed danger from arrest of oil-globules in the capillaries of the brain or spinal cord in vital regions still exist. In such conditions a fatal result is not long delayed, a few hours only sufficing to bring the case to a close. When the pulmonary trouble is the chief one, a longer time may be required to determine the final result, whether recovery or death. At best, however, the struggle is a brief one, and is determined one way or the other within less than forty-eight hours.

Treatment of Fat Embolism.—The first indication for treatment is to prevent, if possible, and at all events to diminish, the entry of fatty matter into the blood-current. The two conditions that foster this accident are the churning up of bruised and broken fatty tissue by movements of a part, and the tension resulting from the accumulation of wound-secretions that have no vent. Immobilization of the injured part and relief to tension by provision for free drainage are therefore of primary importance. The second indication for treatment is to sustain and stimulate the action of the heart. For this purpose alcohol, digitalis, and strychnia in full doses will be found useful.

REPAIR OF WOUNDS.

The repair of all breaches of tissue is accomplished by essentially the same process, subject only to minor peculiarities of structure. This process has been described in a preceding section (Process of Repair). By reference to this section it will be seen that the essential element of repair consists in a modification of the normal nutritive processes at the seat of injury, by which the tissues to be repaired return to their embryonic state and new embryonic tissue

is formed between them, with which they blend. By the organization and development of the new tissue a permanent bond of union is formed. In no case is union of divided tissue effected without the interposition of new material. When divided tissues are at once brought into perfect apposition, and there retained and shielded from disturbance, the amount of new tissue required for the accomplishment of union will be extremely small, and may be with difficulty recognizable; but its existence in some degree is nevertheless undeniable.

When the process of repair whereby the union of divided surfaces is secured proceeds without complication or interruption, union by first intention or by primary adhesion is said to have taken place. (See Chapter III.) This primary union is the ideal to be sought for whenever possible. To secure it it is necessary that the divided surfaces be brought together and kept in close apposition; that the wound be protected and kept from all further injury; and that adequate local nutritive conditions be maintained. Whatever interferes with any of these conditions will introduce a complication in the healing of a wound. It is not infrequently the case that wounds occur in which from the outset it is apparent to a surgeon that in some one or all of these respects it will be impossible to secure the necessary conditions, so that no attempt to secure union by first intention can be made. Thus the loss of tissue may be so great that apposition of the divided surfaces is impracticable, or some motion is unavoidable, or there is pre-existing infection, or such relation of the wound to the bodily excretions or secretions exists that some contamination is inevitable. The presence of any of these conditions will make it obvious that a wound should not be closed. Again, the tissues bordering the wound may be so bruised or reduced in their vitality by general or local causes that their power of sustaining the necessary processes of repair is uncertain, perhaps obviously hopeless. In all such cases the method adopted by the surgeon for the treatment of the wound will be quite different from those in which primary union is expected. Healing by second intention is the process which is now the resource of the surgeon, as it is also in those cases in which attempts at primary union have been made and have failed. By its means the ultimate healing of the wound is secured.

The conditions which may thwart the ideal primary repair of the wound will have to do with either the apposition, the protection, or the nutrition of the wounded parts. Under the first of these headings the surgeon must consider the natural gaping of divided tissues and the necessity of supplying adequate means of retaining them in coaptation. The inevitable aggravation of this natural gaping by certain positions of the body or of the limbs and by motion at joints suggests at once the necessity of considering a favorable posture for wounded parts, so that relaxation of the injured tissues as complete as possible may be secured. The accumulation of blood and of wound-secretions between the divided surfaces is a frequent cause of lack of success in attempts at securing primary union. Under conditions of typically perfect protection from external infection, as in most subcutaneous wounds, and in some operation-wounds made under rigid conditions of asepsis, such accumulations of blood and wound-secretions may not introduce any serious complication into the healing of the wound. Later, these effusions become absorbed, or they are diffused among the adjacent connective tissue-spaces, and the natural processes of repair proceed. In yet other cases the blood-clot, remaining as an intervening mass between the wound-surfaces, serves as a support and scaffolding for new tissue which is thrown out from the surrounding parts, and which penetrates the mass of the clot and coalesces with it, and finally replaces

it by fibrous tissue that unites the previously separated wound-surfaces. Union by secondary intention is thus accomplished without suppuration or waste of nutritive material. As a rule, the most assiduous effort of the surgeon must be to prevent any accumulation of blood or wound-secretions in any wound which he is called upon to treat. Perfect apposition may, again, be prevented by the presence of foreign matter between the wound-surfaces. Shreds of clothing, splinters of wood, sponges, bits of foreign matter of every conceivable character, at times are found in wounds, and their removal is to be carefully secured by the surgeon.

For the protection of a wound it is requisite that it be guarded first from motion, since by motion the apposition of the wound-surfaces is disturbed, the delicate new adhesive material which has already been formed is ruptured, and the conditions of the original injury are renewed in tissues already weakened by that injury. The wound must be protected also from mechanical violence, such as rude handling, friction, and gross mechanical injuries of every kind. It must be protected from chemical irritants, and especially from the products of decomposition of retained secretions or of portions of dead tissue; and, lastly, it must be protected from infection from poisonous agents, especially the more common infecting organisms everywhere abounding in nature.

The local nutritive conditions to which attention must be paid have to do with the circulation and the innervation of the parts to be repaired. A dependent position of the injured part or an impediment to the free return circulation by improper bandaging may produce excessive and persistent congestion and interfere with its repair. Temperature is not unimportant: prolonged cold will impair nutrition, and too high a temperature may cause local death. Too great tension of wound-flaps or tension from pent-up secretions impairs local nutrition by obstructing the flow of blood in the capillaries, as well as by the reflex effects of irritated nerve-fibrils, and also mechanically prevents rest and coaptation of deeper parts. The details of treatment to be applied in every wound have their rational basis in the principles thus outlined, which will serve for the safe guidance of the practitioner.

Treatment of Wounds.—*Arrest of Hemorrhage.*—To stop bleeding is the first care of the surgeon in his treatment of a wound. The physiology of spontaneous hemostasis and the methods of securing artificial arrest of hemorrhage are given at length under Injuries of the Blood-vessels. The aim of the surgeon should always be to secure the arrest of bleeding by means that shall cause the least disturbance in the future repair of the wound. Unnecessary ligatures are therefore always to be avoided. When ligatures are unavoidable, those made of absorbable material, as catgut, are to be preferred, and the size of the thread should be as small as is consistent with the strength required to occlude the vessel. When non-absorbable materials are used for ligatures, as silk thread, if it has been perfectly disinfected and primary union of the wound can reasonably be expected, this too may be cut off and left buried in the wound. The first and most generally applicable means for restraining hemorrhage is that of direct pressure made upon the bleeding point. This may be by the finger or by a tampon, or by an instrument, as a pressure-forceps. These means are often, in the nature of the case, but temporary expedients. In many instances, however, the temporary use of pressure will be all that will be required for the arrest of hemorrhage that at first was very abundant. When copious and continuous capillary oozing persists, it may frequently be controlled by pressure with compresses wrung out in water as hot as can be born by the hand—115° to 120° F. The use of heat as a hemostatic is to be preferred to cold, as being more favorable to local nutrition and subse-

quent active repair. The use of hemostatic forceps, which when once applied automatically compress the orifices of bleeding vessels, is a very efficient and convenient means of applying pressure. Many vessels, which at first bleed freely, after a few moments' compression in this manner will no longer bleed when the forceps are removed. If the bleeding does persist, torsion may be applied, which, being effectual in many instances, will reduce the ultimate need for ligatures to a minimum. As a rule, hemostatic agents which produce tough clots of blood, as the salts of iron, or which are strong irritants, such as turpentine, or which destroy tissue outright, as the actual cautery, are to be carefully avoided. The free access of cold air is an active hemostatic and the least harmful. Often when continuous oozing persists from a wound under a mass of soft blood-clot, if the wound is freely opened and the accumulated clot thoroughly removed further oozing becomes definitely arrested. A dilute solution of iodine has both hemostatic and antiseptic properties, and may sometimes be used with advantage. Iodoform added to a compress applied upon a bleeding surface has a distinct hemostatic effect. From among all these resources the surgeon will be called in a given case to make use of those which shall be available, efficient, and least harmful, keeping in view always the ideal of wound treatment—subsequent union by primary intention.

Complete immediate hemostasis is not to be sought for in the treatment of wounds in which easy apposition of the wound-surfaces cannot be obtained, and in which dead spaces or open defects remain which it is possible for the surgeon to fill in by tissue organized in and supported by a moist blood-clot. When a surgeon is master of a sufficiently perfect antiseptic technique to secure healing under such a blood-clot, and the circumstances are favorable, he may make the attempt. He will then encourage, or even provoke, sufficient bleeding to fill up all the dead spaces and the wound-defects with blood previous to the application of a dressing, and will subsequently protect the clot from adhesion to or disturbance by the external dressing. (See page 29.)

Cleansing of the Wound.—Great care should be taken to remove from a wound not only all foreign matter which may have been deposited within it, but also all dead or dying tissue, and, as a rule, all blood-clots. The means required for effecting such cleansing must be adapted to the nature of the material to be removed. The forceps, scissors, curette, sponge, irrigating stream, each may find its use. By means of these simply the more gross and perceptible impurities may be removed. Of greater importance ofttimes is the cleansing of the wound of those microscopic organisms which may induce suppuration and putrefaction. (For the consideration of the means required for this latter degree of cleanliness or sterilization see Operative Surgery.) Suffice it here to say that in his treatment of wounds the surgeon should never lose sight of the natural resisting power of living tissue to such organisms, and that in his efforts at sterilization he should irritate and injure the living tissue as little as possible. Strong and irritating antiseptic lotions are therefore, as a rule, to be avoided as direct applications to wound-surfaces.

When, however, a wound is already manifestly contaminated, it will be good practice to irrigate it thoroughly for a considerable period of time with a germicidal lotion of sufficient strength to secure the destruction of whatever septic material may have gained access to it. A solution of carbolic acid, 1 : 40, or of corrosive sublimate, 1 : 1000, will be found most generally suitable for such a purpose. When the full sterilization of a wound, even by the use of antiseptic irrigations, is impracticable, or it is so situated that it cannot be kept free from subsequent renewed contamination, as in many wounds involving the outlets of mucous canals or when the wound opens into suppurat-

ing cavities, resort must be had to tamponing the wound-cavities with materials impregnated with a permanent antiseptic, as iodoform or boric or salicylic acid. In these latter cases, of course, union by granulation is what commonly occurs, but what is practically primary union may sometimes be attained by "secondary sutures."

Coaptation.—In the coaptation of wounds the aim of the surgeon must be to bring the severed parts as far as possible into the same relations with each other as existed before the wound was inflicted, and especially to secure the closest possible apposition of every portion of the wound-surfaces. When important nerves, muscles, and tendons have been divided, especial care must be taken to bring and secure together the divided ends; all dead spaces where secretions may gather are to be prevented; and by various means and devices the tissues are to be retained in their restored relation until definite reunion has been accomplished. Under the term "coaptation" all the various aims and methods referred to are included. In the section devoted to Minor Surgery the means of accomplishing coaptation are described in detail. Here, however, it will be proper to speak of the general principles which should guide the surgeon in the choice of means and methods.

First, much tension must be avoided. When tissues are put unduly upon the stretch in an effort to bring them together, the circulation of the blood within them is impeded, nutrition is impaired, the formation of sloughs is invited, and suppurative disturbances are promoted. It is far better to be content with whatever amount of coaptation can be easily secured, and to seek for the healing of any surfaces left uncovered, either by granulation and ultimate cicatrization or by skin-grafts. In the second place, care must be taken while securing coaptation to avoid such adjustment of sutures or other retentive apparatus as would be likely to produce strangulation of any portion of the tissue. Sutures too closely applied and too tightly drawn are a frequent cause of necrosis of wound-edges; the pressure of compresses and bandages may likewise be so great as to produce local tissue-necrosis, so that good judgment should always be used in their application. Thirdly, the relaxation of tissues by position should not be overlooked by the surgeon. The spontaneous gaping or falling together of wounds in varying attitudes of a wounded part need but be noticed to suggest the advantage to be derived from placing a part in that position or attitude in which any tendency to gape during the healing process will be reduced to a minimum. The general rule is, therefore, in order to favor coaptation of a wound, to put the part in that position in which the greatest relaxation of the wounded structures can be secured, and in this position they should be fixed and held until firm union has been accomplished. As an accessory to the use of position for securing relaxation is the device of sliding toward the wound tissues somewhat distant from it. By the use of sutures traversing a deeper portion of the wound, and made to embrace portions of tissue on either side at a considerable distance from the wound-edges, and then secured after the manner in which an upholsterer secures the two sides of a mattress together, wounds which gape widely at first may often have their edges so approximated that they are easily brought together without tension.

The choice of materials for ensuring continued coaptation is worthy of consideration. When a wound is small and there is no tendency to gape, or when that tendency has been overcome by attention to position, the use of a simple compress held in place by a roller bandage may be all that is required to ensure undisturbed healing. In general, however, additional means for securing undisturbed coaptation will be required. For this purpose are used adhesive strips and sutures.

Adhesive strips, as direct applications to wound-flaps to secure their apposition, should rarely be used. Being disinfected with difficulty, they are always to be looked upon as surgically unclean. They favor infection likewise by retaining wound-discharges underneath them and in their substance; they cover up a wound from the surgeon's inspection; they often irritate the skin to which they are applied; and, finally, from their tendency to become loosened, they are unreliable in the support which they give. Strips of gauze fixed with collodion are more effective and are perfectly aseptic. For purposes of supplementary support, however, placed *out*side of the immediate wound-dressing to prevent tension, to produce compression, and to ensure fixation of the dressings, adhesive strips are invaluable.

Sutures.—The most certain, exact, and generally available of the means for retaining divided surfaces in coaptation is the suture. As "stitches of coaptation," applied superficially and close to the wound-margins, they keep the cutaneous edges of the wound together. As "stitches of approximation," having been passed more deeply and at a greater distance from the wound-margins, they approximate and hold together the deeper surfaces. As "stitches of relaxation," embracing tissues at some distance on either side of the wound, they relax the adjacent tissues, so that the wound-surfaces may be brought together and tension be avoided. The materials available for sutures will be discussed elsewhere. (See Operative Surgery.) Whatever form of thread is chosen should have been rendered aseptic by previous preparation, and should likewise be immersed anew in the antiseptic solution at the time it is used.

Drainage.—As the surgeon proceeds with his efforts at securing coaptation of a wound he must make provision for the escape of the secretions which are the immediate result and accompaniment of every wound. When perfect coaptation, deep as well as superficial, has been secured, and when by the most scrupulous and exact observance of antiseptic precautions the surgeon is assured that his wound when dressed is as free from infection as a subcutaneous one, means of drainage may be dispensed with, and the local absorbents may be relied upon to remove whatever secretions are poured out in excess of the quantity needed for repair. As a rule, however, it will be important for the surgeon to provide means for the free and continuous escape of wound-secretions. It will often be sufficient to leave open the most dependent portion of the wound. In some cases enlargement of wounds by free incisions or the making of counter-openings may be practised for the purpose of securing free escape of secretions. In many instances it will be good practice to introduce the sutures at the operation, but not to tie them until after the cessation of the primary copious bloody and serous oozing which occurs during the first twelve to twenty-four hours after the occurrence of a wound (secondary suture). Septic infection having been prevented by the use of antiseptic dressings, at the end of this period the wound-surfaces may be brought together, with an increased probability of securing union by first intention without the necessity of any further means of drainage. Frequently, however, the surgeon will be compelled to resort to the introduction into a wound of some foreign material for the purpose of conducting away its discharges. This substance may act by capillarity, serving to keep the wound-surfaces apart and permitting the outflow of liquid along the interstices among its strands, or there may be provided tubes through which free flow of the discharge is secured. For the escape of pus a tubular drain is always required, and whenever provision is to be made for the escape of much secretion, if absolute certainty of drainage is desired such a tube must be used. Rubber tubing is the most universally applicable means of drainage, being

flexible, unirritating, easy to manipulate, easily sterilized, nearly always attainable, and cheap. A drainage-tube, of whatever substance composed, is a foreign body, and as long as it remains in a wound is liable to produce disturbance. It should therefore be removed as soon as the period of profuse secretion which made its original use necessary has passed away, or as soon as the cavity which it was intended to drain has become obliterated.

Dressings.—In the treatment of a wound after hemorrhage has been checked, its surface has been cleansed and purified, coaptation has been accomplished, and drainage has been provided for, a suitable dressing must be applied. Two main objects are to be accomplished by a dressing: first, the absorption of whatever secretions may come to the surface; and second, the protection from infection and from injury and motion. The materials which may be available for surgical dressings are fully treated of in the section devoted to Operative Surgery. Here, however, some general considerations concerning dressings are in place. Septic infection is to be guarded against by covering the part with soft and absorbent material that will receive and keep aseptic the discharges that drain away from a wound, and that will prevent the access of septic infection from other sources to the wound. For this purpose many substances may be found useful: among those more commonly employed are cotton wool, loosely-woven cotton cloth from which all oily matter has been removed, jute, sawdust, moss, etc. While all these substances are more or less hygroscopic, their usefulness as absorbent dressings depends chiefly upon the multitude of minute spaces existing between their meshes or fibers, and a certain degree of openness of mesh or looseness of fiber is requisite to enable them continuously to absorb thick and viscid fluids. It is not enough that these materials when applied should themselves be simply sterile, for when they are filled with wound-secretions they may then be infected from without and become the medium of conveying infection to the wound. It is better that portions of the dressings should themselves be impregnated with antiseptic materials, which could actively antagonize or inhibit the activity of any septic matter that might gain access to the secretions imbibed by them. The necessity of this is realized if the extreme difficulty, almost impossibility, of sterilizing absolutely the skin of the patient or the fingers of the surgeon is recalled. For this reason the best results in securing the healing of their wounds will be obtained by those surgeons, all other things being equal, who make use of wound-dressings containing proper proportions of corrosive sublimate, the double cyanide of zinc and mercury, boric or salicylic or carbolic acid, or similar antiseptic agents. By the use, further, of very voluminous dressings it is possible to give additional security against the conveyance of infection from without to a wound, and to protect it more certainly from mechanical violence and from motion.

Changes of dressings are made at long intervals, and thus the ideal rest is secured to the injured part while repair is going on. As to when such changes are required, various considerations must determine the action of the surgeon. The body-temperature of the patient, as indicated by the thermometer, should be especially relied upon as an index to the character of the processes going on in the wound. If, after an elevation of one or two degrees above the normal for the first forty-eight or seventy-two hours after a wound has been inflicted and dressed, the temperature sinks to nearly the normal point, and remains there with but slight fluctuation, the surgeon is assured that undisturbed repair is progressing, and that no demand for interference is present by reason of anything in the wound itself. If, however, the temperature continues elevated

after the first two or three days, or if, after having once fallen, it again rises, and especially if a series of morning remissions and evening exacerbations show themselves, the evidences are unmistakable that inflammatory and suppurative disturbances, with retention of secretion and septic absorption, are going on, and that a change of dressing with thorough exploration of the wound is required. When also the external layers of the dressings become moist with the secretions that have been imbibed from within, it is imperative that the dressings be renewed. This does not apply, however, to the frequent staining of the external layers of a dressing by the copious sero-bloody primary wound-secretion, which, when very hygroscopic materials are used, often occurs within a short time after the application of a dressing. In these cases the dressings quickly become and remain dry, and do not require to be changed. When drainage-tubes have been employed it is desirable that they be removed, in most cases, within a week or ten days, or often much earlier, for which purpose the dressing must be renewed. When for the purpose of controlling hemorrhage tampons have been left *in sitû*, these should be removed as early as the third day, and thus they would form another indication for a change of dressing. If the wound becomes the seat of suppuration or of sloughing, such frequency of dressings is required as may be needful to secure the adequate drainage and cleansing of the infected part. In general, changes of dressings should be made as rarely as possible, and only for the purpose of meeting distinct indications. In changing dressings the same strict antisepsis should be observed as in the operation itself.

Local Treatment.—While proper attention is being given to a wound the needs of the wounded part should not be overlooked. Nothing which could interfere in any way with its most perfect well-being should be considered insignificant. The natural warmth of the part, perfect freedom of the circulation, the control of muscular spasm, and the most perfect quiet and comfort are all of importance to be secured.

Position.—A position that will be comfortable to the patient should if possible be selected. This will always be one in which the muscles are relaxed and the return circulation of the blood to the heart is favored. The relation of position to drainage should be kept in mind, and in the arranging of the means for drainage whenever possible the drains should be so placed as to be most efficient when the part shall have been placed in a position of the greatest comfort.

Compression.—Gentle, uniform, and continuous pressure is of great value in promoting rapid repair after injury. It restrains excessive local hyperemia, limits effusion, and promotes absorption of effusions already present; it antagonizes muscular spasm and contributes to rest of the part. A greater and more methodical application of pressure than is needful for maintaining simple apposition of the separated parts is required in order to obtain the full power of compression in favoring the repair of a wound. Compression should be smooth and uniform, gentle but firm, carefully avoiding any constriction. In most cases it may be best effected by covering the wounded part with layers of cotton wool and applying compression with bandages. The wool by its elasticity tends to distribute evenly the compression exercised by the bandage and to keep the pressure continuously uniform.

Immobilization.—While the means of compression just described will in many instances be sufficient to give whatever extraneous aid is required to prevent motion in the wounded part, in many others there will be needed some further assistance in securing the desired immobility. For this purpose splints of various kinds are available. Whenever any form of plastic splint can be

used, it should be chosen; such splints accurately take the shape of the part, forming a firm mould that encases and fixes the limb without pressing unduly on any one point. As a result, such splints are borne with comfort, and thus indirectly contribute still more to the well-doing of the wound. In an emergency, however, the ingenuity of the surgeon may be able to bend to his purpose, for giving support and fixation to a wounded part, a multitude of different substances.

Constitutional Treatment.—The existence of pain or general restlessness requires the administration of opiates for their relief. The age of the patient, his previous constitutional condition, the coexistence of disease or tendencies to disease, and the hygienic conditions in which he is placed, each must engage the attention of the surgeon in order that whatever special indications they present may be met, and every possible influence that might interfere with repair be guarded against. Even the mental state of the wounded should be regarded. The surgeon who is able to arouse hope, expectation, and faith in the minds of his patients will see their wounds heal more rapidly and certainly than when opposite states of mind exist. As regards the influence of age upon the healing of wounds, although in some cases aged persons display unimpaired ability to repair their wounds, yet as a rule in the aged healing is much more sluggish and more likely to suffer from disturbance. In aged patients especial attention must be paid to their nutrition, to maintaining their bodily warmth, and to giving them the stimulating effects of abundant sunlight and pure air.

In all cases whatever departures from a perfect standard of health a patient may present should engage the attention of the surgeon. Plethora, anemia, obesity; that peculiar vulnerability associated with the scrofulous diathesis; alcoholism; the exhaustion from overwork, underfeeding, or mental strain; the depression produced by vicious habits and the habitual inhalation of vitiated air,—these are some of the conditions for the relief of which the surgeon should see that proper constitutional treatment be given.

Closely allied to the conditions just named are certain well-marked diseased states, such as syphilis, tuberculosis, malaria, diabetes mellitus, and scurvy, which by the nutritive defects which they determine delay repair, often arrest it, and subject wounds to the most serious complications. The pre-existence of pyemia, septicemia, erysipelas, phlebitis, or any diffuse inflammation will add special dangers to any traumatism. Diseases of the various organs of the body, and particularly cardiac, pulmonary, hepatic, and renal diseases, modify the effects of wounds, both directly by the constitutional states which they create and which are unfavorable to repair and diminish the resisting powers of the tissues in general, and indirectly by the reaction of the injury upon the pre-existing affection, producing in it temporary exacerbation or permanent and excessive aggravation, with, not infrequently, speedy death. Each of the conditions named when present will demand constitutional treatment in order to neutralize as far as possible any influence for evil which it might exert upon the healing of the wound.

The general hygiene of the patient should be made as favorable as possible. Food insufficient in quantity or bad in quality, extremes of temperature, absence of sunlight, depressing climatic conditions, lack of exercise, insufficient and impure air,—these not only create previous constitutional conditions unfavorable to repair, but, when continued after the reception of a wound, directly diminish the activity of its reparative processes. The diet of the patient should be regulated so that his supply of food should be ample, palatable, and digestible, due regard being paid to personal taste and instincts.

In connection with the subject of alimentation attention should be paid to the action of the bowels and all the excretions and secretions of the body.

An abundant supply of sunlight and of pure air is especially important for the well-doing of a person who is confined by a wound to one place, and thus is dependent upon what is brought to him from without for the purification and renewal of the air which he must breathe. This is alike necessary for isolated cases in their own homes and for those in the crowded wards of a hospital.

After-Treatment.—The least possible interference with a wound while the healing process is going on is a cardinal principle in surgery. Too early and too frequent interference inevitably prevents the steady progress of the healing process. Infrequent dressing is eminently conducive to that absolute rest which is to be kept in view whatever method of treatment is adopted. When the first dressing of the wound has been conducted in accordance with the principles that have been described, the after-care from the surgeon will be limited to a watchful oversight of the means of protection and immobilization, of drainage, and of apposition that have been employed, so that they may be removed, substituted, or reinforced by others as soon as they are no longer called for or have become inefficient. The prevention of the access of septic organisms, and the removal as fast as formed of materials that may decompose or become the lodging-places of these organisms, constitute two great indications, to fulfil both of which the surgeon must continually strive to the best of his ability if he would acquit himself of reproach for the results of disturbance that may supervene in the progress of the wound. Inflammatory, erysipelatous, gangrenous, or septicemic complications attacking wounds are not always to be regarded as unfortunate and unavoidable accidents, but must sometimes be accepted as the results of errors or failures in the treatment which the wounds have received. When in the first dressing of a wound it has been possible to close it after perfectly satisfying the indications for treatment that have been detailed, it should not be disturbed until a sufficient time has elapsed for the adhesion of the wounded parts to become firm. From ten to fourteen days may often be permitted to pass before the dressings are removed. The indications which might call for earlier interference, such as the removal of drainage-tubes, have been detailed in a preceding paragraph; but whenever the external protective dressings remain dry, the wound is free from pain and fetor, and there is no acceleration of the pulse or elevation of the temperature, the dressings may be left undisturbed. Sutures may be allowed to remain as long as their support seems to be desirable, provided they are not causing irritation or suppuration. In the latter case they should be removed at once. It is impossible to fix arbitrarily the periods for the renewal of the dressings: each case must be a law unto itself. In the changing of the dressings and in all the manipulations required about the wound the utmost gentleness should be used.

INTERCURRENT COMPLICATIONS.

The regular course of the healing of a wound may become disturbed by inflammation, entailing suppuration and possibly gangrene, and if healing is ultimately secured it is accomplished only by a prolonged process of granulation. By the absorption into the general circulation of materials formed in wounds thus complicated the general phenomena of septicemia and of pyemia may be produced.

Inflammation.—With but few exceptions an inflamed wound is a septic wound, and the cause of the inflammation is the irritation of the products of

decomposition of retained secretions. It is accordingly those wounds in which the retention of secretions is most difficult to prevent, as of wounds of joints and other cavities, wounds leading down to fractured bone, and deep irregular punctured wounds, in which severe inflammation is frequently met with. To give free vent, therefore, to all wound-secretions that may have been retained is the first thing to be attended to in the treatment of such a wound. This may require nothing more than the cutting of a stitch, so that the natural gaping of the wound may suffice for the required vent, or it may require counter-incisions and the use of drains. Whenever an inflammation shows a tendency to spread into the adjacent parts, abundant, thorough, and systematic incisions into the affected area must be made, sufficient to provide for the free escape of all irritating secretions. Wherever there is a possibility of a foreign substance having been left in the wound, such as a splinter of wood, a piece of glass, a rusty nail, a bit of clothing, a detached piece of bone, etc., it should be carefully sought for and removed. If the inflammation has been caused or aggravated by mechanical irritation, by motion, or by the premature use of the wounded part, the recognition of such a fact will at once lead to its correction. When the causes of the inflammation have been removed, the parts should be placed in an elevated and comfortable position and subjected to such additional means for relieving the pain, heat, and swelling of the part, and overcoming the vascular congestion on which these depend, as the judgment of the surgeon may determine. In brief, however, it may be said that for the relief of inflamed wounds the surgeon will find of especial value the use of irrigation with cooling antiseptic solutions.

Gangrene.—The appearance of gangrene in a wound calls for the immediate adoption of even more energetic and thorough antiseptic methods of treatment than have been prescribed in the preceding paragraphs. All loose gangrenous tissue should be removed at once with knife and scissors, and the living tissues exposed should be freely and thoroughly cauterized by an 8 per cent. chloride-of-zinc solution, which should be injected into every cavity and recess of the wound. Free incisions and counter-incisions should be made into the swollen and infiltrated tissues leading from the gangrenous focus, so as to permit the escape of secretions and débris and to enable the disinfecting liquid to reach every infected part. The wound should be left uncovered, and continuous irrigation with an antiseptic solution established. For such irrigating liquid a 1 per cent. solution of carbolic acid or of acetate of aluminium or a 1 : 15,000 sublimate solution may be used. The antiseptic irrigation should be continued until permanent arrest of the gangrenous process is manifest, all necrotic tissues have come away, and a healthy granulating surface has formed.

Erysipelas.—The appearance of erysipelas is always due to some defect or neglect in the antiseptic precautions. It is always of specific septic origin, and it most especially calls for that method of treatment adapted to septic wounds. (For a full consideration of this subject see Erysipelas.)

Suppuration.—The occurrence of suppuration in a wound makes it necessary that full provision should at once be made for the easy and perfect escape of the pus. This has already been considered in what has been said in regard to drainage. Some further thought, however, should be given to the management of a suppurating wound, with a view to the restriction of the process of suppuration and the hastening of the healing of the wound as much as possible. When the wound is shallow and widely open, and not too extensive, iodoform gauze may be applied upon its whole surface as a dressing, and will diminish greatly the amount of pus secreted and stimulate the granulating process. The final healing may then be accelerated by the application of a secondary suture

when possible or the employment of skin-grafts. When the suppurating cavity is deep or tortuous, or its external opening is comparatively small, antiseptic irrigations are of value. Care should be taken in the use of all such irrigations not to inject the fluid with so much force as to break up adhesions already formed. Care must also be taken that the possibly poisonous antiseptic be not retained in the wound. This is best accomplished by finally flushing the wound with warm boiled water to wash away the antiseptic solution. Injecting a fresh solution of peroxide of hydrogen into a suppurating wound answers the same purpose, and is an efficient means of decomposing any retained pus and of sterilizing the wound-cavity. Solutions of bichloride of mercury, 1 : 2000, of carbolic acid, 2 per cent., or of boro-salicylic acid in saturated solution, are also efficient. When, notwithstanding the use of these means, the granulating process remains sluggish and the wound-cavities delay in contracting and healing, more strongly stimulating applications are indicated. Naphthalin in powder freely sprinkled over the sluggish surface, or the balsams of Peru or of copaiba freely instilled, or tampons of gauze saturated with these agents, may be used. If these are not efficient, superficial cauterizing agents, such as carbolic acid of full strength, fused nitrate of silver, or an 8 per cent. solution of chloride of zinc may be used. In all these cases constant attention should be paid to keeping the deeper parts of the wound-cavities in apposition by properly-applied pressure, and to securing absolute rest for the injured parts. Especial care must be taken that the external dressings that are applied are such as will freely absorb the pus which is brought to the surface. Nothing will more aggravate the condition of a suppurating wound than a dressing that dams back and causes retention of its secretions. Viscid pus is not absorbed to any great degree by the ordinary cotton dressings, and if they are used they must be frequently removed and the wound cleansed. In ordinary pine sawdust of moderate coarseness the surgeon will always find an easily obtainable substance which absorbs pus freely. It can be made aseptic by baking, and then antiseptic by wetting with a sublimate solution. This sawdust made into convenient-sized pads by enclosing in any thin gauzy stuff, like cheese-cloth, may be used as a dressing, with a certainty that retention will not be caused by it, so that infrequent dressing may be the rule even in such wounds.

When by any of the means described a vigorous granulating surface has been obtained and the case is not suitable for secondary suture or skin-grafting, the further treatment of the granulating surface must be one of protection while the gradual process of cicatrization by extension of the cuticle from the edges is going on. Bland or mildly stimulating ointments spread on soft antiseptic dressings of some kind are commonly used for this purpose. Suitable material for such ointments are the simple cerate of the Pharmacopeia, oxide-of-zinc ointment with which a little carbolic acid has been incorporated (ʒss to ℥j), boric-acid ointment 15 per cent., iodoform with a petroleum basis, such as carbolated cosmoline (ʒj to ℥j), make invaluable applications to such surfaces, and should be employed by preference when the wound is near a mucous outlet or other possible source of infection. An efficient protection, and one even more cleanly and in harmony with ideal asepsis, is to be found in strips of rubber gauze or in the fine oiled-silk material known as "protective." These should be sterilized by immersion in a carbolic or bichloride lotion of suitable strength for some time before they are used, and when applied upon a granulating surface which has previously been sterilized, and then covered by a suitable antiseptic absorbent dressing, the whole forms an ideal dressing for a granulating surface. Whenever the granulating surface is of any size, resort should be had to skin-grafting for the purpose of hastening its cicatrization

whenever practicable. This is a most valuable means for shortening the period of cure in cases of open wounds, and deserves to be frequently used by surgeons. (For the technique of skin-grafting see the chapter on Plastic Surgery.)

INCISED WOUNDS.

By incised wounds are meant those clean-cut divisions of tissue which are produced by the edges of a sharp instrument. They may vary in size from the most trivial to formidable and deep incisions of many inches in length—from a superficial scratch to wounds opening deep cavities or almost severing entire members from the body. Their surfaces present in a minimum degree an imperceptible layer of devitalized tissue destroyed by the impact of the cutting instrument, tissue, which is quickly removed in the early stages of normal repair and produces no disturbance in the healing of the wound. For this reason they present conditions most favorable for speedy healing, and deserve from the surgeon careful attention to all the details of cleansing, apposition, and rest which have been described in previous pages, so that primary union may be obtained.

Symptoms.—Pain resulting from an incised wound is severe and sharp at the moment of its infliction, subsiding into a smarting or burning which persists for some time; hemorrhage is free, and the gaping of the tissues is restrained only by the limits of the contractility of the tissues divided.

Treatment.—In the arrest of hemorrhage, which in general will be accomplished with but little difficulty, care must be taken to avoid any means or agents which could later prove a source of disturbance in the healing process. The use of all styptic agents should be especially avoided. Bleeding from all but vessels of considerable size will be arrested by temporary pressure, by exposure to the air, or by the application of hot water aided by compression. The mutual pressure of the wound-surfaces against each other after they have been brought into apposition serves to restrain any tendency to further hemorrhage. When large blood-vessels are wounded ligatures are required; wounds involving such vessels are most dangerous, and may quickly terminate fatally from loss of blood, so that the most energetic and instant resort to measures for the arrest of hemorrhage is called for in such cases. When a vessel is but partially divided, it is more difficult to stay the bleeding from it than if it is cut through entirely. In such cases the first thing to be done is to complete the division of the vessel, ligating it later if necessary.

The drainage of incised wounds, when with proper care their deeper parts can be maintained in apposition, is very simple. In the more extensive wounds capillary drains or small tubular drains during the first twenty-four or thirty-six hours will suffice. In a large proportion of cases where compression and immobilization of the part can be effected no provision for drainage is required. The apposition of the wounded surfaces should be attended to with the utmost care and minuteness, so that, by the use of sutures, compresses, bandages, and position, coaptation of every part should be perfect and no spaces be left for the collection of secretions. The protective dressings required by incised wounds the coaptation of the surfaces of which is possible are very simple. Exposure of the line of suture to the air, so that the desiccation of the slight amount of secretion that gathers there may form a protective crust, gives excellent results when the conditions of the wound are such as to make it practicable. A light, dry, clean absorbent dressing of some kind is all that is required at any time. The provisions for rest in the case of incised wounds may and should be made absolute by splints. The removal and readjustment of

dressing should be long deferred. The ideal to be aimed at is perfect healing without local discomfort or constitutional disturbance under a single dressing.

LACERATED AND CONTUSED WOUNDS.

A lacerated wound is one in which the tissues have been forcibly torn asunder; a contused wound, one in which the wounding force has been of a crushing character. In many instances both the lacerating and crushing elements are mingled. In any case the character and course of both classes of wounds are similar, so that they may properly be considered together. The surface of such wounds is irregular, shreddy, possibly presenting long dangling strips of fibrous and tendinous tissue, with more or less blood-clot filling the exposed cavities, and with a variable amount of dead or partially disorganized tissue scattered upon its surface. The skin-wound is irregularly torn, less in extent than the wounds of the deeper structures, from which it is more or less separated, while its borders present an area of variable dimensions that is livid and cold, ready to fall into necrosis. The great increase in the use of machinery in modern times, and of rapidly-moving and heavy vehicles operated by steam, electric, and horse-power, has vastly multiplied the frequency of lacerated and contused wounds.

Such wounds produce greater shock than do incised wounds, but are accompanied by less appreciable pain. The pain is dull and aching in character; the hemorrhage is generally slight, owing to the surface irregularity that favors the coagulation of the blood flowing over it, and to the fact that the larger blood-vessels have had their coats so irregularly torn that an occlusive clot is at once formed in the torn ends. The tissue-interspaces for some distance from the wound-opening become infiltrated with diffused and clotted blood, and in many instances foreign material, dirt of every conceivable character, is ground into the wound-surfaces, so as to defy every effort to remove it entirely. In cases of severe injury of this kind the partial syncope resulting from shock so diminishes the force of the circulation as also materially to lessen the tendency to hemorrhage. Although for these reasons primary hemorrhage is generally slight, serious later hemorrhage is not infrequent, either within a few hours, when the heart's action has regained its power and local reaction has set in ("intermediate" or "reactionary" or "consecutive" hemorrhage), or at a more distant period, when by the separation of sloughs the vessels are again opened ("secondary" hemorrhage). The external appearance of these wounds often gives no suggestion of the extent of the damage which has been done. They should therefore always be examined with great care, and the possibilities of far-extending subcutaneous injury should be kept in mind.

More or less death of tissue is inevitable in the after-course of such wounds. Some tissue, often much, is killed outright by the violence, while yet more is left in a seriously damaged state, prone to fall into necrosis from the defective nutrition that for a time exists in the part. Much of the abundant and irregularly diffused blood-clot which is present will subsequently disintegrate and liquefy. When, with greater or less rapidity according to the activity of the nutritive processes in the part, all necrotic tissue has separated and been removed, and the blood-clot has either been absorbed or has broken down and escaped, there remains behind a uniform granulating surface, and the further course of the wound is toward healing by granulation.

All the conditions presented by these wounds are such as to render them specially liable to septic infection of serious character.

Treatment.—Although there may be but little hemorrhage at the time of

the first dressing of a lacerated or contused wound, yet if vessels of any size have been torn it is the part of wisdom to apply ligatures to them, though they may not be bleeding at the time. The period of reaction from shock is to be watched with especial care to guard against possible hemorrhage. Should this hemorrhage at any time occur, the application of a ligature is imperative, even though the bleeding may have ceased spontaneously as the heart's action is weakened; for so soon as the reaction again comes on and the heart beats strongly once more, the hemorrhage will surely recur. The primary cleansing of the wound should be conducted with great care by rubbing sweet oil thoroughly over the surface, including the adjacent skin, then cleansing by soap and warm water well scrubbed on, following this by washing with alcohol, and finally by thorough scrubbing with sublimate solution, 1 : 1000. All detached particles of bone and of the soft parts should be carefully removed, and tissues into which foreign matter has been so ground that the complete removal of the dirt is impossible should be trimmed away with scissors or knife. Bruised portions of tissue that are still attached should be carefully cleansed and replaced and preserved from further traumatism, since much that appears to be hopelessly destroyed may be saved in many cases by care in fostering its nutrition. Thorough scrubbing and irrigation of a contused and lacerated wound with a warm antiseptic lotion until no element of sepsis is left within it is important, for all the conditions of these wounds are such as to create and present to a large degree the material favorable for the rank development of septic organisms. The natural resisting power of the tissues, which enables the surfaces exposed in ordinary incised wounds to resist the development of sepsis and to preserve the minute devitalized fragments of tissue that are present from undergoing putrefaction, is no longer to be relied on, for the bruised wound-surfaces have to struggle to retain their own vitality, and large masses of devitalized tissue and more copious effusions of putrefiable secretions have to be disposed of.

The fullest provision must be made for drainage from all the recesses of the wound. Free counter-incisions must be made wherever necessary for this purpose. Efforts at accomplishing apposition of the wound-surfaces must be subordinated to the need for drainage and the provision for the unhindered separation of necrotic tissue. In cases of severe contusion a degree of uncertainty will always exist as to the ability of the injured tissue to retain its vitality, and a certain amount of necrosis is to be expected and provided for. This necrosis will be reduced to a minimum in proportion as the provisions for making and keeping the wound aseptic are thorough and successful. When adequate antiseptic measures are practicable, greater efforts at securing coaptation of the wound-surfaces are proper. Special care should be observed to avoid all tension of the wounded tissues in the endeavor to approximate them. In a large proportion of contused and lacerated wounds there will be such an amount of destruction of tissue that any attempt at closing them to secure primary union will be manifestly contraindicated. In such cases the efforts of the surgeon should be chiefly directed toward protecting the wound from sources of disturbance during the time that the separation of the sloughs and the process of granulation are going on. These are the cases in which local septic inflammations, gangrene, erysipelas, and general septic infection are most prone to occur. The manner in which such disturbances are to be met has been fully discussed in preceding pages. While the constitutional symptoms produced by them will often require special treatment, they will spontaneously subside if adequate local antiseptic measures are employed. The latter, therefore, should always engage the first and most constant attention of the surgeon.

Brush Burn.—By this term is meant a peculiar form of superficial lacerated and contused wound caused by friction applied to the surface of the body, as when a portion of skin is brought into contact with a rapidly-moving belt of machinery, or by an involuntary slide down a steep incline, or by the slipping of a rope through the closed hand. In this injury the superficial tissues are ground off and an eschar of considerable depth results. They should be treated by antiseptic fomentations until the eschar has separated and a granulating surface has formed, which should then receive the treatment elsewhere described.

PUNCTURED WOUNDS.

Deeply perforating wounds made by pointed substances will partake of the nature of either incised or contused and lacerated wounds, according to the sharpness of the point of the wounding instrument. Punctured wounds made with sharp, clean-pointed instruments, as pins, needles, trocars, dagger and stiletto points, partake of the nature of limited incised wounds, and unless in their course they have wounded organs of importance, as large blood-vessels or nerves, the withdrawal of the instrument is followed by rapid and perfect recovery. Should the puncturing instrument, however, be contaminated with active septic material, an acute septic inflammation will result, depending upon its depth from the surface for its importance, and demanding free incisions for the relief of the pent-up secretions. For its further care those measures which have been described as required for inflamed and infected incised wounds will be indicated. Punctured wounds which are formed by the thrusting into the tissues of irregularly-shaped and blunt substances, such as splinters of wood, nails, a bayonet, and the like, form deep and narrow wound-tracks, the walls of which are contused and lacerated, while minute fragments of devitalized tissues or small fragments of infected material are driven in and deposited in the depths of the wound. The dangers and difficulties attending ordinary contused and lacerated wounds are aggravated in these cases by the long and narrow track which leads from their bottom to the surface. Should no septic material have been introduced by the wounding body, such wounds may yet be expected to heal kindly and promptly if care is taken to avoid their subsequent infection from without and to keep the wounded part at rest while repair is taking place. In view of the impossibility of adequately disinfecting such a wound by mere applications to the surface at the time of the dressing, as a general rule it should be freely laid open to the bottom by additional incisions, and there should be thorough disinfection of the wound and the adjacent integument. It should then be covered with an abundant antiseptic dressing, which should be supplemented by any posture or by the application of whatever apparatus that may be required to keep the part at rest. If, notwithstanding this, inflammation of the deeper part of the wound develops, immediate resort should be had to additional free incisions to give vent to pent-up effusions and for subsequent disinfection and drainage. The more deep and narrow the wound-track, the more important that free and early incisions should be made. Still more important, if possible, are such early incisions when the puncture has involved strong fasciæ, the thecæ of tendons, or joint-cavities. Delay in resorting to such incisions is not only sure to produce extensive local damage, but may even prove dangerous to life.

Not infrequently portions of puncturing bodies are broken off and left imbedded in the tissues. In some cases such imbedded substances may remain innocuous for an indefinite period of time. In yet other instances their presence provokes irritative symptoms of a marked character. Foreign

bodies in the neighborhood of joints, or piercing nerves, tendons, or blood-vessels, are sure to be followed by excessive pain, muscular spasm, or hemorrhage. Diligent effort should be made to detect and remove foreign bodies at the bottom of punctured wounds whenever there is reason to suppose from the nature of the body or the nature of the tissues wounded that they will become a source of peril or discomfort if allowed to remain, or in any case when the conditions are favorable to making such a search without an unduly extended or dangerous dissection. The instrument inflicting the wound should always be inspected to determine whether any of it has been broken off and left in the tissues. For the removal of such bodies the enlargement of the original wound may suffice, or possibly counter-openings at distant points may be required, so as to give more ready access to the body sought for. Such counter-openings may be of additional value in providing means for thorough drainage. In attempting the removal of minute bodies, such as the fragment of a needle or a small bit of glass, the search may often be facilitated by raising a triangular flap in the centre of the base of which is the original point of puncture, the apex of the flap lying in the direction toward which the body has penetrated. This flap should include the skin and superficial fascia, and when raised gives more easy access to the deeper tissues, and permits a more free and thorough search for any small body which may be imbedded among them. To make such an operation bloodless, Esmarch's bandage is often of the greatest use. The removal of a puncturing body when it projects from the surface, or lies so near the surface that it can be readily seized, is usually easy, but in some cases, by reason of the irregularity of its surface or its being barbed, as a fish-hook or arrow-head, its removal is difficult. Whenever the location of such an entangled body permits it to be easily pushed through to the other side, such a course should be adopted. When this manœuvre is not feasible, whatever incisions may be required to free the body from entanglement and allow it to be easily plucked out should be made.

The hemorrhage in punctured wounds is usually slight and requires no special attention. Should it be at all free, the possibility of the wounding of a large vessel should suggest itself, and a careful review of the anatomical relations of the puncture should be made. Should the hemorrhage not be easily controlled by pressure, the wound should be enlarged, the bleeding point identified, and a ligature applied. A false aneurysm is the not infrequent result of partial divisions of arteries in punctured wounds. Punctured wounds impaling a vein and an artery lying in contact with each other are occasionally the cause of arterio-venous aneurysms. Such sequelæ call in many cases for free incisions and for exposure of the wounded vessels and ligature above and below the point of wound.

GUNSHOT WOUNDS.

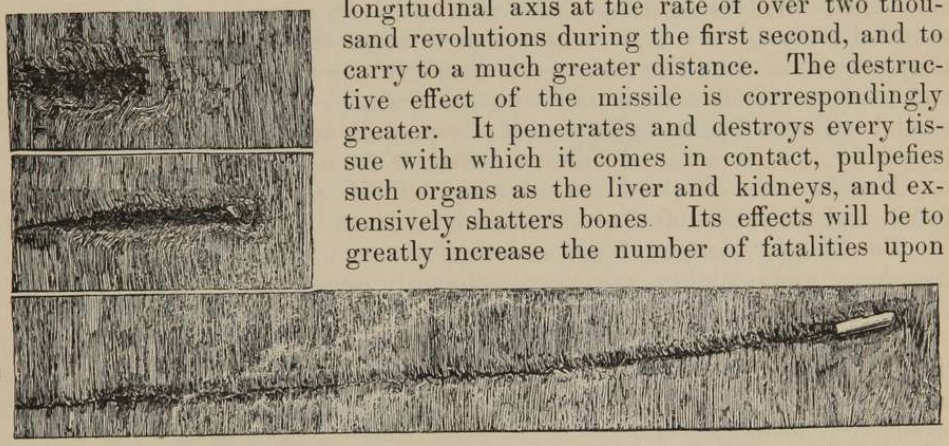
The term "gunshot wound" is applied generically to injuries inflicted by missiles, whatever their character, whose force is derived from the explosive power of gunpowder. This definition, therefore, includes every grade of missile, from the smallest bird shot to the immense projectile fired from mammoth pieces of heavy ordnance, and every grade of injury, from the mere peppering of the surface of the skin with grains of gunpowder or minute shot to the laceration and comminution of extensive portions of the body.

The character of the injury produced when the missile has penetrated the tissues, which is usually the case, is that of a contused, lacerated, punctured wound; when the surface is merely grazed, it partakes of the nature of the

brush burn, as already described. In occasional instances a large missile moving with slight momentum fails to break the skin, but produces extensive damage to the subcutaneous tissue. The missiles which are more frequently met with in gunshot wounds are (*a*) the shot used in fowling-pieces, which are of various sizes, from that of a buck shot, which weighs 133 grains, to that of the smallest bird shot, one of which weighs only $\frac{1}{5}$ of a grain; (*b*) pistol bullets, varying in size from about $\frac{1}{5}$ of an inch to $\frac{1}{2}$ of an inch in diameter, and weighing from 20 grains to 240 grains. The size of a pistol bullet is usually designated according to the decimal part of an inch which makes its diameter; thus a 22-caliber bullet is one whose diameter is 22–hundredths of an inch. (*c*) The rifle bullet, which is the missile of the modern arm of precision, long and generally conoidal, and weighing from $\frac{3}{4}$ to $1\frac{1}{2}$ ounces. For military use yet larger missiles have been devised which hardly arrive at the dignity of cannon shot, and yet are heavier than the rifle balls of the infantryman, such as the projectiles thrown by the mitrailleuse, Gatling, and Hotchkiss guns.

The Männlicher rifle, which is now coming into general use as a military weapon, projects a bullet of small caliber (.25–.32 caliber; 6.5 to 8 millimeters in diameter), which, by the use of cellulose powder, shells of cupro-nickeled steel, and a more abrupt rifling, is driven with greatly increased velocity, and made to revolve upon its longitudinal axis at the rate of over two thousand revolutions during the first second, and to carry to a much greater distance. The destructive effect of the missile is correspondingly greater. It penetrates and destroys every tissue with which it comes in contact, pulpefies such organs as the liver and kidneys, and extensively shatters bones. Its effects will be to greatly increase the number of fatalities upon

Fig. 20.



Relative Penetration of Bullets across the Grain of Oak, showing their deformation: A, ordinary .45-caliber lead bullet (powder, 69 gr., penetration, 3.2 in.); B, new .30-caliber German-silver-jacketed bullet (powder, 37 gr., penetration, 5.3 in.); C, cupro-nickeled-steel-jacketed 30-caliber bullet (powder, 37 gr., penetration, 19.5 in.).

the battle-field, both by the larger number of men injured by a single bullet and by the necessary removal to a far greater distance from the battle-field of the field hospital, so as to be beyond the range of the firing. Figure 20 shows (A) the relative penetration in oak, across the grain, of the .45-caliber lead bullet and the great deformation of the ball; (B), the .30-caliber German-silver-jacketed bullet and its deformation; and (C), the .30-caliber cupro-nickeled-steel-jacketed bullet, which still retained its original form.

The repair of gunshot wounds is often disturbed by foreign matter carried into the wound by the projectile, such as portions of clothing, gun-wadding, buttons, pieces of coin, splinters of wood, etc. The mere explosion of powder from a gun fired at short range may produce a serious injury which combines the characters of a burn with those of contusion and laceration.

Gunshot wounds derive especial significance from—1. The special tissue or organ injured; 2. The conditions under which the wound was inflicted; 3. The presence or absence of septic infection.

Injuries to Special Tissues.—*The Skin.*—The effects of grazing the skin and of contusion without penetration have already been referred to. When a penetrating wound has been inflicted, the wound of entrance is generally small and less in diameter than that of the missile itself, owing to the elasticity of the skin, which has been stretched by the ball before being penetrated by it. It is also apt to be dirty, both from the powder if the wound was at short range, and from wiping the dirt from the ball as it enters. Such a wound will appear insignificant to one unfamiliar with its real gravity. Should other foreign matter be carried in with the ball, the wound of entrance will be correspondingly increased in size. Should the ball pass clear through the body or limb, the wound of exit will be larger and more ragged than that of entrance, the difference being determined by the lessened momentum of the ball and the want of support to the tissues at the point of exit, as a nail driven through a board splinters largely the under side or point of exit. Conical bullets, having greater penetrating power than round, produce in the skin-wounds which they make much less difference in size than formerly resulted from the use of round bullets. By subsequent sloughing of the contused margins of the wound of entrance it often becomes after a few days of greater magnitude than that of exit.

Fasciæ.—Especial interest attending wounds of fasciæ arises from the fact that their interlacing fibers are often to a considerable degree split and crowded aside by the ball as it passes through them, so that the orifice that they present is much less free than is found in the softer tissues on either side, and tends to interfere materially with the drainage of the deeper parts of the wound. Dense fasciæ again frequently present sufficient resistance to a ball, especially if it is a round one, to deflect it from its original course.

Muscles when involved are subjected to widespread damage through contusion and laceration of their substance and extensive infiltrations of blood.

Tendons, by reason of the resisting nature of their structure and their roundness and mobility, are more frequently either pushed out of the way or deflect the bullet.

Blood-vessels, especially arteries, whose walls are more resistent and elastic than those of veins, are not infrequently pushed aside. Even in such cases, however, such contusion of their structure is often inflicted as to determine subsequent sloughing and secondary hemorrhage. Both partial and complete division of large blood-vessels is a frequent concomitant of gunshot wounds, and is also the most frequent cause of immediate death by reason of the hemorrhage following. Traumatic aneurysm and arterio-venous aneurysm may result in certain cases, as has already been noted in ordinary punctured wounds.

Nerves.—Large nerve-trunks when wounded present no special symptoms that call for extended notice here. The functional disability resulting from such wounds will depend upon the special function of the particular nerve, and may be more or less complex and important. Severe pain may result primarily from inflammatory processes in the injured nerve, or later from its being involved in a contracting cicatrix or by development upon its end of a neuroma. Trophic changes of every degree are among the ultimate results of nerve-injuries. (See Injuries of Nerves.)

Bones.—A ball striking upon a bone usually inflicts much damage upon it, splitting and comminuting it, often producing fissures that extend into neighboring joints. The bullet may become lodged in the bone, remaining as a source of irritation, and often of suppurative inflammation, until removed.

The Great Cavities of the Body.—Balls penetrating the cranial cavity will produce symptoms according to the region of the brain injured; though always

serious, the wounds they inflict are not necessarily fatal. Penetrating wounds of the thorax may involve the lungs, the heart, or the great vessels, and, if not immediately fatal, present special difficulties in the inflammatory complications or in the resulting extensive pleural or pericardial effusions. Penetrating wounds of the abdominal cavity, in addition to the dangers from hemorrhage and from ordinary inflammatory complications, have the special dangers incident to possible wounds of the stomach, intestines, bladder, and the various other abdominal viscera. (See Wounds of the Abdomen and its Viscera.)

The Conditions under which the Wound is Inflicted.—Gunshot wounds differ especially from the ordinary operative wounds inflicted by a surgeon in the special conditions incident to warfare which make it difficult, often impossible, to give to the patients the full degree of care which they require, and which often expose them to further injury that greatly aggravates the original severity of the wounds. In dealing with these conditions is found the special field of military surgery. In civil life, however, it often happens that gunshot wounds are sustained under conditions that resemble those of military campaigning, as in the case of accidental wounds occurring among hunting-parties in regions remote from help. The frequent absence of skilled help and of the materials for the proper dressings for such wounds adds greatly to the dangers which attend them. The necessary transportation of wounded men for long distances, often with the most crude resources for their comfort, is another fruitful source of evil, and has many times demanded the sacrifice of a limb or has occasioned the loss of a life which under more favorable circumstances could have been saved. In the accidental gunshot wounds of civil life also it is by no means the rule that adequate surgical skill and proper dressing materials are at once attainable.

The Presence or Absence of Septic Infection.—This is a factor of the highest importance in determining the favorable or unfavorable course of a gunshot wound. If such a wound is preserved from septic infection, the wound of entrance is quickly closed and its remaining track, however long it may be, or however much lined by contused necrotic tissue, or whatever organ it may have traversed or bones it may have shivered, is reduced to the condition of a subcutaneous injury, and is thereby saved from a thousand dangers that might otherwise complicate its healing. Fortunately, experience has shown that in many instances a penetrating bullet does not carry with it septic material, and that if a wound which has been thus made is preserved from subsequent infection, an aseptic course of healing will take place. The question of the removal of the bullet itself in such cases becomes a secondary matter, depending entirely upon the importance of the later symptoms of disturbance which its presence in the tissues might occasion. On the other hand, the introduction of sepsis into a gunshot wound is sure to determine inflammatory and suppurative symptoms of the most pronounced type, and to call for the most energetic and thorough interference on the part of the surgeon. Secondary hemorrhages are to be feared; necrotic débris and the pent-up products of septic inflammation will require to be evacuated; increased dangers to life and limb will be incurred; and in the most favorable event a prolonged convalescence will result.

Diagnosis.—The circumstances attending the infliction of a gunshot wound will usually be sufficiently clear to settle the fact that a given wound is due to the penetration of the tissues by a projectile driven by the explosive force of gunpowder; but the surgeon in investigating the case may find it important to determine the course which the missile has taken, the organs injured, and the final resting-place of the missile, provided it has not already escaped by an aperture of exit. The external marks of injury may

give no clue whatever to the character and extent of the deeper injuries which have been received. In forming any conclusion as to the extent and nature of the wound which has been received, a careful investigation, therefore, must be made into all the symptoms attending the injury, such as shock, hemorrhage, functional disturbance, local pain, and tenderness, as well as an inspection of the external signs of wounding. All such investigations should be made with the most scrupulous care to avoid touching the wound itself unless under the most rigid antiseptic precautions. When it is possible to ascertain the direction from which the missile came and the position of the body or limb at the time the wound was received, valuable information as to the course which the missile has taken through the tissues may sometimes be gained by putting the parts again into the same position. The possible deflection of the bullet by bone or fasciæ is not to be forgotten, and must be given due weight in explaining otherwise confusing symptoms. The slight differences which have already been remarked upon as existing between the orifices of entrance and exit should be borne in mind in determining the point of primary penetration when two apertures exist. The amount of pain attending the reception of a gunshot wound varies much, and is of little value as a diagnostic symptom. In the excitement of the moment many wounds are received with no consciousness of the fact on the part of the injured person, who discovers it later only through the hemorrhage or the functional disability which results. In other cases a sharp stinging pain or a dull, numb sensation indicates to the person that he has been wounded. Sometimes the shock of even slight wounds is very great.

Probing a Wound.—When the circumstances of the case or the symptoms which are present make it important that the deeper recesses of the wound should be searched, this is to be accomplished by the insertion of the finger of the surgeon if possible, or by the use of suitable probes, and all the steps of the process of search should be conducted with most careful regard to the requirements of rigid antisepsis. Such probings are not to be done as a matter of routine, but only when some distinct indication is present. Free enlargement of the external wound should be made without hesitation whenever it will facilitate the prosecution of the search, and as far as possible reliance should be placed upon the finger of the surgeon for gaining the desired information to the exclusion of metallic or other probes. When it is necessary to pursue the investigation into depths which are beyond the reach of the finger, a metallic probe of suitable length and having a bulbous tip of considerable size may be used. Such a probe having the tip made of porcelain biscuit, and known as Nélaton's probe, has the special value that when the tip comes in contact with the bullet at the bottom of the wound it retains the mark of the lead upon it, and thus gives an absolute demonstration that it has been in contact with the bullet or a fragment of it. Before using it its freedom from any similar prior stain must be ascertained. The stem of an ordinary clay pipe has been used extemporaneously for the same purpose. The "telephonic probe" of Girdner is an ingenious application of the telephone which may occasionally assist in identifying the location of a bullet in the tissues. This device may be extemporized whenever an ordinary telephone receiver is accessible: one of the wires of the telephone having been attached to the probe, the other is made fast to a metallic plate, which is placed upon any portion of the surface of the body previously moistened. The probe is now inserted into the wound for the purpose of the search, while the telephone receiver is held to the ear of an assistant; whenever the probe comes in contact with the bullet a distinct click is heard in the telephone—a click which is not elicited except by contact

with metal. Other methods for utilizing the electric current for detecting and locating a bullet imbedded in the tissues have been devised; some of these are ingenious and successful as experiments, but none are susceptible of being utilized in general practice.

Probing should be done with gentleness and care. It cannot be too strongly impressed on the mind of the surgeon that all probing should be abstained from until such time as the final, thorough examination and dressing of the wound can be done, when once for all the probe may be resorted to in accordance with the restricted indications for its use hereafter mentioned.

Treatment.—Shock is to be combated in accordance with general principles. Persistent hemorrhage of sufficient extent to require special interference for its arrest indicates a wound of a vessel of considerable size. In such cases the rule is imperative to enlarge the wound sufficiently to expose freely the bleeding vessel and to ligate it upon both the proximal and distal sides. Should the vessel not have already been completely severed by the ball, it should be divided between the ligatures after their application. Hemorrhage occurring secondarily during the after-history of the wound demands the same treatment, and often involves an extensive dissection in the necrotic tissue. When, by reason of its anatomical position or the difficulty of finding it in the sloughing tissues, it is not practicable to expose the wounded vessel in this way, ligation of the main artery of supply in its continuity must be resorted to, but only after a determined effort has been made to ligate it in the wound itself.

From the standpoint of treatment gunshot wounds are divisible into two classes—first, those which are capable of primary occlusion of the external wound and of conversion into practically subcutaneous wounds; and secondly, those which must be treated as open wounds throughout. A large proportion of gunshot wounds are capable of being kept within the first of these two classes.

First class.—The first effort of the surgeon, therefore, should always be scrupulously to protect the wound from contamination from without. The one exception to this rule is found when necessity for interference for the arrest of hemorrhage is so great that its urgency may compel the disregard of every other precaution. The external wound may be of such extent as to be manifestly incapable of being sealed up by primary occlusion, but such a condition gives no warrant for the neglect of every possible effort at antisepsis from the beginning. The mere lodgment of a bullet in the tissues is not of itself an indication for the introduction of an exploring finger or probe, nor is it justifiable to disturb the wound by the new traumatism of an exploration until distinct evidence has appeared that the missile is seriously interfering with the repair of the wound by its presence, or unless there is good reason to believe that there has been carried into the wound with the bullet septic material, such as fragments of clothing. That exploration of a gunshot wound which is called for by reason of such manifest extensive laceration and destruction of tissue that the questions of excision and amputation require to be decided, is of an entirely different character from that which has as its end the quest for a bullet and its removal. Such explorations are made on general surgical principles, and become a part of the more formal and extensive operative procedures to which they lead. It is not infrequent, in cases where the foreign body has been allowed to remain undisturbed in its new position among the tissues, and satisfactory and rapid healing of the original wound has been secured, that the body subsequently becomes a source of irritation, so that its extraction is necessitated. A late operation of this kind, when it can be surrounded by every precaution, and is done among tissues which are no longer infiltrated and from which all

bloody extravasation has long been absorbed, is attended with much less danger than a primary operation would have been.

A gunshot wound from the time that it is received until adequate antiseptic cleansing and dressings can be applied should be left exposed to the air without any covering whatever, inasmuch as the air is less likely to be septic than any ordinary dressing which could be applied. By such exposure desiccation of the secretions about the wound-aperture is favored and a protective crust is formed. As early as possible after the infliction of the wound the external aperture and the surrounding area of skin for a number of inches should be thoroughly cleansed with soap and water and sterilized by the free application of a solution of corrosive sublimate, 1 : 1000, or of carbolic acid, 1 : 30. It should then be covered with an abundant dressing of absorbent antiseptic material. Almost anywhere ordinary linen or other similar dressings can be used after being made aseptic by heating in an oven to a point just short of burning. The wound-opening itself should by preference be covered by a bit of oiled silk or rubber protective previously sterilized, but this is not absolutely essential; the part should now be immobilized, if it is a limb that has been injured, by an adequate splint, which should extend sufficiently far above and below the wound to keep at rest all the muscular tissue of the part from origin to insertion. The wound should not be disturbed until definite healing has been accomplished, unless symptoms of septic infection should declare themselves, especially by a rise of temperature, thus converting the wound into one of the second class, next to be considered.

The second class of cases, which must be treated as open wounds, include those in which the extent of the wound is too great to give any hope from the first of securing its primary occlusion; those in which these attempts have been made, but have failed; and those in which such attempts have been deferred or omitted until the wound has become manifestly septic by reason of its exposure, its having been subjected to uncleanly and premature explorations, or the application to it of contaminated dressings. Even in this second class of cases all explorations and other operative measures should be deferred, if possible, until they can be done with the necessary disinfection, and can be accompanied by adequate protective dressing. Treatment should be conducted with scrupulous attention to the thorough disinfection of every accessible recess of the wound and to perfect freedom of drainage. The appearance of high fever, inflammatory swelling, progressive infiltration, gangrene, and other evidence of progressive septic contamination calls for the energetic and thorough application of all the resources for the control of sepsis which are within the command of the surgeon.

The primary examination and cleansing of the wound should be conducted with the view of making it aseptic if possible. Frequent partial cleansings should be avoided; repeated probings, cuttings, irrigations, and squeezing for the purpose of evacuating the wound-secretions and débris, which keep up a continued irritation of the wound, should be replaced by one thorough primary examination and cleansing. This should be conducted under an anesthetic, with deliberation and minute attention to the ultimate object in view—the destruction and prevention of sepsis. The external wound should be freely enlarged when necessary, so as to permit the introduction of a cleansed and disinfected finger for purposes of exploration. Bullets, splinters of bone entirely detached, pieces of clothing, and other foreign bodies which are found during the examination should be carefully extracted. A bullet, after having in the early part of its course inflicted injuries which require to be treated by the open method, not infrequently continues its course in such a manner that

the second part of its track may heal primarily behind it, and the bullet remain shut off from the first part of the wound, and there, becoming encysted, remain permanently without inducing further mischief.

The treatment of such a deep wound-track should be conducted on the same principles as those which control the more superficial wounds; it should not be probed nor irrigated, nor in any manner interfered with, unless evidences of inflammatory disturbances of its walls appear; no search should be made along it for the bullet; much less should the presence of the bullet at its bottom be considered an indication for an attempt at its removal, unless easily accessible from the opposite side, when it should be removed antiseptically. The disinfection and drainage of the superficial portion of the wound should be conducted with all care and thoroughness. Should deeper disturbances manifest themselves, the exploration, cleansing, and drainage of that portion of the wound would then be required. Enlargement of the aperture of communication with the superficial wound, and free counter-incisions to the extent required for its easy and perfect drainage and for the removal of any foreign and irritating bodies along its track, will be necessary.

A certain proportion of these injuries will require primary resections of joints, partial or complete, and amputations, as a part of the care required in the primary dressing. The necessity for these more important operative procedures will have become revealed in the course of the explorations which have been made. The judgment and experience of the surgeon as to his ability to ward off the dangers which threaten badly shattered joints and bones and extensively-mangled soft tissues, and to conduct the wound to a satisfactory healing so as to preserve a useful limb, must influence the decision in many cases as to whether a conservative method of treatment or the opposite should be adopted. In yet other cases, when, in addition to extensive injury to a bone or penetration of a joint, the main vessels or nerves of the limb are injured, or when extensive loss of the soft tissues has taken place, or when a part of the limb has been carried away, no alternative is left to the surgeon but amputation.

When the necessity of amputation is unquestionable, it should be done as soon after the shock from the primary wound has passed away as is practicable, provided this is before septic infection, inflammatory infiltration, and secondary traumatic fever have developed. This is the period characterized by old authors as the *primary period;* which, in pre-antiseptic days, extended over the first thirty-six to forty-eight hours. This is followed by a period extending over a variable time, during which there is progressive local inflammatory infiltration and general fever. This period is termed the *intermediary period.* During this period no operative interference is to be attempted other than that required for the removal of necrotic tissues or for affording adequate drainage, unless spreading gangrene of the wound develop, when distant amputation through tissues yet sound should be done as quickly as possible. When the primary inflammatory infiltration has become limited and begins to subside, and free suppuration from the wound-surfaces has become established, another period is said to have been reached, known as the *secondary period.* When the secondary period has been reached, amputation through tissues yet sound should be done without further delay.

The prolongation of the primary stage by antiseptic treatment—continuous antiseptic irrigation being the method which in general is best adapted to these cases—makes it possible for the surgeon to delay amputation until such time as, in his judgment, the patient will be in the most favorable condition to bear the operation. In some cases it will happily have served to demonstrate the possibility of recovery without amputation, for in not a few instances the

possibility of saving a limb will depend entirely upon the success of the efforts to prevent the wound from being invaded by septic infection. As soon as it is evident that these efforts have not been successful, amputation should be proceeded with, before the full local and constitutional symptoms of sepsis have developed.

Point of Amputation.—The choice of the point at which the amputation shall be made may be greatly influenced by the facilities at the command of the surgeon for keeping the wound aseptic. If these be adequate for the purpose, the section may be made at whatever point may be desirable to give the patient the most useful stump, even though bruised and lacerated parts be included in the flaps. These are preserved from inflammatory disturbance, their full vitality is regained, and they participate in the formation of the stump without disaster from sloughing. When, for any reason, the wound cannot receive adequate antiseptic treatment, amputation, if possible, should be made at a point sufficiently far above the injury to exclude all bruised and lacerated tissues from the flaps. A blind groping for a bullet at the bottom of a deep sinus should never be attempted. The enlargement of the external aperture and the dilatation of the deeper track, as required for the purposes of the cleansing and drainage of the wound or the counter-incisions made when the length of the track and the location of the ball demand it, should be ample enough to permit the sufficient exposure and ready seizure of the bullet if it is to be removed at all. For the purpose of facilitating the removal of a bullet when exposed many styles of forceps have been devised; it is not necessary that mention of any special one should be made. Any pair of forceps with slender and firm jaws, with slightly projecting teeth or with roughened points to increase the security of the grasp upon the bullet, will answer. The bullet will commonly be found to be somewhat battered and misshapen and entangled in interlacing strands of fibrous tissue that hold it closely, so that some little difficulty is often experienced in freeing the bullet so that it can be removed after it has once been exposed. If the bullet is firmly impacted in bone, it must be first loosened by the chisel or elevator, and then removed.

Gunpowder grains imbedded in the skin may be picked out by a sharp-pointed bistoury and a fine curette, or be left to spontaneous discharge by suppuration. In any event, a permanent tattooing will remain as a mark of the wound.

Arrow-wounds.—The wound made by an arrow is a punctured incised wound. Such wounds demand special mention only in connection with the question of the treatment of the arrow when any portion of it is lodged in the wound. The barbed head of the arrow, by becoming entangled in the tissues which close over it after it has penetrated them, forms a condition that is especially difficult to overcome if the arrow has penetrated to any depth. The general principles of surgery which are applicable to the search for and removal of all foreign bodies imbedded in the tissues are equally applicable to imbedded arrow-heads. If the shaft of the arrow is still attached to the head, it affords a valuable guide along which the dissection of the surgeon may be made for adequate exposure and disentanglement of the arrow-head. It should never be pulled upon for the purpose of removing the arrow, for the effort will certainly be futile, and if the shaft becomes separated from the head its further service as a guide is lost. If, however, the arrow has so far penetrated the tissues as to make it feasible to push it clear through and out on the other side, that treatment should be adopted; and in that case the shaft should be used to push out the head, the exit of which through the skin should be helped by the proper use of the knife. The head and the ribbon which attaches it to the shaft being

then removed, the shaft itself can be withdrawn. Arrow-heads do not become encysted like bullets. The experience of military surgeons is uniform that an arrow-head lodged in the soft tissues invariably produces serious results. Hence the rule is without exception that an arrow-head left behind and lodged in the tissues must be removed as soon as possible, even if this removal should require the severest and most dangerous operation (Bill).

POISONED WOUNDS.

Certain wounds remain to be considered which are associated with the inoculation of special hurtful substances. They have long been classed together as poisoned wounds, although in some the poison injected is of a chemical character, while in others it is microbic. A distinction, however, should be made between wounds that are subjected to microbic and those subjected to chemical influences. The former constitute the general class of infected wounds, in which are to be grouped not only all those heretofore described as subject to the usual septic infection, but also those which are infected by special microbes, as rabies, glanders, anthrax, actinomycosis, etc. Chemical poisons differ from microbic poisons in that they are incapable of self-reproduction, and that their deleterious effects are proportionate to the amount of the poison at first introduced into the body. In this class are to be grouped the bites and stings of insects and of reptiles. It is not be overlooked that in ordinary infected wounds the local and general symptoms which are produced are due largely to the action of the chemical poisons or ptomaïnes which are generated by the micro-organisms that infest the wound, and not to the presence of the micro-organisms themselves. Such wounds are therefore of a double nature. In all cases where there is a tendency to spreading gangrene this mixed character of the poison is especially marked. The acrid ptomaïne by its chemical effect upon the tissues with which it comes in contact produces their death and converts them into a fertile soil for the rapid multiplication of the invading micro-organisms, which, again, as they multiply, produce a renewed supply of the ptomaïne, that attacks a fresh layer of tissue; and thus the vicious circle is completed and the progressively destructive process is maintained. There are, therefore, three great classes of poisoned wounds:

First, that of **mixed** or **bio-chemical infection**, which includes all the ordinary septic wounds that have been treated of in the preceding pages, and likewise those special wounds which are at times accompanied with marked tendencies to spreading inflammation and gangrene, such as those received in the dissecting-room, during post-mortem examinations, by butchers and fish-dealers from tainted meat and fish, and those resulting in that rapidly-extending gangrenous process known as "malignant œdema."

Second, **chemical poisons** alone—the bites of insects and reptiles.

Third, **microbic infection** alone—rabies, glanders, etc. This latter class differs so widely and materially in every respect from the first two as to deserve an entirely separate consideration. We shall accordingly group the first two under the one head of *Poisoned Wounds proper*, while the latter class we shall treat under the designation *Surgical Diseases due to Microbic Infection*. A number of these are usually derived from animals.

POISONED WOUNDS PROPER.

Dissection Wounds.—The term "dissection wounds" is applied to septic wounds of special virulence contracted in the dissection of dead bodies, both in

the dissecting-room and especially in post-mortem examinations. It is applicable also to a similar class of injuries sustained by surgeons in operating on the living; similar wounds occur also in butchers, fish-dealers, cooks, and other persons whose vocations may demand their handling putrefying animal material. Only a very small proportion of the pricks inflicted upon themselves by medical students and surgeons in dissecting the bodies of the dead or in operating upon the living are followed by any serious consequences. For the development of the more grave results it is necessary that there shall be some special virulence in the tissues or fluids by which the wound is inoculated, or that the individual who receives the wound should be in a condition of general constitutional depression, so that the natural resisting power of his tissues is greatly diminished. The worst cases occur when both these conditions happen to be combined. Experience has shown that the tissues of the recently dead are more frequently capable of communicating serious infection than those in which the process of decomposition is well advanced. The dissection of bodies in which death has been caused by virulent infective processes, as puerperal fever, erysipelas, or pyemia, is especially dangerous. Occasionally the wetting of the hands, on which there is no perceptible scratch or breach of surface, by the acrid fluids of a body dead of virulent infective disease may be attended with all the results for which the presence of a prick or scratch or abraded surface of some kind is usually necessary.

Symptoms.—The symptoms presented by a dissection wound may be those of any grade of septic infection, from that of slight local inflammation and suppuration to that of rapid, progressive gangrenous inflammation, with extreme general prostration from septic absorption, the development of pyemic foci in other parts of the body, and death. A not uncommon form is that in which the inflammation extends especially along the lymphatics, which appear as red lines, and produces marked swelling of the axillary glands.

Treatment.—The treatment of these wounds differs in no way from that which has been laid down for a septic wound in general. When an individual is conscious of the reception of the wound at the time, energetic local antiseptic treatment should be immediately instituted; thorough scrubbing and cleansing of the wound and the surrounding integument over a wide area should be made; the wound itself, if a puncture, should be enlarged sufficiently to permit of the certain introduction to its deepest point of the antiseptic to be used. The wound should then be thoroughly swabbed out with some such strong antiseptic agent as pure carbolic acid, solution of corrosive sublimate, 1 : 500, or solution of chloride of zinc, 8 per cent.; the part should be covered with an abundant dressing of absorbent material, which should be kept wet with a solution of corrosive sublimate, 1 : 2000, for three or four days; that is to say, until sufficient time has elapsed to demonstrate whether or not the disinfection of the wound has been successful. When this has been assured, any simple emollient protective dressing may be substituted until complete healing of the wound has taken place. When, through the neglect or inefficiency of primary antiseptic care, advancing phlegmonous inflammation or lymphatic irritation and glandular enlargement begin to develop, the surgeon should not wait until suppuration and sloughing of tissue have taken place before incising the inflamed and infiltrated regions, but should at once make sufficiently free incisions to open up thoroughly every infected district and to permit the free exit of the inflammatory secretions with which the tissues are infiltrated. The early resort to free incisions of this character will prevent much destruction of tissue and serious impairment of function, will relieve pain, and greatly abbreviate the course of the attack. Abundant antiseptic irrigations should be practised upon all the

tissue-spaces opened up by these incisions; the incisions themselves should be kept open by tents of iodoform gauze until all tendency to spreading inflammation has subsided and a healthy granulating process has developed. Meanwhile, the whole limb should be kept enveloped in wet bichloride dressings. Abscesses, whenever and wherever formed, should be opened as soon as possible and treated after the general manner already described. The constitutional treatment required will be conducted on general principles, and will include stimulants in large doses, opiates, and tonics.

Malignant Œdema, known also as *Gangrenous Emphysema* and *Gangrêne Foudroyante*, is a rapidly-spreading gangrenous inflammation in which the affected tissues become distended with the gaseous products of decomposition, due to infection by a special micro-organism. (Pl. III, Fig. 1). This micro-organism was identified by Koch in 1882, and is a rod-like bacillus, resembling in form and size that of anthrax, but somewhat smaller, with rounded ends. The bacilli are joined together in threads after a peculiar fashion. Unlike the anthrax bacillus, they have the property of spontaneous motion and of spore-formation in the living body; they grow only in the absence of oxygen; they only rarely enter the animal body with any activity; they abound in garden soil, and may be met with in any kind of soil or dust. The gangrenous and putrefactive phenomena which are marked features of the disease in question are said not to be primarily produced by the bacillus, but to be due to the admixture with it of the ordinary putrefactive forms. According to Park (*Mütter Lectures on Surgical Pathology*, 1890 and 1891), when a pure culture of these specific bacilli is injected there results an extensive hemorrhagic œdema of the subcutaneous cellular tissue, without any appearance of putrefactive action and quite free from gas-formation; but when an impure culture is injected or when garden earth is used for inoculation, the distinctive œdema of the previous instance becomes a mixture of emphysemic œdema and gangrene. These organisms must be planted subcutaneously in the areolar tissues in order to produce the typical results. Inoculations upon abrasions or open wounds are harmless, owing to the free access of the inhibiting oxygen of the atmosphere.

Symptoms.—The local symptoms of the disease are those of a rapidly-extending gangrene surrounded by an extensive ever-spreading area of swollen, livid tissue, infiltrated by foul-smelling, acrid secretion and the gaseous products of decomposition. The œdematous tissues emit a fine crepitus when pressed by the finger; the overlying cuticle is raised into blebs filled with reddish offensive serum; the sloughing tissues are bathed in a thin putrid fluid. The general state of the patient is one of great prostration and profound septicemia, accompanied by apathy and sometimes by delirium. Death supervenes usually within from one to two days; after death putrefaction goes on with great rapidity. Examination of the viscera shows them to be congested and œdematous and the subject of multiple hemorrhagic infarcts.

The **diagnosis** of malignant œdema is simple. The clinical picture which it presents is clear and not likely to be mistaken for anything else. The first symptom is hemorrhagic œdema of the subcutaneous cellular tissue, to which is added infection with ordinary putrefactive organisms; a rapidly-spreading gangrene results, with the addition of an emphysemic element to the previously existing œdema from the gases of putrefaction. This mixture of emphysemic œdema and gangrene is the pathognomonic clinical feature of the disease. Microscopic examination of the œdema fluid will show numerous bacilli of the disease. The **prognosis** is always grave; with rare exceptions the disease marches rapidly to a fatal termination.

Treatment.—The treatment must be heroic and radical from the moment

of the recognition of the disease. If a limb is attacked, immediate amputation should be done at a point well above the line to which the disease has extended. When amputation is not feasible, a radical excision of the affected tissues should be done, with the most thorough, continuous, subsequent antiseptic treatment. The general strength should be sustained by vigorous stimulation and by other tonic and supporting treatment.

BITES AND STINGS OF INSECTS AND REPTILES.

These are minute punctured wounds into which has been injected some poisonous secretion from distinct poison-glands or from modified salivary glands of the animal inflicting the bite.

Insect-bites and Stings.—In the case of insects the poison inoculated is acid in its nature; the results of its injection present every degree of variation in severity, from that of the simple local irritation produced by the minor and more common insects, such as the flea, the mosquito, bedbug, various forms of mites, etc., to the greater local reaction and considerable constitutional disturbance following the stings of the more aggressive and venomous hymenoptera, such as bees, wasps, hornets, and yellow-jackets, and the still more virulent and dangerous centipedes, spiders, tarantulæ, and scorpions. As a rule, the stings of even the most venomous of insects are unattended with danger to life, but where many have been inflicted or when the person is weak and feeble severe constitutional disturbance, marked by chills, fever, and great prostration, and even ultimate death, may result, the severity of the symptoms depending upon the amount of the poison which has been absorbed into the general circulation. The wounds inflicted even by spiders and scorpions of the largest size rarely prove fatal.

Treatment.—Alkaline local applications should be used, such as dilute aqua ammoniæ or solution of bicarbonate of sodium. Ordinary loam mixed with water to form a mud poultice is useful as an extemporaneous application. Local inflammatory disturbances must be treated upon general principles; constitutional symptoms must also be combated according to the special indications of the particular case.

Serpent-bites.—In the United States naturalists have discovered twenty-seven species of poisonous serpents and one poisonous lizard; eighteen species of these are true rattlesnakes; the remaining are divided between varieties of the moccasin or copperhead and of the viper. The poisonous lizard is the Texan reptile known as the "Gila monster." In all these serpents the poison fluid is secreted in a gland which lies against the side of the skull below and behind the eye, from which a duct leads to the base of a hollow tooth or fang, one on each side of the upper jaw; which fang, except in the case of the vipers, is movable and susceptible of erection and depression. When not in use, the fang hugs the upper jaw and is ensheathed in a fold of mucous membrane. In the vipers the fang is permanently erect. In the act of biting the contents of the poison-sac are forcibly ejected through the hollow fang. In India venomous snakes abound, of which the chief are the hooded cobra, the viper, and the bungarus. In Europe the most dreaded serpent is the common viper, while Africa, South America, and Australia and the islands of the Pacific are not wanting in many varieties of venomous serpents. The physical appearances of all serpent-venom are nearly alike: it is a viscid fluid, varying in color from a pale amber to a deep yellow, and containing in solution certain albuminoid principles which are the toxic elements, the nature of which has not yet been made out. According to the researches of Mitchell and

Reichert, venom induces rapid necrotic changes in living tissues with which it is brought in contact. It renders the blood incoagulable, disintegrates the red blood-corpuscles, and produces such a change in the capillary blood-vessels that their walls are unable to resist the normal blood-pressure, and wide and rapid blood-extravasation results. Profound depression of the respiratory nerve-centers is the most common cause of death from serpent-venom, although cardiac paralysis, hemorrhages into the medulla, and general disorganization of the red blood-corpuscles may likewise each be a sufficient cause of death.

Symptoms.—Much similarity characterizes the effects which follow bites of all varieties of poisonous serpents. The amount of the venom injected and the rapidity with which it enters the circulation govern the intensity and the rapidity of the symptoms produced. The local symptoms are pain—at first slight, but later becoming more severe—with rapid tumefaction and ecchymotic discoloration in the vicinity of the wound. Symptoms of cardiac and respiratory depression soon manifest themselves by feeble and fluttering pulse, faintness, cold perspirations, mental distress, nausea and vomiting, and labored respiration. In the more intense cases of poisoning death may result in a short time by the paralyzing effect of the venom upon the heart, but more frequently the struggle extends over a number of hours. When life is prolonged over forty-eight hours, the special symptoms of venom-poisoning give place to those which are due to the disintegrating effect of the venom upon the blood and the tissues; that is to say, a sapremia of intense form remains, which may prove fatal by exhaustion or may be slowly recovered from. When death takes place from the primary effects of the venom, it is ushered in by delirium and coma, with intensification of all the primary symptoms.

The post-mortem appearances are those which would follow the blood-changes and the visceral disturbances that have been described. In the neighborhood of the bite the tissues are infiltrated with hemorrhages and with the results of rapidly-extending gangrene, the right heart is engorged, the general blood-mass is fluid, and all the internal organs, especially the brain, spinal cord, and kidneys, are congested and present multiple ecchymoses.

Treatment.—When a bite by a venomous serpent has been received, instantaneous and energetic efforts must be made to prevent the entrance of the venom into the general circulation. When the bite has been upon any portion of a limb, a ligature should at once be thrown around the limb above the wound, and by twisting be drawn so tightly as absolutely to check the circulation of blood in the part. This ligature should be a broad one, so as to diminish later pressure-effects; then free excision of the wounded part should be done. When the bite is upon a part of the body other than a limb, immediate excision should be practised, and, when this is impracticable, vigorous suction of the wound should be made, which can be done without fear if no cracks or abrasions of the lips or mouth are present, for the poison is harmless when taken into the mouth. Should a hot iron be accessible, its vigorous and free application within the wound might safely replace excision or suction. When none of these procedures are practicable or have been only imperfectly applied, there remains the device of permitting the poison to be admitted into the general circulation in instalments by slackening the ligature a little at intervals, and then tightening it again, while constitutional treatment is being resorted to for the purpose of antidoting the poison thus slowly admitted into the circulation. Permanganate of potassium, in 1 per cent. aqueous solution, freely injected by means of a hypodermatic syringe into a serpent's bite, without especial regard to the amount used, is asserted by Lacerda of Rio Janeiro to

be an absolute antidote to serpent-venom, and whenever practicable should be given a trial. Hypodermatic injections of ammonia have also proved useful.

The constitutional treatment available in cases of serpent-bite is limited to the use of cardiac stimulants, especially alcohol, which is to be combined when possible with digitalis; both are to be given freely by the mouth and hypodermatically. The state of the pulse is to be taken as the guide to indicate when the proper amount of stimulation has been reached, it being remembered that alcohol does not act as an antidote to the poison, but simply sustains the vascular and nervous systems while the poison is being eliminated through the natural emunctories. The toxic sequelæ in cases that survive are to be treated upon general principles.

SURGICAL DISEASES DUE TO MICROBIC INFECTION.

As the result of bacteriological investigation, the number of surgical affections which have been demonstrated to be due to infection by a specific microbe has become quite considerable. The processes of suppuration and the general septic disturbances of infected wounds have already received full attention as respects their bacteriological relation. To these must be added a series of distinct surgical diseases in the causation of each of which a specific micro-organism has been demonstrated to be the active agent. This list includes the following diseases: *Anthrax*, *Rabies*, *Glanders*, *Actinomycosis*, *Erysipelas*, *Tetanus*, *Gonorrhea*, *Tuberculosis*, and *Leprosy*. Of these the last five are described elsewhere. The first four it seems proper to consider along with "Poisoned Wounds." They are usually derived from animals.

Rabies is generally admitted to belong to this class, and is accordingly included in the present study, although a satisfactory demonstration of its specific micro-organism has not yet been made.

There is much evidence to show that syphilis also should be included in this list, but the complete and indisputable evidences of its microbic origin are still wanting.

ANTHRAX,

Malignant Pustule, *Wool-sorter's Disease*, *Charbon*, or *Milzbrand*.—A disease caused by infection with a peculiar rod-like bacillus, and characterized by an acute inflammatory primary local lesion, with subsequent general infection of the fluids and tissues of the body, with tendency to rapidly fatal ending. The bacillus of anthrax is the largest of the pathogenic organisms, and was the first to be detected, having been identified as early as 1849 by Pollender in the blood of cattle suffering from the disease. The organism is a straight rod, from 5 to 10 micro-millimeters in length and 1 to 1.25 micro-millimeters in breadth; it is devoid of motion, and in the bodies of living animals multiplies exclusively by segmentation. Under certain conditions in dead nutrient media spore-production also occurs. The disease, according to Pasteur, is spread among animals by germinating spores, which, having become attached to plants and grass, are taken in with the food and develop the primary lesion in the mouth or in the walls of the intestines. The tenacity of life of these spores is very great.

Among animals the herbivora are especially susceptible to the disease, less so the omnivora, and least so the carnivora. The disease occurs in all latitudes and in any portion of the world. It is most widely spread in Russia and Siberia, and is particularly common in Hungary and in certain parts of France and Germany. The disease in man is always acquired from affected animals

or from the products of such animals. Any part or tissue of an animal dead from anthrax is capable of communicating the disease. In its dried state the bacillus is able to preserve its virulence for many years, and through any substance to which it may become attached the disease may be communicated; even the feet and probosces of flies which have alighted upon the diseased animal or upon the infected product may carry the disease, and earth-worms carry it from the buried animals to the grass above. Persons who work in industrial establishments where the products of diseased animals may be among the objects of their labor, as hides, horse-hair, and wool, are peculiarly subject to the disease; hence one of the names by which it has been known, Wool-sorter's disease.

Infection may occur equally from inoculation with the bacillus or with spores. When the skin is the site of the primary lesion, some minute scratch, abrasion, or insect-bite may suffice for the inoculation; the unbroken skin affords ample protection from the virus, but the spores when inhaled or swallowed may reach the circulation through a healthy mucous surface.

Symptoms and Course.—The attention of the surgeon is required only in those cases in which the primary lesion is external; cases in which the bacillus enters the organism through the gastro-intestinal canal or the respiratory passages fall under the domain of internal pathology, and for their description the student is referred to text-books on general medicine.

The character of the primary lesion when external infection has taken place depends upon the anatomical structure of the part affected. If it is dense and vascular, a circumscribed carbuncular inflammation develops—**anthrax carbuncle, malignant pustule**; if the infection is in the midst of loose connective tissue with comparatively scanty blood-supply, a diffused inflammatory infiltration manifests itself—**anthrax œdema.** In either case after infection a variable period of incubation intervenes before the manifestation of special symptoms. This period may be from a few hours to three days; in rare instances a longer period, even of ten to fourteen days, has occurred.

Anthrax Carbuncle.—A slight burning and itching at the point of infection, with the rapid development of a papule surmounted by a small vesicle, which, bursting, discloses a central eschar, are the first manifestations of the disease. The inflammatory infiltration at the base and circumference of this primary papule rapidly increases, with development of a ring of secondary vesicles around the margin of the primary eschar, and with gradual extension of the tissue-necrosis. In rare instances the progress of the disease becomes spontaneously limited at this point; a gradual subsidence of the swelling takes place; the slough becomes detached by suppurative inflammation, and the ulcer heals by granulation. More commonly, the œdema and infiltration continue to spread, the eschar extends, phlebitis and lymphangitis develop, and symptoms of general intoxication follow, terminating speedily in death.

Anthrax Œdema manifests itself by the appearance at the point of infection of a livid diffuse œdema which rapidly spreads in all directions; the swelling may become enormous in its extent and size, and at different points local gangrene of the skin and subcutaneous tissue may occur, preceded by the formation of blebs upon the surface, filled with bloody serum. In rare instances spontaneous recovery from this variety of anthrax takes place.

The local pain is slight, and, as long as the diseased process is limited, there is but little general elevation of temperature, the patient often continuing to be about and manifesting simply slight chills and mild fever. General infection is shown by well-marked rigors, high fever, with great weakness, delirium, feeble pulse, sweating, diarrhea, and acute pains in many portions of

the body. Cough, rapid respiration, and cyanosis indicate pulmonary disturbance. Collapse, often sudden in its development, closes the scene.

Pathology.—The tissue-changes which are discernible in cases of anthrax are dependent upon the multiplication and diffusion of the bacilli in the capillaries and lymphatics. The local changes of œdema and necrosis are due to the blocking up of the capillaries by the bacilli and to their irritating effect upon the capillary walls, which produces such abundant inflammatory exudation into the paravascular and connective-tissue spaces that acute ischemia results. When general infection has taken place, the capillaries in every part of the body teem with bacilli, which accumulate in largest numbers at points where the blood-current is slowest. In the most vascular organs, like the spleen, liver, and kidneys, the bacilli especially abound. They form thrombi in the capillaries and lymphatics, from which multiple and more or less extensive extravasations into all the tissues result, and transudations into the various serous cavities are produced.

Diagnosis.—The typical anthrax carbuncle is not likely to be confounded with any other affection. The early superficial depressed eschar, the tough slough closely attached to the surrounding tissues, the lack of sensitiveness of the swelling, the widely-extending infiltration, the absence of suppuration, and the general symptoms which attend its later course form a picture distinct from that which characterizes simple inflammatory carbuncle with its prominent center, its multiple soft, suppurating, sloughing foci, its local pain, and indolent inflammatory course. The multiple small carbuncles of glanders have little in common with the carbuncle of anthrax. Anthrax œdema at its outset may be confounded with acute phlegmonous inflammation or with malignant œdema. Phlegmonous inflammation is characterized by its tendency to suppuration, which at once distinguishes it from anthrax. In malignant œdema the necrosis is attended with rapid disintegration and liquefaction of the dead tissue, in marked contrast with the tough and adherent sloughs of anthrax.

In all cases of suspected anthrax microscopic examination of the fluids of the affected part should be made. The anthrax bacillus can be readily stained and identified under the microscope. Microscopic findings may be made still more positive by inoculation experiments.

Prognosis.—External anthrax which is allowed to take its own course, or in which the treatment is too long delayed, is very grave, but when an early diagnosis is made and energetic, rational treatment is at once instituted, the prognosis is usually favorable. When general infection of the system has occurred, the result is uniformly fatal. The prognosis of the œdematous variety is more grave than that of the carbuncular, in consequence of the greater liability to general infection which attends the former. In either case the fatal termination is due, probably, as indicated by the most recent researches of bacteriologists (Bollinger), to toxic ptomaïnes formed in the body by the bacilli as the products of their growth.

Treatment.—All treatment must be conducted upon antiseptic lines, and should be energetic, and instituted at the earliest possible moment. Excision of the infected area should, if possible, be done, the incisions being carried wide of the disease, through healthy tissue if possible; special care must be taken to prevent infection of the operative wound from the diseased mass that is excised. To guard against the results of possible infection, the exposed surface remaining after the excision should be thoroughly mopped over with a strong solution of carbolic acid, 1 : 10, or even with the pure acid, or of chloride of zinc, 1 : 8, or the actual cautery may be applied. The immediate application of the actual cautery at the seat of inoculation, whenever such an inocu-

lation is recognized as having taken place, will destroy the virus and prevent subsequent evil. When excision of the entire infected area is impracticable, multiple deep crucial incisions should be made into it, accompanied by injections of carbolic acid, 1 : 10, by means of a hypodermatic syringe, systematically administered so as to diffuse the carbolic solution throughout the entire extent of the base of the affected tissue and through the surrounding healthy tissue. The punctures should be made just outside the borders of infiltration, the needle passed to the center of the infected area, and the solution slowly expelled as the needle is withdrawn. The carbolic solution should be mopped freely into the cuts, and injections should also be made into the substance of the diseased mass, so as to thoroughly saturate it with the antiseptic, while at the same time an ice-bag should be kept applied upon its surface, and the whole part should be enveloped in compresses saturated with sublimate solution, 1 : 1000. The carbolic injections may be repeated every six hours until the disease is manifestly under control or until symptoms of carbolic-acid poisoning are developed. The treatment of the subsequent slough is to be conducted on general antiseptic principles.

The constitutional symptoms of prostration and threatening collapse are to be met by stimulant, tonic, and supporting measures.

HYDROPHOBIA (RABIES, LYSSA).

Hydrophobia in man is an infectious disease resulting from the inoculation of a specific virus from an animal suffering from rabies. After a variable period of incubation following the primary inoculation, the disease declares itself by certain spasmodic muscular phenomena, followed by great general prostration and ultimate rapidly-ascending paralysis, significant of lesions of the spinal cord, in which organ, especially the medulla oblongata, the effects of the virus are chiefly centered.

Etiology.—Hydrophobia in man is always the result of inoculations with the virus of a rabid animal, most frequently the dog (90 per cent.), less frequently cats, wolves, and foxes. There is no proof that even among animals there is any spontaneous development of rabies: among them, as in man, it is always caused by direct inoculation from an already rabid animal. There is reason to believe that the bite of an infected dog even during the period of incubation of the disease may produce hydrophobia in man (Bollinger). The lack of disposition to bite upon the part of a dog during this period, however, renders the danger of such an occurrence comparatively small. Instances are recorded where the disease has resulted from accidental wounds sustained during the post-mortem examination of rabid dogs and in laboratory experiments. Not all persons bitten by rabid animals develop hydrophobia. In the nature of the case it is impossible to secure reliable statistics on this point. In many cases, certainly, bites are inflicted by dogs supposed to be rabid, but that are in fact not so; in other cases bites have been inflicted by dogs really rabid in which the infecting saliva was wiped off by the clothing through which the teeth passed, and the wounds were thus preserved from infection. In yet other cases wounds that were really infected have been subjected to adequate immediate cauterization, and thus the later development of the disease prevented. There is, however, sufficient experience to warrant the general statement that about 12 to 14 per cent. of those who are bitten develop the disease (Roux), and of these all die. As regards immunity, no relation is traceable either to age or sex.

While the ordinary medium of infection is the saliva of a rabid animal, the

disease can also be produced by inoculation with other fluids and tissues of such an animal. All the conditions relating to the propagation, development, and course of the disease indicate that it is due to a specific micro-organism, which, by its multiplication within the body, finally causes the ultimate overwhelming symptoms of the disease. This micro-organism, however, has not as yet been satisfactorily demonstrated.

Pathology.—No well-defined, gross pathological changes attend hydrophobia. Microscopic examination of the medulla oblongata and the spinal cord shows irritative lesions, marked by an infiltration of the perivascular sheaths with leucocytes, which at points may be accumulated in considerable number. Hyperemia and moderate œdema of the brain and spinal cord and their membranes as a rule are present. The pharynx, fauces, and neighboring lymphatic glands are usually congested, as is also the mucous membrane of the stomach and intestinal canal; the lungs and kidneys present general diffused, congestive conditions, the whole condition indicating the presence in the circulating fluid of an intense irritant. The heart, spleen and liver are, as a rule, normal.

Symptoms.—*Stage of Incubation.*—A period varying greatly in length intervenes between the time of inoculation and the appearance of any constitutional disturbance. The average period of incubation is about six weeks; it is seldom less than fourteen days, and may be protracted to some months. There is credible evidence that in extremely rare cases this period has been prolonged to between one and two years. During this time the persons bitten feel well and present no symptoms whatever of the dormant disease; the local wound heals kindly. In the young the period of incubation averages less than in the old.

Premonitory Stage.—The outbreak of general symptoms is usually preceded by a brief period, generally not more than twenty-four hours, rarely extended to two or three days, during which ill-defined premonitory symptoms manifest themselves; some uneasiness or pain is felt in the region of the wound, the cicatrix of which may become congested and tender; in other cases all such local symptoms are absent. Symptoms of constitutional disturbance declare themselves with headache, loss of appetite, sleeplessness, and much mental depression and irritability, with tendency to aimless wandering about, accompanied by great anxiety and apprehension, especially if the patient recalls the fact that he has been bitten. A general hyperesthesia soon shows itself, as evinced by sensitiveness to currents of air and to light. The stage of the full development of the disease is now ushered in by noticeable spasms of the muscles of deglutition, causing a sense of tightness and choking about the pharynx, producing difficulty in speaking and in swallowing, and hence dread of fluids, although there is intense thirst. Examination of the pharynx will show that its mucous membrane is congested and that there is an abundant secretion of viscid saliva, which, since it cannot be swallowed, causes frequent hawking and spitting to get rid of it. Occasionally the precursory symptoms are absent, and the first manifestations of the disease are spasmodic contractions of the pharynx occurring while attempting to drink or precipitated by some mental agitation; at other times some oppression of breathing is first noticed, culminating in marked suffocative attacks from spasmodic contractions of the upper respiratory muscles, combined usually with the already described pharyngeal symptoms.

Stage of Excitement.—The disease has now fully declared itself. The spasms of the muscles of deglutition and respiration are more marked and more easily excited; swallowing becomes impossible; the mere suggestion of

it suffices to bring on spasm. Currents of air, an unexpected touch, the slightest source of agitation, will suffice to provoke the convulsion. The embarrassment of the breathing caused by the spasms of the respiratory muscles is often great, producing a sensation of impending suffocation; frequently the entire muscular system will share in the convulsive attacks. These successive muscular spasms are separated by periods of complete relaxation, there being no tonic spasms, as in tetanus.

The mental faculties remain for the most part unimpaired, though excitement, anxiety, and terror occupy the mind. Intervals during which hallucinations develop are common. The duration of the convulsive paroxysms is variable; they rarely continue longer than from one-half to three-quarters of an hour, and usually for a much shorter period. During the paroxysms the excitability and restlessness of the patient, combined with dyspnea and with hallucinations, may produce a condition similar to mania. In the intervals between the attacks the mind appears clear: these intervals are likewise of variable length, very brief at times, at others prolonged for several hours. In rare instances the convulsive paroxysms are completely absent, the patient complaining merely of great anxiety and difficulty in breathing. In exceptional cases the patient is able to swallow food during the entire course of the disease, although the act is accompanied by pain. As a rule, the taking of solid food is impossible, but in exceptional cases such food is swallowed without difficulty. The pulse at the beginning of the attack is normal in character, but, as the disease progresses, grows gradually weaker and quicker, until as death approaches it is no longer perceptible. The body-temperature is somewhat increased, ranging from 100° to 103° F., seldom rising as high as 105°. The urine is scanty, free from albumen, and frequently contains an appreciable amount of sugar.

This stage of excitement may prevail from thirty-six to seventy-two hours; during its course death may occur amid the convulsions from exhaustion or from asphyxia; more frequently there is a gradual transition to a state of comparative tranquillity—the last stage of the disease, the *stage of paralysis.* There is then a gradual remission of the severe symptoms; the reflex nervous excitability diminishes, resulting in freer respiration and the recovery of the ability to swallow, while the general debility and prostration rapidly increase. The convulsions become feebler and cease entirely. If life is sufficiently prolonged, a condition of rapidly-ascending paralysis supervenes, and symptoms of respiratory and cardiac failure develop, terminating in death. The duration of the final stage of hydrophobia is brief, being, as a rule, between two and eighteen hours.

Diagnosis.—Hydrophobia is to be distinguished from tetanus, from the effects of mental agitation and fear simulating hydrophobia (hydrophobia imaginaria, lyssophobia), and from certain forms of hysteria and epilepsy in which symptoms affecting the organs of deglutition are manifested analogous to those observed in genuine rabies. The positive history of a bite from a probably rabid animal, the prolonged period of incubation in hydrophobia, the fact that in this disease the spasms affect the muscles of deglutition, and not those of mastication, as in tetanus, and are not tonic in their character, and that the respiratory embarrassment is due to spasm of the laryngeal muscles, and not to those of the chest, will suffice to distinguish between these affections if any doubt should otherwise exist. The pseudo-hydrophobic symptoms which are sometimes manifested in the course of other affections of the nervous system are distinguished, as a rule, by the absence of the general reflex excitability which is a marked feature of genuine hydrophobia. The development of symptoms closely

simulating genuine hydrophobia, through the effects of fear and anxiety, in persons of highly excitable and imaginative temperament who have been bitten by animals which were not rabid, is well authenticated. Such cases may even proceed to a fatal termination, although, as a rule, under appropriate treatment recovery takes place; which fact is sufficient to demonstrate that the case was not one of true hydrophobia. Upon the result of an examination of all the circumstances that surround the case must depend the conclusion as to the real character of such an attack.

Prognosis.—The prognosis is absolutely hopeless in genuine hydrophobia when once the symptoms of the disease have declared themselves.

Treatment.—*Palliative treatment* is all that any case admits of, but the utmost importance attaches to prophylaxis. The patient should be kept in a dark and quiet room, and as absolutely free from every source of agitation as possible. Morphia should be administered hypodermatically in amounts sufficient to relieve pain. The severity of the spasmodic paroxysms should be mitigated by inhalations of chloroform. Thirst should be relieved as far as possible by rectal enemata.

Prophylaxis.—Every wound inflicted by a possibly rabid animal should be subjected as soon as possible either to free excision or to thorough cauterization. In any interval that must elapse until this can be done constriction should be applied upon the proximal side of the wound if possible. If the part bitten is one in which the knife can be used freely, excision is preferable, the cuts being made wide of the bitten part, the resultant wound being thoroughly disinfected and sutured or treated openly as its special conditions may require. If cauterization is more feasible, it should be done with the actual cautery if possible, which should be applied deeply and thoroughly. Of chemical caustics, caustic potash or fuming nitric acid is to be preferred.

Prophylactic inoculations with emulsions of the dried spinal cords of rabbits infected with hydrophobia, after the method of Pasteur, have certainly been proved to be of value in establishing absolute immunity against the strongest hydrophobic infection if the series of inoculations is completed a sufficient time before the actual development of constitutional symptoms. The earlier the inoculations are begun after the infection has been received, the greater the certainty of the immunity conferred by them. The practical application of the method depends upon the discovery that the virulence of such infected spinal cords may be reduced progressively from the highest degree to nothing, according to the length of time during which the cord is preserved in a dry and pure atmosphere, fourteen days' drying being sufficient to destroy all virulence. Injections are made, beginning with emulsions of the weakest virulence and passing gradually to the strongest. The duration of treatment varies slightly according to the severity of the bites. In bites about the head the incubation period is often very short; in such cases, therefore, promptness of action is especially necessary, and in order to save time the number of injections made during the earlier days of the treatment is increased.

Institutions for carrying on this method of treatment have been established in various parts of the world. The result of these inoculations, made at the institute of Pasteur during the five years 1886–1890, is, that of 7925 persons who had been bitten by animals either proven by experiment to have been suffering from rabies or recognized by veterinary surgeons as suffering from that disease, and who had then submitted to the inoculations, only 73 had died, a mortality of but 0.92 per cent. In view, therefore, of these results, and in view of the great danger of the possible development of hydrophobic symptoms in a person bitten by an animal suffering from rabies, and the utter hope-

lessness attending the progress of such an attack, it would be the part of wisdom in all cases of bites from presumably rabid animals to subject such patients to the Pasteur treatment if possible.

GLANDERS (FARCY; EQUINIA).

Glanders is a contagious, eruptive, ulcerative disease, primarily of horses and their congeners, asses and mules, caused by their infection with a specific micro-organism, the *bacillus mallei* (p. 9). It is capable of being transmitted to men, as well as to many of the lower animals, by inoculation. The special manifestations and course of the disease vary much, being dependent upon the location and character of the tissues first inoculated and the amount and virulence of the inoculating material.

The bacillus of glanders is a small rod, somewhat shorter and broader than the tubercle bacillus; it is either straight or slightly curved, rounded at its ends, and is usually found in pairs, the two lying parallel with each other and held together by a delicate pellicle. The existence of spores is in doubt. The bacilli may be killed by exposure for ten minutes to a temperature of 131° F. (55° C.). Carbolic acid in 5 per cent. solution destroys them in five minutes, and corrosive sublimate in 1 : 5000 solution in two minutes. Their tenacity of life under ordinary circumstances is great, so that virus that has been in the dried condition for many months may be effective.

Etiology.—Infection occurs usually through some abrasion or wound; the possibility, however, of infection through an unbroken skin by rubbing the virus into the hair-follicles has been demonstrated. Inoculation through an unbroken surface along the mucous lining of the nasal and respiratory passages, or the conjunctiva, is not rare through the lodgment thereon of particles of infected muco-pus deposited there by the snortings of infected animals. As a rule, diseased horses are the source of infection in the human subject; in rare instances the disease has been transmitted from man to man. But a small proportion of the persons who are exposed to infection develop the disease.

Pathological Anatomy.—The histological changes determined by the presence of the bacillus in the tissues consist of a low grade of inflammation, resulting in the formation of nodules of embryonal or granulation-tissue, which speedily break down into pus, forming more or less extensive abscesses, which, when they open upon free surfaces, degenerate into ill-conditioned phagedenic ulcers with undermined edges, surrounded by extensive areas of inflammation. Dissemination of this series of diseased processes may take place throughout all the organs and regions of the body by continuous extension, by transmission along lymphatic channels, and by emboli carried in the blood-stream. The lesions of glanders appear first in the skin and the subcutaneous cellular tissue, and upon the mucous membrane of the nares and respiratory passages. Post-mortem examinations show similar lesions in the lungs, many of the muscles, the larger joints, and the great viscera. The cartilages and bones are likewise involved, sometimes primarily, but more frequently secondarily through contiguity. The lesions of ordinary pyemia are superadded to the specific lesions of glanders as soon as the suppurative processes become at all general.

Symptoms.—The symptoms that follow infection with glanders may be rapid in their course, manifesting a high grade of malignancy, and terminating in death within two or three weeks, or they may be slower in their development and progress, extending over a period of many months; hence the classification which has been made into *Acute* and *Chronic Glanders*. When the

lesions are well marked and abundant in the skin, the special term **Farcy** has been applied, more particularly to the disease among horses.

After infection a stage of incubation of varying length elapses, usually of but a few days, but possibly prolonged to two or three weeks. Vague symptoms of general malaise usher in the special symptoms of the disease; an inflammatory nodule appears at the point of inoculation, attended with pain and an extending zone of inflammatory congestion, involving especially the lymphatic trunks; fever develops; the primary nodule suppurates and breaks down into an ill-conditioned phagedenic ulcer. If the primary lesion is in the mucous membrane of the nose, the progressive ulceration soon destroys the soft parts and attacks the bones, the neighboring tissues of the face, pharynx, and palate become involved, and the whole of the face and neck becomes swollen and inflamed. In the further course of the disease, without regard to the seat of the primary lesion, multiple nodules develop on different parts of the skin; these quickly suppurate and degenerate into offensive ulcers, or larger swellings and abscesses are formed which become converted into extensive and deeply-burrowing ulcers. These diffused skin lesions may appear within one or two days from the onset of the attack, or their appearance may be delayed some weeks. In the second or third week of the attack an outbreak occurs upon the mucous surfaces, primarily that of the nose if it has not been the seat of the original lesion. Other mucous surfaces—of the eye, mouth, fauces, respiratory and gastro-intestinal tracts—rapidly take on the same conditions. If the infection has been an internal one, the gastro-intestinal disturbance, the fever, and the general prostration may cause the case to simulate for a time typhoid fever. The due development of external manifestations suffices in time to correct the error. In cases running an acute course febrile exacerbations become marked. The emaciation and prostration increase, all the symptoms of profound septic infection develop, with delirium, terminating in stupor and final death in collapse. In some cases the fatal result is accelerated by the disturbances consequent upon bronchial and pulmonary conditions.

In those cases which pursue a *chronic course* the development of the lesions is more gradual and less generalized. The constitutional symptoms depend upon the number, size, and situation of the local lesions, and upon the amount of general septic infection which is present. Often, cases after pursuing a chronic course for a time take on an acute character and rapidly hasten to a fatal termination; in other cases death occurs from exhaustion and septicemia or from pulmonary and bronchial complications. Many chronic cases, however, ultimately display a gradual amelioration of all the symptoms; cicatrization of the ulcers and healing of the abscesses slowly take place, and eventual recovery is secured, more or less perfect, but the patient is always seriously crippled. The average duration of the chronic form is about four months.

Diagnosis.—The acute form in its earlier stages is liable to be confounded with acute suppurative lesions, and even, in some of its manifestations, with rheumatism and typhoid fever. Its later manifestations may be referred to pyemia, which usually complicates it, but when the local phenomena are once fully developed the diagnosis is free from uncertainty; the knowledge that a patient has had to do with horses will aid in forming a diagnosis. The chronic form is more likely to be confounded with syphilis or tuberculosis. Where doubt exists search should be made for the specific micro-organisms in the nodules or the discharges; their detection will render the diagnosis positive. Inoculation experiments on animals may also be resorted to.

Prognosis.—The acute form of glanders is always fatal. When it man-

ifests a tendency to run a chronic course the prognosis is relatively favorable, for about one-half such cases ultimately recover. As long as the lesions remain limited to regions accessible to direct surgical treatment hope may be entertained of securing a cure.

Treatment.—Prophylaxis is of the utmost importance. This consists simply in the immediate destruction of all animals affected or suspected; the burning of all substances soiled with the infecting discharges; and the utmost carefulness on the part of all persons having to do with infected animals to guard against the possibility of inoculation.

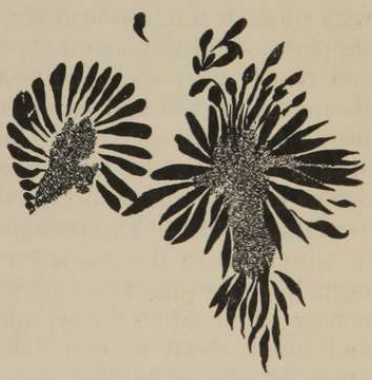
When a point of inoculation has occurred, immediate thorough disinfection and cauterization should be done. If nodules and abscesses develop, they should be at once thoroughly laid open, curetted, and disinfected. Chloride of zinc in solution, 1 : 8, is to be recommended for such disinfection. All surfaces that have been affected should be subjected to continuous antiseptic applications. The general treatment must consist of tonics, nutrients, and stimulants freely administered.

ACTINOMYCOSIS.

Actinomycosis is an infectious disease due to the presence in the tissues of a peculiar fungus, termed actinomyces (ray fungus), and characterized by the development of tumor-like masses at the points of infection, which readily undergo softening and suppuration, with continuous extension of the original process into adjacent tissue (Fig. 21).

Etiology.—The source from which the infecting fungus is derived has not been determined. The disease has as yet been found only among herbivorous and omnivorous animals, including man. The medium of infection is probably some article of food. The recognition of the disease as a specific one is of recent origin. Bollinger first, in 1877, described the relation of the fungus to certain swellings of the lower jaw in cattle. Its recognition in man is due to the labors of Israel and Ponfick, especially the latter, the results of whose researches were published in 1882. Since attention was called to it many cases, not a few of which have occurred in the United States, have been identified by different observers. The disease has heretofore been confounded with sarcoma, since the granulation-tissue which composes the greater mass of the tumors has the microscopical structure of the round-cell sarcoma. Section through the tumor, however, will show many soft, sulphur-yellow colored spots in strong contrast with the general reddish tissue of the growth. If the tumor has already fallen into suppuration, the pus will be found to contain numbers of sulphur-yellow miliary bodies; these are frequently united together in clusters, and have a soft consistence and an unctuous feel. By pressure these clusters are easily separated into smaller granules. These little granules, when viewed under the microscope, are found to consist of intertwined mycelia, the single threads of which have bulbous termini. In many cases a single filament will terminate in a mass of bulbs

FIG. 21.



Actinomyces.

branching in various directions. A frequent, and apparently the highest, type of development is when the granule is composed of a multitude of filaments radiating from a common center, their bulbous termini presenting upon the periphery. That this ray fungus is the specific cause of the disease has been established by cultivation and inoculation experiments.

Pathological Anatomy.—The primary effect of the lodgment of the fungus in the tissues is to excite a low grade of chronic inflammation, resulting in the accumulation of a mass of granulation-tissue, in the midst of which the fungus is imbedded. By the continued formation and accumulation of such masses swellings of considerable size result. The disease may remain stationary in this stage for an indefinite time, though, as a rule, degenerative processes begin early, the breaking down of the tumor resulting from a process of suppurative inflammation. The fungus is probably not itself pyogenic; the suppuration that occurs is due to secondary infection with pus-microbes.

Symptoms.—In cattle the disease occurs most frequently in the lower jaw, hence the name "lumpy jaw" by which it has been characterized; in man, likewise, the lower jaw is most frequently affected, and in a very large proportion of cases the disease has its site in some tissue adjacent to the mouth (of 73 cases reported by Moosbruegger, in 41 the jaws, mouth, throat, tongue, or œsophagus were involved; in 14, the respiratory tract; in 11, the intestines; in the remaining 7 the point of infection was not ascertained). Wherever the disease is, the symptoms are those of an ill-defined, slowly-increasing swelling. The lymphatics are not involved, and there are no glandular enlargements until secondary infection has occurred; suppuration sets in early when the growth is in regions most likely to be infected with pus-microbes. A chronic abscess is now inaugurated, and the local and constitutional symptoms which follow are due to the activity of the secondary infective process and the extent of the septic infection which results. Diffusion of the actinomyces, with the development of the disease in distant organs and parts of the body, may occur when the fungus or its spores have obtained entrance into the general circulation through an opening in a vein-wall which may have occurred during the process of ulceration: such general dissemination is of rare occurrence. In general, the disease remains localized, and extends steadily from the original point of infection into adjacent tissues, invading every tissue with which it comes in contact, irrespective of its anatomical structure. Before suppuration takes place the swelling is quite firm on pressure and free from pain and tenderness; the condition of suppurative inflammation, once established, favors the growth and extension of the specific disease by setting free and diffusing the actinomyces. The pus discharging from actinomycotic abscesses always contains the actinomyces, which can usually be detected by the naked eye as minute yellowish granules.

Diagnosis.—The presence of the specific fungus in the granulation-tissue or mingled with the pus is the one diagnostic feature of actinomycosis. It has been most frequently confounded with sarcoma; in some of its manifestations it may be mistaken for syphiloma or tuberculosis; sarcoma does not suppurate and break down as early as the actinomycotic granuloma. Tuberculosis is attended with glandular infection, actinomycosis, previous to secondary infection, not at all; in suspected syphiloma adequate specific treatment will suffice to establish its presence or absence within a few weeks. In any case, resort to the microscope should be made as early as possible, and the detection of the fungus will positively establish the diagnosis.

Prognosis.—The clinical course of actinomycosis is that of a malignant tumor. Without radical surgical treatment it tends to indefinite extension, and

ultimate death by exhaustion, sepsis, or pyemia. When the disease is early recognized and the affected part is susceptible of thorough extirpation, a cure may be obtained.

Treatment.—Absolute extirpation of all infected tissue should be done whenever practicable, the incisions being carried through sound tissue at some distance from the visibly infected part. If this is impracticable, the suppurating cavities and sinuses should be laid open freely and the surrounding infected tissue should be excised as far as possible; thorough curetting of the remaining diseased tissue should be done, followed by numerous injections of a strong carbolic solution (1:20) into the substance of the tumor that may still remain. Into any sinuses that have not been fully laid open tampons saturated with solution of chloride of zinc (1:8) should be packed, and the whole diseased surface that has been exposed should be dressed with similar tampons. The wound should be kept open and the curetting and cauterization repeated as often as any suspicious points show themselves. Recently-published experiences of veterinarians indicate that iodide of potassium given internally in full doses, pushed to the point of iodism, has a specific curative effect upon actinomycosis in a large proportion of cases in cattle. It should therefore be given a trial in cases in human beings.

CHAPTER XVII.

SYPHILIS.

SYPHILIS[1] is an infectious, contagious, and inoculable disease, transmissible also by heredity. It first manifests itself by an indurated or infecting chancre, followed by general lymphatic enlargement, afterward by eruptions of the skin, usually symmetrical and at first superficial, and by allied conditions of the mucous membranes, later by chronic inflammation and infiltration of the cellulo-vascular tissue and bones and periosteum, and finally by special productions in the form of small swellings, which may invade any tissue or organ of the body, but chiefly involve the connective tissue, and are known as gummata.

During all the acute symptoms, and for a period extending over several years, the patient has acquired an immunity against fresh infection. The disease is probably caused by the entrance of a specific microbe into the system, and although the final and conclusive evidence, consisting of the isolation, culture, propagation, and re-inoculation of the micro-organism, is still lacking, the clinical facts alone are sufficient, in the light of our present knowledge of the microbic diseases, to place syphilis in that class. Considered in this manner, as has been done by Finger, the various symptoms and stages of syphilis are to be explained as follows:

The general symptoms in the primary stage of syphilis—the languor, fever, malaise, pain, etc.—are due to intoxication by the ptomaïnes produced by the virus, as these symptoms are too ephemeral and changing to be ascribed to localizations of the virus. In the secondary stage the various eruptions on the skin and mucous membranes are caused by local deposits of the virus. Their virulence proves this; but a great many of the so-called secondary symptoms

[1] The histology and pathology of syphilis will doubtless before long have to be rewritten from the bacteriological standpoint. At present the observations of Cornil are the most accurate and reliable in our possession, and have been closely followed in this work. (See Cornil *On Syphilis*, American edition.)

are of intoxicative character, being due to tissue-products passing into the circulation, and causing a general, often severe, nutritive derangement. After the second stage comes a long stage of latency—for many a period of cure; for others, only an interval between the second and third stages. That the virus still exists in the body is shown in many cases by its hereditary transmission. The general health is not perfect. The immunity against fresh infection is the chief characteristic of the above latent period. We do not know how long it lasts, but its duration is certainly limited, in some cases at least, as the undoubted cases of re-infection show. The immunity, as mentioned, began even in the primary period. It is an immunity only against fresh virus. The first virus which caused the infection may still cause relapses.

The immunity in the primary stage is due to tissue-products of the virus in the circulation, the infected foci being still strictly localized. In support of this there is the undeniable fact that, under certain conditions, persons may acquire immunity against syphilis without passing through its stages. Hereditary syphilis teaches us this. The specific products of syphilis have been taken into account in explaining the following two kinds of immunity from syphilis: 1. Colles's immunity; 2. Profeta's immunity. By Colles's immunity is meant that which is shown by those healthy mothers who, owing to syphilis in the father, have borne syphilitic children, but have themselves apparently escaped infection. This immunity has been proved in thousands of cases, and there is no longer any doubt that it may exist. Caspary and Neumann even inoculated without result, and Finger has done so three times. The immunity in such cases is due to the tissue-products of the syphilitic virus which have passed from the fœtus, by diffusion, into the maternal circulation, causing immunity from syphilis without the symptoms of syphilis. It is true exceptions are published, but they are few and uncertain. Profeta's immunity ("*la loi de Profeta*," Fournier) is the immunity of the children of syphilitic parents, either or both being syphilitic. The children in many such cases are born healthy and remain healthy, but some of them are proof against the contagion of syphilis just as if they had had the disease. This immunity also is due to tissue-products of the virus passing into the fœtal blood, and not to the entrance of the virus itself.

In fact, all immunity from syphilis (and the same holds with all other infectious diseases) is due to the "tissue-products" of its organized virus passing into the circulation; for (1) this immunity occurs even in the primary period; (2) it outlasts the period of activity, and even that of the presence of the virus in the body; (3) it can be transferred independently of the virus itself. How this immunity is to be explained essentially is, however, still an open question. Tertiary symptoms are not due to the syphilitic virus *per se*, but to its tissue-products. A moderate amount of tissue-products of the virus (or only slight virulence or greater resistance of the body) causes simple immunity; an increased amount or greater virulence of morbid products of the virus causes tertiary syphilis. It has frequently been asserted that there is no relation between the various stages of syphilis, as there is none between the character of the syphilis of the person who supplies the poison and that of the one who receives the infection. Certain cases, however, will be grave or "malignant" from the earliest period, and the dosage of virus or a feeble power of resistance in normal cells may well be factors in determining this gravity. The definition given above includes all the periods of the disease, which are as follows:

First. **Period of primary incubation**, or that intervening between the exposure to contagion and the appearance of the chancre, on an average about three weeks.

Second. **Period of primary symptoms** (chancre and adenitis).

Third. **Period of secondary incubation,** or that between the appearance of the chancre and the development of secondary symptoms, on an average about six weeks.

Fourth. **Period of secondary symptoms** (syphilides of the skin and mucous membranes, mucous patches, roseola, papules, pustules, etc.). This period may last from one to three years.

Fifth. **Intermediate period,** during which there may be no symptoms, or irregular, slight, and less-symmetrical and less-generalized manifestations. The patient is protected as regards fresh contagion, but if he begets children they are likely to suffer. This period is very variable, lasting from two to four years and ending in complete recovery or in

Sixth. **Period of tertiary symptoms** (tuberculo-ulcerous syphilides, periostitis, osteitis, gummata, etc.). The duration of this period is unlimited.

This separation of syphilis into periods is, to a certain extent, artificial, but it corresponds, however, to the course of most cases, and is desirable for purposes of dogmatic description.

In considering the **methods of transmission** of syphilis, it must never be forgotten that it is not necessarily a venereal disease. While it most frequently has its origin in sexual connection, yet it quite often occurs from the contact of the buccal mucous membrane of a nursing child with the nipple of its nurse, or *vice versâ*, or by the common use of the same drinking-glasses, etc., or midwives and physicians may be infected in practising the vaginal touch. It is the secretion from a chancre or mucous patch which most frequently determines the disease: the result is always an infecting chancre. The theory of the transmission of syphilis from *all* the lesions of venereal disease—*i. e.* the doctrine of the identity of gonorrhea and chancres—prevailed without opposition during several centuries. At the present time it is entirely abandoned.

When a person is exposed to impure connection, the lesions do not immediately intervene; there occurs a period of from two to four weeks, an average of twenty-one to twenty-five days, before any symptoms appear, and sometimes a longer time elapses—six weeks or two months.

This period of incubation, which precedes the appearance of the indurated chancre, is known as the **period of primary incubation.** Whenever an inoculation, whether intentional (as in some unjustifiable experiments which have been made) or accidental, with the secretion or pus of a secondary lesion or with the blood, is successful, it produces a chancre, preceded by this long period of incubation, and the symptoms of syphilis are then developed in their regular evolution and successively appear. Mucous patches and moist papules not only have the power of causing a chancre and syphilis by contact, but are probably the most frequent source of its transmission. Syphilis transmitted by a syphilitic nursing infant suffering with mucous patches of the lips is seen as a chancre upon the nipple of the nurse, provided the latter is not its mother and has never had syphilis. Again, syphilitic papules of the nipples of a syphilitic nurse occasion a chancre upon the lip of a healthy infant.

Secondary lesions of syphilis may extend over a long time. Syphilis may thus be communicated by a syphilitic person for several years after the beginning of the disease. In marrying during this period there is danger of communicating the disease to the wife and of having syphilitic children.

There has been, as far as we know, not one trustworthy case of the transmission of syphilis by means of any of the normal secretions, even where the most careful and persistent attempts at inoculation have been made. Thus there are no reliable cases of syphilitic contagion by the spermatic fluid or of inoc-

ulation by this liquid. The tears and saliva obtained from syphilitic persons have been inoculated upon healthy persons without producing the disease.

As the blood itself is undoubtedly contagious and inoculable, while the fluids of the various secretions do not possess these properties, it is very probable that the passage of the serum of the blood through the glandular membranes and cells arrests the contagious particles and renders the secreted fluids harmless. Whatever may be the lesion or fluid or organism determining the transmission of syphilis, it appears that except in cases of hereditary syphilis the result is always the same, an infecting chancre, preceded by a period of incubation.

SECTION I.—PRIMARY SYPHILIS.

The Chancre.—We are not in possession of absolutely conclusive evidence as to whether or not the virus of syphilis remains localized during the period of primary incubation, but it is probable that when inserted under the skin it remains there a certain length of time without any other action than gradually to prepare the cells which are in immediate relation with it for the hyperplasia which soon constitutes the chancre.

The chancre always appears at the point of inoculation. If we suppose that the syphilitic poison is from the first carried everywhere in the economy, it is difficult to understand why there is not, during one or two months, any other lesion elsewhere than at the point of entrance. The primary lesion is invariably met with at the point inoculated, never elsewhere; and secondarily, a neighboring gland is swollen after the appearance of the chancre, then several glands; such glands, as we know from our study of other diseases, arrest for some time the diffusion or generalization of morbid products and tumors.

This conception of the localization of the virus at the beginning of the contamination is very important in a practical point of view. It would indicate that the destruction of the chancre at the moment of its appearance would prevent syphilis. While there is great difference of opinion among syphilographers upon this point, the weight of authority is against the probability of the abortion of syphilis by excising or otherwise destroying the chancre. Most authorities are agreed, however, that cauterization or excision of an abraded or absorbing surface soon after exposure, and *before* the development of the chancre, is strongly indicated, and has probably in several cases prevented constitutional infection.

The infecting chancre has a period of incubation varying from ten days to six weeks, the average being about three weeks.

It is an excellent general rule for prognosis in cases of suspicious ulcers upon the genitals to assume that if an interval of ten days or more has elapsed between the last exposure to contagion and the development of the sore, the latter is probably the initial lesion of syphilis.

It begins sometimes by a superficial papule, which generally extends in circumference and depth; sometimes by an excoriation or a superficial fissure, often very slight. As it spreads upon the skin there are seen accompanying redness and desquamation of the epidermis; upon the mucous membranes a superficial abrasion or an ulceration covered by a grayish or yellowish false membrane; there is also observed an induration, sometimes giving the sensation of a hard nodule, fibrous or cartilaginous; at other times, that of a thin plate like parchment or paper. There may be no absolute loss of epidermis over the surface of a chancre, but merely a gradual thinning of the epidermic layers from the margins of the sore toward its center. Ulceration, when it exists, is a simple cup-shaped depression; its surface is smooth and the margins are not

abrupt. At the center of the chancre there is found a false membrane, beneath which is a raw vascular layer, bleeding readily.

Section of a chancre shows, in addition to the usual lesions of cutaneous inflammation, a special and characteristic change—a sclerosis or thickening of the coats of the venules and arterioles, affecting chiefly the tunica adventitia. This thickening of the arterioles and venules is very important. In connection with the preservation of the firm trabeculæ of the derm and of most of the fasciculi of the connective tissue and of the elastic tissue, it gives to the infecting chancre its most essential clinical character—**the induration.**

The induration may be either superficial or deep, depending upon the arrangement of the vessels, which form on the skin two horizontal networks—one beneath the papillæ, the other deeper at the base of the derm. When the former is affected we have a superficial induration. If the sclerosis has involved at the same time both sets of vessels, the intermediate branches being equally affected, we have a more extensive nodule, varying in thickness according to the region of the skin involved.

In the first case the induration is foliaceous or parchment-like; in the second it is woody and gives the sensation of cartilage. Almost always the sclerosis is continued along the coats of the vessels farther than the induration itself. These lesions do not develop very rapidly; which fact, taken in connection with the changes of the tissues involved, explains the long duration of a chancre and the persistence of the indurated nodule.

The induration of a chancre usually occurs at the end of the first week, dating from its appearance; it may not show itself until much later. The induration is progressively developed from the surface—that is, from the papillary network—to the deep cutaneous and subcutaneous layers.

The variations in thickness of the affected part give rise to different degrees of induration. *Laminated* induration is thinner and less distinct than the parchment variety, and gives to the fingers the sensation of a piece of paper. *Parchment* induration is that which gives to the fingers applied to the circumference of the chancre the sensation of a piece of parchment forming the base of the erosion. *Nodular* induration is that in which the base of the chancre is hard and thick, feeling between the fingers like a nodule of cartilage or wood; it is the most characteristic. *Annular* induration is that in which only the margins of the chancre are indurated and form a hard ring, the tissue in the center retaining its normal elasticity.

The most readily recognized and the most characteristic chancre has the shape of a cup-like depression seated upon the indurated and elevated skin.

The histological relations of the connective tissue and vessels beneath the chancre will explain the anatomical reasons for these several forms of induration. The laminated or parchment induration corresponds to a sclerosis limited to the papillæ of the derm and to the vascular network of the papillæ; deeper or nodular induration corresponds to a sclerosis of the cutaneous and subcutaneous connective tissue and of the vascular network of these parts, which latter is much larger than the superficial network, and is therefore slower in forming and in disappearing than a similar lesion of small vessels.

Traces of induration have been observed four or five years after the beginning of the chancre. Ricord has found remains of the induration ten and fifteen years subsequent to the primary lesion.

The induration and its extent are best appreciated by seizing the chancre at its margin between the thumb and finger, drawing it upward, so that it may move upon the subcutaneous tissue, and then using slight pressure in a direction parallel to the surface of the chancre.

The degree of induration varies very much according to the seat or region of the primary lesion. When occurring upon the glans penis, upon the mucous membrane of the prepuce, or in the fossa glandis, the chancre is generally very distinctly indurated; upon the skin of the penis and the general integuments the induration is not so marked or extensive. In women the induration of the chancre is greater upon the labia majora than upon the labia minora and fourchette.

The induration of an infecting chancre is not only variable, but, in rare cases, it may be absent. Therefore it is not positive and constant, and Cornil believes that induration is a symptom less important in infecting chancre than the characters of the erosion and the condition of the surface of the chancre, especially if, in addition to these, we take cognizance of the several indurated, movable, painless, and hypertrophied lymphatic glands, which never suppurate unless the chancre has been irritated by caustic or other applications followed by infection with pyogenic microbes.

The induration generally does not remain at its height longer than three or four weeks, and the chancre heals entirely in five or six weeks; but the indurated nodule, if it were primarily large and cartilaginous, may persist and be still recognizable for years.

According to Fournier, three times in four the indurated chancre is single. Multiple infecting chancres all begin at the same time, for the primary lesion of syphilis is not, as a rule, auto-inoculable, and therefore it has no tendency to be reproduced alongside of the primary sore, as is the case with chancroid.

The **appearance** of infecting chancre is varied. Between an erosion or slight abrasion situated upon a parchment-like base that may be readily overlooked, and an ulceration with a nodular cartilaginous base of considerable size, even an inch in diameter, there are found several intermediate degrees.

The **most frequent seat** of chancres is the genital region; they are very seldom met with upon other parts of the body; this is especially true with men, less so in the case of women.

The usual seat of chancres of the genital organs with men is the glans penis, the internal surface of the prepuce, and especially the fossa glandis and frenum. Three-fourths of all chancres are found in these localities. At times they are found upon the skin of the penis, at the meatus urinarius, upon the scrotum, in the urethra, or upon the groin.

In women the labia majora are the most common seat of genital chancres; then follow the fourchette, the labia minora, the clitoris, the skin of the pubes or groin, the neck of the uterus, etc.

It is doubtful if an infecting chancre has in a single instance been found upon the vagina, and yet this canal is certainly the part most exposed to contagion. This immunity may possibly be due to the structure of the vaginal mucous membrane, which is covered with thick layers of pavement epithelial cells, and to the absence of glandular orifices over its entire surface; the vaginal mucous membrane possessing papillæ and prominent villi, but no glands.

Extra-genital chancres, particularly those of the anus, are very much more common in women than in men, yet all chancres of the anus in women do not indicate unnatural sexual relations: the anal orifice is so situated that in dorsal decubitis the fluids from the vulva flow over and often contaminate it.

Anal chancres are usually situated at the margin of the anus, at the bottom of one of the radiating folds of skin produced by the contraction of the external sphincter. The ulceration is apt to follow the lines of these folds, and thus to assume an elongated or linear character. They are hard, and do not give rise to the painful symptoms of fissures of the anus. They have been observed as high as the upper margin of the internal sphincter.

The seats of extra-genital chancres are the anus, mouth, lips, tongue, uvula, palatine arches, tonsils, cheek, nipple, etc. A cephalic chancre is almost always infecting. Chancroid is scarcely ever seen upon the lips or face.

The **diagnosis of chancre** is a matter of such great practical importance that it may be well, even at the risk of repetition, to enter into it somewhat fully:[1]

1. In dealing with lesions *apparently non-venereal* in their origin and character we should consider carefully the following points:

(*a*) The *anatomical situation* and the *course* of the lesion. Among those particularly to be viewed with suspicion may be mentioned herpetiform erosions of the lips, papules on the tip of the tongue, squamous or "scabby" ulcerations of the skin, scratches which obstinately refuse to heal, chronic inflammations at the tip of the fingers resembling felons, etc.

(*b*) *Indolence, absence of suppurative tendencies, and persistence in spite of treatment* are negative signs which should lead us to believe that any cutaneous or mucous lesion is not of a simple nature.

(*c*) *If the morbid products are slight*, rather serous than purulent, tend to form into crusts or to assume a pseudo-membranous form upon an eroded surface, syphilis should be suspected.

(*d*) The *consistence of the base* upon which the lesion is situated is one of the most important diagnostic points, and should always be carefully investigated. If, upon palpation, instead of the usual inflammatory swelling and thickening, shading off into the surrounding tissue, we meet with a cartilaginous, elastic, sharply-circumscribed resistance, we may immediately suspect very strongly that we are dealing with a syphilitic lesion, although even this symptom cannot be considered as infallible.

(*e*) If the *lymphatics of the groin* become slightly swollen and painful and progress no farther, or if these symptoms occurring in a single gland subside spontaneously, it is probable that they are due to a sympathetic adenitis, such as follows many irritations of the skin or mucous membrane. If, on the contrary, they steadily augment in size and hardness, are almost painless, and constitute a chain of little tumors including several or all the inguinal glands, it may be considered strong presumptive evidence of specific disease, though even yet not conclusive.

In addition to these points the history of the case must carefully be inquired into—the probabilities of infection, in regard to which we should not be misled by the beliefs of the patient—and the period of incubation, which, when it can be clearly established, is of great value.

Confrontation—i. e. examination of the person from whom the disease has probably been contracted—will often, not invariably, decide the matter, but, in this country at least, is rarely obtainable.

Difficulties of diagnosis are greatest during the first week or ten days, and steadily diminish with the age of the lesion, which, if syphilitic, is almost certain to assume in time a definite character. The chief points among those mentioned are the period of incubation, the presence or absence of induration, and the condition of the nearest lymphatic glands. If, however, all of these seem to point to syphilis, the experienced observer will still refrain from giving a positive opinion, no symptom or group of symptoms being absolutely conclusive as to the specific character of any primary lesion; certainty only being attained by the development of some of those general or constitutional phenomena which in from six to eight weeks follow the infecting chancre.

[1] In doing so we shall follow closely the paper of Ch. Mauriac, which is the best résumé of this subject with which we are acquainted.

2. The *region occupied* by a chancre may cause errors or difficulties in diagnosis.

(*a*) In the *cephalic region* chancres of the *hairy scalp*, of the supraorbital prominences, and of the chin and cheeks are the most deceptive. They always assume an ecthymatous form, and are so concealed by the hair that it is impossible to judge of the character of their surface. In all such cases the hair must be carefully shaved, and if we then find that we are dealing with an ulceration lacking the ordinary characteristics of ecthyma, and glazed, flat, or even elevated, our suspicions should be aroused, and after eight or ten days will usually be confirmed, if the sore is syphilitic, by the development of induration and of neighboring lymphatic enlargement.

Razor-cuts on the chin, cheeks, or lips which, after having healed, reopen and become covered with a crust, should on *a priori* grounds be suspected. This is equally true of pseudo-furuncles, acneiform pustules, cracks around the circumference of the nostrils, etc., which persist without giving rise to pain, and become bloody, encrusted, and surrounded by an area of subinflammatory, œdematous swelling. We should then carefully examine the preauricular, parotidean, and submaxillary lymphatic glands.

A *stye* which behaves in an unaccustomed manner or is accompanied by hyperplasia of the lid, or a conjunctivitis which becomes localized and causes an isolated swelling, should be attentively watched.

In the *neighborhood of the mouth* errors of diagnosis should be less frequent than in other portions of the cephalic region, because it has been shown so often that the lips, tongue, and fauces are frequently brought into contact with syphilitic discharges and constitute one of the principal channels of infection. Here, however, as elsewhere, the chancre assumes at the very outset the appearance of ordinary lesions. Thus, upon the lips the chap, crack, or fissure often found in the median line, the little aphthous erosions, herpetic ulcerations, and cigar or cigarette burns, simulate very closely the characters of the initial lesion, and, as the latter will almost invariably be attributed by patients to some such ordinary cause, may give rise to serious error.

At the end of the first week, however, the specific characters of labial chancre are usually so distinct as to render diagnosis easy.

In several instances these chancres have been mistaken for epithelioma, and have been excised. The diagnostic differences may be indicated as follows:

Labial Chancre.	Epithelioma.
No marked difference between the sexes.	Twenty times more common in males than in females.
The ulcer may involve either lip.	Almost invariably situated upon the lower lip.
Occurs at any age.	Rarely occurs before middle life.
Patient often strong and robust.	Patient usually in impaired health.
Is insensitive.	Often sharp, burning, lancinating pains.
Regular in outline, smooth surface, elevated.	Irregular in outline, ragged, filled with fungous granulations, bleeding easily.
Indurated and sharply circumscribed base.	Induration less cartilaginous, unequal, not clearly circumscribed, and more extensive.
Evolution of sore usually occupies a few weeks at the most.	Sore may be months in developing after its first appearance.
Glandular involvement follows closely on appearance of sore.	Glands are not implicated for three or four months, often not until later.
No marked odor from secretion of sore.	Odor often extremely offensive.
History of exposure to syphilitic inoculation often obtainable.	Frequently no such history.
Heals rapidly or disappears under mercurial treatment.	Not affected or rendered worse by such treatment.

While there is a possibility of error in diagnosis between a chancre and an epitheliomatous ulcer when a macroscopical examination alone is made, there is, on the contrary, no such apprehension when a microscopical examination of the lesions is instituted. The histological structure and arrangement are so very distinct and unlike in these lesions that a mistake cannot well occur. In the epithelioma we have the ingrowing of the interpapillary layers of epithelial cells, the branching or budding outgrowths from the sebaceous glands which constitute the very characteristic epitheliomatous pegs, and the formation of the cell-nests or pearls upon these pegs, which are all so strikingly different, when contrasted with the histological structure of a chancre, that no doubt as to diagnosis remains.

Upon the *sides of the tongue* ulcerations, produced by the continual contact of that organ with rough and carious teeth, have been mistaken for chancres. This error should be guarded against, but is not so serious in its results as the failure to recognize the specific lesion when it is situated at the point of the tongue, the possibility of its communication to innocent people being, in such cases, an element of unusual importance.[1] In the first five or six days it is impossible to diagnosticate it, but if the original little inflamed papule enlarges and extends, becoming elevated above the surrounding parts; if its epithelial covering drops off and its surface becomes diphtheritic; if superficial cauterization with crayons of nitrate of silver, which so rapidly cure the common small painful papule of the tongue, have no effect upon it,—there is a strong presumption that it is chancre. This will be confirmed later by the appearance of submaxillary glandular enlargement and induration of the sore.

Of all the chancres of the cephalic region, however, that of the *tonsils* or of the *isthmus of the fauces* presents the greatest diagnostic difficulties, on account of the effacement of its characteristics by the surrounding inflammation. If in a case of prolonged sore throat there be an appearance resembling a single mucous patch, and there be no history of antecedent syphilitic poisoning, it becomes probable that the trouble is chancrous; and this probability is greatly increased if any induration can be felt by palpation with one finger in the pharynx and another external to its walls; if enlargement of the glands above the angle of the jaw occurs; or, of course, if the patient confesses to having been peculiarly exposed to contamination.

The sore is much more common in this region in females than in males, Mackenzie noting the fact that out of 7 cases of primary syphilis of the tonsils which he had met with, 6 were women.

(*b*) *Superior and Inferior Extremities.*—Chancres of the *hands* are often seated at the margin of the nail and closely resemble simple whitlows. They may be diagnosed by their long duration, their abrupt limitation, the hardness of the tissues around and beneath them, and the consecutive engorgement of the epitrochlear ganglion. Upon the dorsal face of the phalanges the initial lesion at first simulates an inflamed papule or boil, but is less painful, discharges no "core," and is elevated, not excavated.

The anterior face of the *forearm* in both sexes, the anterior surface of the *thigh* in men and the posterior surface in women, are the parts most exposed to contagion.

The chancre of *vaccino-syphilis* occurs after the evolution of the vaccine sore. It can only be confounded with the ulcerations described by Blot under the name of "vaccinal phagedenism," which are rounded with abrupt borders and indurated bases, and are often accompanied with engorgement of the axil-

[1] The same remark applies to mucous patches of the tongue and lips with even more force, as they are so much more frequent than primary sores.

lary lymphatic glands. The diagnosis from appearances is difficult, but may be made by noticing the fact that these sores run an acute course, and are readily cured by poultices or emollient applications, which, of course, have no effect on chancre.

(*c*) Upon the *trunk* the *mammary* and *hypogastric* regions are those most frequently involved. In the former locality the initial lesion is most likely to be mistaken for eczematous excoriations, fissures, and small furuncular or papillary tumors. The diagnosis rests upon the presence of the characteristic induration, elevation, etc., and upon the polyganglionic axillary enlargement. In cases where syphilis has been transmitted during suckling confrontation is almost invariably possible and furnishes the most satisfactory guide.

Chancres of the hypogastrium are generally large and ulcerating, and are most liable to be mistaken for chancroids.

(*d*) *Genital Organs.*—The diagnosis of sores situated in this locality is chiefly between chancre, chancroid, and herpetic ulceration. The diagnostic table given below expresses the main points of difference.

Chancre.	Chancroid.	Herpetic Ulceration.
Origin:		
Due to contagion from a chancre, a syphilitic lesion, or blood or pus from a person having syphilis.	Usually due to contact with pus from a similar sore, or to accidental inoculation of the secretion of a chancroid upon a person already affected with syphilis; often to the irritation of pus from other sources.	Mechanical irritation; friction, as in sexual intercourse; chemical irritation, as of acrid discharges; uncleanliness. Occasionally follows cold or fever; may be a neurosis.
Incubation:		
Not less than ten days; often three weeks; very rarely six to eight weeks.	None.	None.
Situation:		
Most frequent upon the genitals. Often seen on the hands, nipples, lips, etc.	Almost always upon the glans penis or prepuce; rare upon other portions of the genitals; scarcely ever seen elsewhere.	Glans penis and inner layer of prepuce.
Commencement:		
Begins as an erosion, papule, tubercle, or ulcer. May remain without ulceration through its entire course.	Begins as a pustule or ulcer.	Begins as a group of vesicles, which may coalesce or may ulcerate singly.
Number:		
Single or simultaneously multiple; occasionally, but rarely, successively multiple.	Often multiple, frequently by auto-inoculation.	Multiple; apt to be confluent.
Shape:		
Round, oval, or symmetrically irregular.	Round, oval, or unsymmetrically irregular, with border described by segments of large circles.	Irregular; edges serrated or described by segments of small circles.
Depth:		
Usually superficial — cup-shaped or saucer-shaped —or may be elevated.	Hollow, excavated, or "punched out."	Superficial.
Surface:		
Smooth, shining, red, glazed; diphtheritic membrane or scab.	Rough, uneven, "worm-eaten," warty, whitish-grayish, pultaceous.	Same as local ulcer, but more superficial.

Secretion: Scanty, serous, auto-inoculable with great difficulty, producing either a chancroidal sore or, in rare cases, a second sore like the first.	Abundant, purulent; readily auto-inoculated	Moderate secretion; auto-inoculated with difficulty.
Induration: Almost always present; firm, cartilaginous, or parchment-like; circumscribed, terminating abruptly; movable upon subjacent parts; skin not adherent; usually persistent: disappears under specific treatment.	Only exceptionally present; may be caused by caustics or other irritants, or by simple inflammation; boggy, inelastic, shades off into surrounding parts, to which it is adherent; disappears soon after cicatrization.	Same as local ulcer.
Sensibility: Very little or no pain.	Painful.	Painful.
Course: Usually regularly progressive toward health, the sore often healing spontaneously. Phagedena uncommon. Second attack also very rare.	Irregular; may cicatrize rapidly or may extend, taking on phagedenic action. No protection against a second attack.	May spread, in exceptional cases, by the appearance of successive crops of vesicles. Usually heals promptly under mild local treatment. Likely to recur, especially in uncleanly patients with long foreskins.
Histology: A new cell-growth. Very little destruction of tissue.	An ulceration, with more or less loss of substance.	Originally an elevation of the epidermis in spots by an effusion of serum.
Bubo: Constant, painless, multiple.	In one-third of the cases; painful, inflammatory, single.	Rare. When it does occur, painful, single, inflammatory.
Prognosis: Good locally; constitutional syphilis will follow in the great majority of cases, but in a few may not appear or may be prevented by treatment.	More serious, locally, on account of loss of tissue; occasional refusal to heal, and possibility of phagedena. *Very* rarely is followed by syphilis.	Always good if the diagnosis be absolute. Should be guarded when there is the least doubt as to the herpetic character of the affection.
Treatment: Excision when seen early; other local treatment of minor importance.	Local treatment curative.	Local treatment curative.

Chancres of the meatus are more often syphilitic than simple in their character. In the former case they are attended with little or no ulceration, are confined to one lip of the meatus, are accompanied by the usual induration and glandular involvement, and are often, indeed usually, not discovered by the patient, who imagines he has a gonorrhea. Chancroid of the meatus is irregular in shape, ulcerated, involves both lips, is painful, and does not have the characteristic induration.

The diagnosis between infecting urethral chancre and gonorrhea may be tabulated as follows:

Urethral Chancre.	Urethritis.
Symptoms appear after a period of incubation rarely less than ten days, often two or three weeks.	Symptoms follow suspicious intercourse in from twenty-four hours to a week, rarely at a longer interval.
Confined to meatus or its immediate neighborhood.	Begins at meatus, but extends some distance backward.
Ardor urinæ felt only at lips; no chordee.	Ardor urinæ felt along the urethra; chordee often present.
Discharge moderate, never purulent, often bloody.	Discharge more profuse, decidedly purulent, not so often or so largely stained with blood.
Induration perceptible to touch, usually involving only one lip of meatus.	No induration.
Invariable enlargement of chain of inguinal lymphatics, which are painless and freely movable, and almost never suppurate.	If lymphatics are involved at all, only one is affected, which often goes on to suppuration.
Sore can almost always be seen as a loss of continuity of mucous membrane.	No loss of continuity perceptible.
Constitutional symptoms follow after from six to eight weeks.	No constitutional symptoms.
Use of syringe painful at meatus.	Use of syringe not usually painful.

The small hard tumors which occasionally appear or may be felt along the under surface of the penis during an attack of gonorrhea, and which are due to inflammation and enlargement of the follicles, should not be confused with chancre. They usually feel like grains of sand or small peas directly beneath the skin, are situated behind the fossa navicularis, have no characteristic induration, and subside spontaneously or go on to suppuration.

When phimosis exists the diagnosis between subpreputial chancres and chancroidal, herpetic, or balanitic ulcerations is often one of great difficulty. It should be founded on the following considerations:

Subpreputial Chancre.	Subpreputial Ulceration (non-syphilitic).
The incubation is that of chancres, ten to twenty-one days or more.	The interval between the exposure and the subsequent ulceration, swelling, etc. is much shorter.
If the site of the original trouble can be felt or can be described by the patient, it will be found to be single.	Several points of ulceration, abrasion, or pustulation will usually be found or described.
Inflammatory phenomena comparatively slight.	Inflammatory phenomena—heat, pain, redness, swelling—very marked.
Swelling hard, dry, indurated characteristically.	Swelling œdematous, sero-purulent, like that of phlegmonous erysipelas.
The discharge from the preputial orifice is moderate, thin, serous or bloody, not readily inoculable.	Discharge profuse, purulent, usually very irritating, and apt to be inoculable, both accidentally and experimentally.
The margins of the preputial orifice are not markedly inflamed or ulcerated.	Almost invariably ulcerated.
At some point the induration can probably be isolated from the surrounding tissues and raised and felt between the thumb and finger.	This is usually not possible, no distinct dividing line existing.
Syphilitic buboes are invariably present.	Buboes, if present at all, are of an inflammatory character.

The diagnosis between a new indurated chancre and an ulceration occupying the site of an old chancre, the induration of which has never entirely disappeared—"relapsing chancre"—is extremely difficult, and, unless a clear history of the case can be obtained, is impossible. The latter cases are often reported as instances of a second syphilitic infection. The opinion must be

based upon the presence or absence of a syphilitic history and the circumstances of the exposure, incubation, etc. The possible effect of local irritation on an old indurated mass should always be taken into account.

The prognosis of syphilitic chancre, considered as a local affection, depends chiefly upon the seat of the lesion. A chancre of the conjunctiva may give rise to a grave ophthalmia; a chancre of the tongue or of the fauces may cause great debility through interference with mastication, deglutition, and digestion. As regards the genital organs, however, the prognosis is almost uniformly favorable. Phagedenic or gangrenous processes are rare; ulceration even is usually very slight, or, if seemingly extensive, is apt to be at the expense of the neoplasm, and not of the normal tissues.

The relation between the constitutional disease of which the chancre is the precursor and the sore itself is a question of great interest. It may be at once acknowledged, however, that our information upon this point is deficient. We are able neither to predict the form of local lesion from the character of the source of infection, nor, on the other hand, can we, with any accuracy, forecast the constitutional condition which will result from any given sore. The varieties of the chancre in form, extent, etc. depend more upon local causes or upon the idiosyncrasies of the patient than upon any special source or peculiarity of the virus. Every syphilographer of experience has seen the most widely-differing forms of initial lesion derived from the same individual, and a similar diversity exists in the forms of constitutional disease arising from a given focus of infection. The amount of glandular implication is also an entirely unreliable guide and presents all sorts of variable phenomena.

The Treatment of Chancre.—Every surgeon whose work has brought him in contact with large numbers of cases of venereal sores must recognize the fact that between the typical soft, suppurating local sore and the distinctly indurated chancre there are large numbers of doubtful ulcers which partake of the characteristics of both: local sores with deceptive inflammatory hardening, and true chancres with equally deceptive inflammatory softening, suppuration, and even loss of substance. Nearly every specialist who has written upon the subject has recognized and been influenced by this well-known fact.

Fournier, perhaps the most eminent living syphilographer, has recorded a case which bears most strongly upon the question under consideration: A female child, six years old, was said to have been infected with syphilis during an attempt at rape. She had marked vulvitis, and upon the labia three grayish, shallow, indolent, indurated ulcers covered with a diphtheritic-looking membrane and raised a little above the general surface. In both groins there were enlarged, multiple lymphatic glands. He positively diagnosticated chancre, but, conforming to his custom in medico-legal cases, declined to testify for a few days. During this time, under a simple dressing, the symptoms disappeared, and the patient, who was carefully observed for several months, never showed any subsequent signs of infection. Fournier believes that the case demonstrates that small inflammatory lesions may so closely resemble chancres as to deceive the most experienced surgeon, and adds that in medico-legal cases the diagnosis should not be made upon the local lesions alone, but should depend upon the development of constitutional symptoms.

The surgeon who is daily called upon to give an opinion in cases which involve the whole future of the individual, his relations to the other sex, his determination toward celibacy or matrimony, his matrimonial relations if he should be already married, the question of the influence of paternity, the institution of a course of treatment extending over years, the diagnosis of any obscure visceral troubles which he may develop later in life, the profoundly

depressing mental effect which a knowledge of syphilitic infection usually has upon intelligent people,—the surgeon who remembers these facts and recalls the views above cited as to the possibility of error should surely hesitate about beginning a course of treatment which will possibly obscure or render altogether impossible the diagnosis. While there is no positive advantage in delay as regards the subsequent course of the case, yet, on the other hand, the gain from the immediate treatment during the primary sore is not sufficient to counterbalance the doubt and uncertainty which that treatment often throws about the future life of the patient. Certainly the cases are comparatively rare in which a careful surgeon would be willing to make an *absolute* diagnosis of syphilis during the existence of the primary sore alone. A few necessary exceptions to this rule may be included under the following heads:

1. Where confrontation is possible and the sore is distinctly a typical one. 2. Where with a typical sore its continued existence would destroy or imperil the conjugal relations of two people or possibly the happiness of an entire family. 3. Sores with characteristic induration, but with marked tendency to spread and involve important regions. 4. Sores in such conspicuous positions, as upon the lips or the nose, that their continuance would involve a general knowledge of the patient's condition.

With these exceptions it is the part of wisdom to wait until the development of glandular enlargement at some point removed from the initial lesion, and not, therefore, by any possibility a result of simple adenitis, demonstrates the constitutional character of the trouble. It is to be hoped—and, indeed, may be confidently expected—that the progress of bacterial investigation will in the near future enable us to make a very early and positive diagnosis, but we cannot do so as yet. It is not necessary, however, to wait for the syphilodermata. Treatment may be safely begun when, after a suspicious sore upon the genitals, consecutive enlargement of the epitrochlear or post-cervical lymphatic glands takes place.

The argument above used against the mercurial treatment of chancre applies with equal force to the local abortive measures which have from time to time been recommended. These include *excision; cauterization; antiseptic measures;* and various *local applications* of mercurial preparations by means of ointments, hypodermatic injections, or otherwise. Taking them in the order mentioned, their relative advantages and disadvantages seem to be as follows:

As to *excision*, it appears unquestionable that it can be of service in but a very small proportion of venereal sores as they usually come under the notice of the practitioner. The opinions of syphilographers, however, vary greatly in regard to the value of this form of treatment, and in the light of the opposing views a safe general rule for practice is to assume that a sore seen within a few days after its appearance, and as yet unaccompanied by any enlargement of the inguinal glands, is still a localized lesion. If favorably situated—*i. e.* upon the skin of the prepuce or of the genitals—it may be removed, the surgeon picking up the sore and surrounding tissue with a pair of toothed forceps, and removing it by a single sweep of the knife or by means of scissors curved on the flat, afterward dressing the wound with iodoform or boracic powder. By this plan of treatment we give our patients whatever small chance there may be of avoiding constitutional disease, while at the same time we expose them to the minimum degree of local pain and disturbance.

When the patient refuses this treatment, or when the sore is so situated that its removal would cause considerable pain, hemorrhage, or deformity, destructive *cauterization* with fuming nitric acid may be employed. In all cases (and these comprise the majority which come for treatment) in which

a week or more has elapsed since the development of the sore, and in which involvement of the dorsal lymphatics of the penis and the inguinal lymphatic glands is observable, cauterization as a routine method of treatment should be rejected, on account of its undoubted uselessness at that stage in preventing constitutional disease; the pain which it causes; the inflammatory action which follows it, and which often produces enough œdema and swelling to cause phimosis, and thus convert an open sore into a hidden one; the subsequent effusion of lymph, which simulates true induration and confuses the diagnosis; and, finally, the greater liability to the production of suppurative action in the ordinarily indolent bubo of syphilis.

The so-called *antiseptic treatment* of the initial lesion of syphilis is a misnomer, so far as the essential character of the sore is concerned, unless it be meant to include only the thorough destructive cauterization of all portions of the infected tissue. Applied simply to superficial dressings placed over the chancre, it can refer only to the prevention of the development of pyogenic organisms upon the surface of the sore. As the tendency of infecting chancres to suppuration is generally unimportant, we can hardly expect advantages from the employment of aseptic or antiseptic methods which are at all commensurate with those obtained by the same methods in ordinary surgical conditions.

The *local treatment* by hypodermatic injection of mercurials beneath the base of the initial lesion and into the mass of indurated lymphatic glands rests upon the view that mercury acts as an antidote when brought directly into contact with the syphilitic germs, and that this influence would probably be especially active if the drug were brought to bear directly upon the local lesions which are the foci of infection during primary syphilis. If we believe that the virus remains localized for a time after inoculation, and is not disseminated through the general system, and that mercury acts by its germicidal influence, this treatment is not unphilosophical, but seems inferior to the more thorough plan of excising both the chancre and the enlarged lymphatics of the groin. The latter procedure would be less likely to result in local troubles, such as abscess or cellulitis, and would certainly be more effective. The rules as to the treatment of chancre may accordingly be expressed as follows:

1. While it is unquestionably desirable to begin mercurial treatment at the earliest proper moment, and while that treatment undoubtedly either suppresses or renders milder the subsequent secondary manifestations, and while there is every reason to believe that in this way the liability to later or tertiary lesions is somewhat lessened, nevertheless the sum-total of these advantages does not warrant the employment of mercury one moment before the diagnosis of constitutional disease is absolutely assured.

2. While in many cases that diagnosis can be made with a high degree of probability from the appearance of the primary sore alone, yet it cannot be said that all possibility of error is excluded until some general symptom, such as the enlargement of distant lymphatic glands, has shown itself.

3. The administration of mercury during the existence of the primary sore, unaccompanied by general symptoms, for the purpose of suppressing or "aborting" syphilis, is not, therefore, justifiable, unless by confrontation the diagnosis can be confirmed, or unless there are urgent and unquestionable reasons for securing rapid cicatrization of the chancre.

4. It is proper to employ cauterization or excision, according to the site of the chancre, in cases in which it is seen very soon after its appearance, and especially when it is known to have followed intercourse with a syphilitic person. The chances of preventing constitutional infection in this way, while slight, may yet be considered sufficient in such cases to counterbalance the dis-

advantages of the method, such as pain, swelling, the production of phimosis or of suppurating bubo, and the obscuring of the diagnosis by the resulting inflammatory exudation.

5. Aseptic or antiseptic measures, while harmless, cannot be considered especially indicated in the local treatment of chancre, and in all probability can have no true abortive influence.

6. The local use of mercurials, hypodermatically or by inunction, is perhaps worth a trial, but it is probably inferior to the more radical methods based essentially upon the same principles—namely, excision and cauterization.

Chancroid.—The form of sore known as soft sore, soft chancre, simple chancre, non-infecting chancre, and chancroid is variously ascribed to the inoculation of a specific virus (the chancroidal), to infection with pus-microbes, and to a mixed (syphilitic and purulent) infection. There is some reason to think that there is a specific virus for chancroid. No final conclusion can yet be stated, though bacteriology will doubtless definitely settle the matter at no distant period. In the mean time we may be content to consider chancroid as a sore which has a very different appearance and runs a very different course from an infecting chancre.

In the case of a chancroid there are observed from the first certain phenomena. The first day we see a small red point, which on the second day becomes a papule, and is converted into a pustule by the end of the second or third day, especially in a region where the skin is delicate. The pustule soon breaks, and beneath the lowest epidermic layers we find a deep suppurating ulcer, which rapidly extends in circumference and depth, becoming at the end of the first week deep and crater-like with perpendicular or undermined edges; its surface is granulating, irregular, and infiltrated with pus, which is abundant and gives it a grayish color. The serum upon the surface of an indurated chancre, on the contrary, is small in amount and transparent.

In the chancroid there is no sclerosis of the vascular walls; we meet with the phenomena of inflammation, but there is no induration or thickening of the wall and no narrowing of the caliber of the vessels. The fibrous trabeculæ of the derm of the region involved are not preserved intact. The fibrils separated by the lymph-cells are themselves destroyed by the softening of the tissue and by the suppuration. These changes upon the surface of a chancroid result in the fibrous tissue losing its firmness and elasticity; its fibrous trabeculæ have a tendency to disappear. The lymph-cells, which collect in great numbers in the granulations and neighboring connective tissue, are large, turgid, and become free by softening the fibrils between which they are placed. The absence of specific induration comparable to that of the indurated chancre, and also a tendency to a progressive destructive involvement of neighboring tissues, result from this anatomical arrangement of elements. From this it will be seen that between chancre and chancroid there is a marked histological difference, one being essentially a prominent papule or new growth, the other an ulcer. A chancroid is apt to be painful and itching; the pus, which is secreted in large amount, is inoculable upon the patient, who frequently inoculates himself inadvertently or from uncleanliness, so that it is often multiple.

Phagedena.—Either a chancroid or a chancre, but oftener the former, may be accompanied by such intense local infection and tissue-necrosis that it spreads with great rapidity both on the surface and toward the deeper structures. It may thus produce one of the most destructive and most obstinate forms of ulceration. It is not known certainly whether this indicates essentially a lessened power of resistance or a new microbic infection. Probably both conditions coexist in the majority of cases.

When the lymphatic glands are affected there may occur a true suppurating bubo, especially if the patient be broken down in health or if he has been negligent of treatment. In this case an inguinal gland is swollen, fixed, and becomes very large; the skin reddens upon its surface, and we soon feel a superficial fluctuation, due to pus formed in the cellulo-adipose tissue surrounding the gland. When this abscess is opened the gland in some cases suppurates, and there is formed an irregular cavity which secretes sanious pus; the skin constituting its borders is red, inflamed, and separated from the tissue beneath. These glandular abscesses, like the chancroid, sometimes become phagedenic.

Chancroid is variable in its duration, which is sometimes quite short, lasting three, four, or five weeks; at other times it continues several months, and sometimes, if it is phagedenic, one or more years.

The Treatment of Chancroid.—While it has been for many years the custom to cauterize freely all soft or suppurating venereal ulcers—*i. e.* all sores diagnosticated as chancroid, whether situated in the genital regions or elsewhere—the introduction into surgery of the principles of antisepsis, and with them of such drugs as iodoform, has greatly modified this routine treatment. It is safe to say that chancroids are neither so frequent nor so severe as they were years ago, and that by the application of antiseptic methods to their treatment a great advance has been made in the ease and certainty with which they can be cured.

In a large majority of cases daily irrigation with sublimate solution of 1 : 500 or 1 : 1000, followed by free dusting with iodoform or by the application of an ointment consisting of one and one-half drams of iodoform to one ounce of carbolated cosmoline, will be followed by speedy cicatrization. If these fail, the continuous application by means of pledgets of cotton or lint of a lotion containing sublimate, boric acid, and peroxide of hydrogen will often cure. If, in spite of this, the sore deepens and extends, destructive cauterization with fuming nitric acid or the acid nitrate of mercury is at once the safest and speediest method of cure.

The objections to the cauterization of chancroids are as follows, and are similar to those mentioned in relation to chancres: First. The pain to which it gives rise. Second. The inflammatory action which follows, and which often in the case of the male produces enough œdema and swelling to cause phimosis, and thus to conceal the sore and prevent the proper application of remedies. Third. The subsequent effusion of lymph, which is apt to cause an induration closely resembling that of the true chancre, and thus greatly to obscure the diagnosis.

The general rule may be followed of meeting indications—that is, of using sedative lotions, lead-water, or lead-water and laudanum, or sulphate of zinc and opium—in the acutely inflamed, painful sores; and of using stimulating washes—sulphate of copper, strong zinc solutions, nitrate of silver, etc.—upon indolent, pale, and flabby ulcers. Special indications having been met, iodoform will generally complete the cure.

SYPHILITIC BUBOES.

Almost at the same time that the chancre becomes indurated the lymphatic glands, connected with it by means of the lymphatic vessels, undergo hypertrophy. The glands nearest to an infecting chancre become enlarged and hard; they roll readily beneath the skin; they are painless and do not suppurate. These clinical characters are unvarying. They are found in the groin when the chancre is upon the external genitals; in the submaxillary glands when the chancre is upon the lips; in the axilla when the chancre is upon the nipple or hand.

The glands of the groin, in connection with a chancre upon the genital organs, are successively involved, the gland first affected being the most inferior of the group upon the diseased side. When the chancre is situated at one side of the frenum, it is not uncommon to find the buboes in both groins, a certain amount of decussation occurring between the lymphatics of the former region. The inguinal glands are all hypertrophied, but are distinct one from another, the skin remaining healthy.

About a month and a half after this enlargement of the glands nearest to the chancre all the lymphatic glands of the body are successively invaded, at least all those which are visible. They appear a little inflamed before or at the same time with the eruption of the cutaneous syphilides. Probably all the glands of the economy are affected, and cases of enlargement of the glands in front of the sacral, lumbar, and dorsal vertebræ have been reported. The subcutaneous glands affected by syphilis are the cervical, maxillary, occipital, etc. Among the most important glands for diagnostic purposes are the post-cervical, which do not enlarge from local causes so frequently as the anterior chains of cervical lymphatics (glandulæ concatenatæ), and which are therefore almost pathognomonic when they undergo painless multiple enlargement at about the period for the appearance of the early secondaries.

In syphilitic lymphatic glands the follicles of the delicate reticulated tissue are hypertrophied, and occasion small lobulated projections upon their surface when the capsule is removed. These glands remain more or less enlarged, not only during the active period of the secondary lesions, but frequently after the syphilides have disappeared.

The following tables will serve to contrast the buboes and lymphangitis characteristic of the two chief forms of venereal sores:

Syphilitic Bubo.	Inflammatory Bubo.
Always accompanies or follows infecting chancre.	Occurs in only one-third of the cases of chancroid; occasionally, but more rarely, in herpetic or balanitic ulceration or in gonorrhea; may follow an infected wound of the lower extremity.
Several glands involved, making a group or chain of small, movable glands in one groin or often in both.	One gland implicated, rarely bilateral.
Appears soon after chancre.	No definite time of appearance.
Slight enlargement.	Great enlargement.
Cartilaginous induration.	Inflammatory hardness.
No inflammatory symptoms.	Always present.
Glands freely movable.	Gland fixed (periadenitis).
Skin normal, not adherent.	Skin red, adherent.
Painless.	Painful.
Indolent, slow.	Runs an acute course.
Terminates by resolution, rarely by suppuration.	Usually suppurates, rarely undergoes resolution.
No marked tendency to phagedena.	Phagedena not very uncommon.
No local treatment effective.	Local treatment required.
Mercurial treatment hastens resolution.	Mercury has no influence upon the condition.

Syphilitic Lymphangitis.	Inflammatory Lymphangitis.
Lymphatic vessels feel hard, like the vas deferens; size of a knitting-needle.	Same, but less hardness.
Painless to touch.	Painful.
No pain on erection.	Erection gives rise to pain.
Skin normal.	Skin red over inflamed vessel.
Terminates by resolution.	Resolution or suppuration.
Local treatment unnecessary and ineffective.	Local treatment of great use.

SECTION II.: GENERAL SYPHILIS.

At about the time of the general lymphatic enlargement—and coincident with or preceding the earliest eruption—we have a characteristic group of symptoms—viz.: 1. *Fever*, varying from 100° F. to 101° F., coming on toward evening and associated with moderate anorexia and malaise. 2. *Muscular and articular pains*, chiefly affecting the muscles and joints of the chest, back, and upper extremities, but sometimes very general and quite severe. 3. *Alopecia*, not confined to the scalp, but involving the hairs of the whole body, distinguished from ordinary baldness by that fact, by the concomitant symptoms of syphilis, and by the irregular, moth-eaten character of the bald spots.

Constitutional syphilis may be diagnosticated when an indurated genital chancre is followed by a painless, hard swelling of the inguinal glands and of others like the post-cervical, which are remote from the spot of local irritation. The change of the lymphatic gland is so characteristic that from it alone the diagnosis of syphilis is possible when the cervical, maxillary, supratrochlear, and other lymphatic glands are invaded, as well as those in the inguinal region, and still more easily when the fever, pains, and alopecia are present.

SECONDARY SYPHILIS.

The eruptions of the skin and mucous membranes soon make their appearance, and constitute the first manifestations of the secondary stage of syphilis.

These **syphilides** usually appear about six weeks after the beginning of the infecting chancre, sometimes sooner; at other times later, even two or two and a half months from the date of the chancre. They are seldom as late as three or four months, yet in rare cases they have occurred after five months have elapsed. The mercurial treatment, when given during the existence of the chancre, has been accused of causing this retardation of syphilides, and doubtless does so, but it must not be forgotten that the evolution of the disease is very variable.

Cutaneous and mucous syphilides are more superficial when they are more recent, and grow deeper as they grow older. Thus the syphilides of the first period of secondary lesions affect only the papillary surface and epidermic layers. These are erythemata, or superficial spots, as roseola; or limited, slight, and temporary inflammations of the papillary and epidermic layers, as papules. The older syphilides, on the contrary, belonging to the later secondary period, appear as pustules or tubercles,[1] which affect the deep cutaneous and subcutaneous layers in connection with the papillary network and epidermis; they are destructive and are followed by cicatrices.

A classification of syphilides similar to that adopted by Cornil and based on their pathological histology is both useful and practical. It is as follows:

1st. **Erythematous syphilides**—erythema; macules; roseola.

2d. **Papular syphilides**—conical, lichen-like syphilide; large papules. —Patches of papulo-lenticular syphilide; papulo-squamous.

3d. **Pustular syphilides**—acneiform; impetiginous; ecthymatous; rupial.

4th. **Gummatous and tubercular syphilides.**

In this classification there is indicated the gradual passage of the superficial lesions of the early period of secondary symptoms into the deeper and later

[1] The word "tubercle" is often used to designate one of the eruptions of syphilis. It refers simply to its visible characteristics, and does not mean that there is any infection with the bacilli of tuberculosis.

lesions of the second period, and finally into the rupia, tubercles, and gummata of the third period.

Syphilides of the first period are almost always *polymorphous;* that is, the eruptions present at the same time the different varieties of roseola, papules, and small pustules or squamous papules. In ordinary eczema or impetigo we have the same elementary lesion of the skin at all points, and the same appearance of all the regions affected; but, on the contrary, there are found in syphilis varied elementary lesions, spots of erythema alongside of papules and vesico-pustules, and other lesions modified according to their location. In other cases there will be seen a papular syphilide in a somewhat chronic state; the papules when upon the skin of the limbs appear dry, their epidermis desquamating. In those regions where the skin is in folds, as upon a dependent mammary gland, the papule, instead of being dry, is moist; upon the palm of the hand, where the epidermis is corneous and thick, the epidermic layers over the papule form hard scales, which have incorrectly been compared with psoriasis. This polymorphous condition and the blending together of the elementary lesions are among the best diagnostic characteristics of syphilides. Syphilides of the late secondary period frequently involve all the layers of the derm and epiderm, and are given compound names, as papulo-vesicular, papulo-pustular, tuberculo-pustular, etc.—names which define themselves.

The syphilides have a *color* which is said to resemble that of copper or of ham; this is owing particularly to extravasations of red blood-corpuscles, and is marked in the eruptions of the first period. The copper color is not seen in lesions of the mucous membranes. Another distinctive characteristic of syphilides, except diffused erythematous roseola, is that they all have a regularly *round shape*, whether isolated or in groups. They form small circles, figures-of-8, etc. Finally, the lymphatic glands are often affected in the region invaded by the eruptions, and the action of mercury upon these eruptions is to cause their rapid disappearance.

The earliest cutaneous symptom in syphilis is almost equally apt to be an **erythema** or a **roseola**, the former a diffused mottling of the surface, affecting chiefly the trunk and abdomen and without appreciable elevation; the latter, somewhat darker in color and apt to show a tendency to become papular. Roseola may indeed be considered as an eruption intermediate between the erythematous and papular syphilides. The diagnosis is usually easy, and can readily be made from simple roseola, the roseola caused by copaiba, by exposure to the atmosphere, by measles, by bites of insects, etc., if the patient be examined with care, if enlarged lymphatic glands and mucous patches are looked for, and, finally, if the special color of the papules and the history of the case be remembered.

The **papular syphilides** may be small or large, and may be associated with such an accumulation of epidermic scales as to receive the name of the papulo-squamous syphilides. The *first* variety (small papules) has received the name of lichen-like or miliary syphilide. The color of the papule is very characteristic. The elevation of the skin is due to a thickening of the papillæ and epidermic layers; but at the summit of the papule and over all the surface forming it the most superficial layers of the corneous epidermis have desquamated, while those at the margin of the papule are continuous with the normal skin of the periphery. The papules remain a varying length of time; they usually disappear in three or four weeks when mercurial treatment has been employed; at other times they continue for two and three months. They are modified according to their location. The mucous patches corresponding to this variety may be small and acuminated. Upon the scalp the eruption appears

as small pustules or papules covered with a yellowish or brown scab; upon the palmar surface of the hands the papules are covered with hard epidermic scales or they are depressed and surrounded by a corneous epidermis.

The *second* variety of papular syphilides is characterized by large papules, having a diameter of from half an inch to an inch, or even larger. In its beginning a pimple is noticed with regular edges and pink surface, which soon assumes the characteristic color, and upon which the most superficial layers of the epidermis are desquamating; at the periphery of the papule the desquamation is arrested, and here is seen a thickened epidermic border. The surface of the papule is smooth and circular.

In the papular eruptions generalized over the entire body the skin where they are situated often becomes so thick as to warrant the term papulo-tuberculous; they unite and form large bands; for example, upon the forehead—*corona veneris*—or surround the mouth and alæ of the nose; they also form circles upon the shoulders, neck, and trunk, and extend over the surface of the limbs. Often, during the period of acme, they are covered with thick scales, which may be removed in irregular fragments by scratching; this form is termed *papulo-squamous*. Their color is always very distinct, intense, deep copper-red.

The essential **histological changes** which enter into the formation of a syphilitic papule are a hypertrophy of the papillæ of the skin, an increase in the number of epithelial layers which form the epidermis, and a proliferation of the cells of the rete mucosum. The blood-vessels are congested, and there occurs an extravasation of the blood-elements into the tissue of the derm which gives the characteristic coloration to the lesion. Desquamation of the superficial layers of the skin is one of the features of the papule. The changes are not limited to the papillæ and superficial corium, but in some varieties extend to the subcutaneous adipose tissue. There is no vascular sclerosis comparable to that met with in the chancre. These changes are modified by situation, duration, etc.

The **diagnosis** of a large papular syphilide is never very difficult. The special color and the arrangement of the papules, the involvement of the palms of the hands and soles of the feet, also of the palmar surface of the fingers and plantar surface of the toes, the enlargement of the lymphatic glands, the frequent existence of mucous patches, are all characteristic. The papular syphilide is indeed the most distinctive of all, and the most common after roseola. It is seldom that a syphilide with large papules continues less than two months, and frequently it remains three, four, or five months, especially if mercurial treatment has not been employed at all or too timidly. There is no form of medical treatment in which the curative power of a remedy is so evident and so admirable as in the use of mercury in cutaneous syphilides, and particularly in the severe forms of papulo-squamous eruption.

Mucous Patches.—A transformation of a syphilitic papule into a mucous patch takes place whenever it is under the continuous influence of warmth, moisture, and friction, as on a mucous membrane at a muco-cutaneous junction or in the creases or folds of skin. Under these circumstances the overlying epidermis or epithelium is macerated and disappears; the papule, originally small, rapidly extends in superficial area; it becomes grayish or opalescent in appearance if seated on a mucous surface; red, smooth, and polished if on the skin. In either case it is moist and has a free secretion, often offensive, and always highly contagious.

The most *common seats* of mucous patches are, first, in the order of their frequency, the genital organs and region of the anus. Their location varies according to the sex. With women mucous patches of the labia and of the

vulva are almost constant; with men, on the contrary, they are not very frequently met with on the prepuce or glans, the most common seats being the scrotum and anus. With women the anus is also frequently the seat of mucous patches.

The *histological structure* of mucous patches consists in a thickening of the epidermic layers and an increase in the size of the papillæ of the skin by a development of the elements entering into their structure. This increase in size of the papillæ causes a corresponding increase in the length of the interpapillary prolongations of cells of the rete mucosum. The blood-vessels of the papillæ are distended with blood. The tissue of the derm is found proliferating.

Diagnosis of Mucous Patches.—It is almost impossible to mistake a mucous patch after a number have been seen. They are formed upon a papule—that is, an inflammatory swelling of the corium and papillæ; their surface is oozing, and the epidermis or epithelium which covers them is saturated or desquamated. Thus, upon the labia majora and minora there are seen whitish patches or small points which resemble moist or pulpy paper, and consist of epidermic cells or changed superficial epithelium; upon a mucous membrane, as on the lips or palate, the epithelium is whitish, opaline, resembling a surface which has been touched with nitrate of silver. The mucous patch, if eroded, has a surface which is red and smooth after the superficial epithelium has desquamated; the shape of the patch is always circular or regularly oval, and the derm is thickened upon its surface. The patches of the vulva and labia majora, likewise of the anus and of the scrotum and scrotofemoral folds, even when in process of healing are very distinct; as the epidermis forms, the derm remains a little papular and the surface dull red.

The syphilitic papules, covered with thick superficial layers of corneous epidermis—that is, with scales—are termed **papulo-squamous syphilides.** They are generally very obstinate, since the layers of the epidermis repose upon the thickened and chronically inflamed derm. These squamous papules, covered with or deprived of their epidermic layers, when situated upon the palms of the hands and soles of the feet, are called **palmar** or **plantar syphilides.** The papules are modified simply on account of their seat and the structure of the skin of the hands and feet. Here the corneous epidermis attains considerable thickness and resistance; it forms a layer which at times measures a millimeter in thickness and is dense and hard like parchment. Thus it offers more or less resistance to the development of the papules, especially at their beginning. Later, however, the epidermis covering the papule is raised, cracked, and partly or completely eliminated, or it forms hard and irregular stratifications.

With syphilitic papules, and at the same time with secondary syphilides, there occurs a lesion allied to the lesions of the epidermis—viz. the changes of the nails.

Syphilitic Onychia is a disease of the nails, the peculiarities of which result from the anatomical structure of the matrix of the nail and of the peri- and subungual papillo-epidermic tissue. There are described two varieties—the dry and the moist.

The *dry* variety of onychia generally accompanies the papular and papulo-squamous eruptions situated upon the fingers and toes, the ends of which are attacked by papules, which pass around their extremities or may be seated at the roots and edges of the nails or under them. Sometimes the nail is cracked and readily broken; it is dry and separated from the skin. Sometimes, when the papules exist at the ungual matrix, there is a swelling of the skin at this region,

and the formation of the epidermic layers of the nail is very much interfered with. At times there is an irregular thickening of the nail by hard scabs, which are stratified and occasion a dense, irregular elevation.

The *moist* variety of onychia occurs with vesiculo-pustular or pustular syphilides. Sometimes true whitlow is met with.

These conditions often terminate in the destruction of the nail, and necessitate rest, antiseptic fomentations, and afterward some simple dressing.

Pustular Syphilides.—The pustular syphilide is found in the form of acne, of impetigo, or of ecthyma. Syphilitic acne is always early and superficial. Impetigo and ecthyma may also occur in the first stages and without any element of gravity, but in other cases, where they appear very early, may be of graver import; during the later eruptions they assume a still more serious aspect, and tend to rapid extension both in depth and superficial area, resulting in pustulo-crustaceous ulcers, of long duration and of extent corresponding to the amount of suppuration and the tendency to confluence of the lesions, which are often accompanied by symptoms of general cachexia, and in exceptional cases even terminate in death.

Syphilitic acne is as much a papule as a pustule in its structure and evolution. It forms a small conical projection, upon the top of which appears a very slight epidermic elevation, caused by a small quantity of serous effusion, which rapidly becomes purulent. The pustule is of short duration, and is soon replaced by a little crust, and then by scales, leaving only a stain, without cicatrix. This eruption appears in successive crops upon the face, the shoulders, the trunk, and thighs, in which latter situation the pustules are often confluent. There are generally at least as many papules or papulo-squamous spots as well-formed pustules, the papular elevation remaining after all traces of the pustule have disappeared from its summit. It is an eruption of the early stages, and behaves like the papular syphilide. It is distinguished from acne vulgaris by its distribution—for it especially affects the belly and thighs, while acne vulgaris is found on the face and shoulders—by its copper color and its greater dryness, and by the absence of white permanent cicatrices.

Syphilitic impetigo appears in the form of little pustules covered by crusts and resembling isolated pimples, or as patches formed by the union of many pustules. The pustulo-crustaceous form is commonly found upon the scalp at the same time that a syphilitic roseola or mucous patches have invaded the general integumental surface.

The impetigo may be the predominant eruption, the scalp, face, and forehead being the points of election. The reason for the transformation of a papular syphilide into the pustulo-crustaceous form upon the face and scalp is found in the abundance of sebaceous glands with which those parts are supplied. These glands, when involved in the inflammatory action, produce a papule; upon the cutaneous surface their secretion is modified, and consists then of a sebaceous liquid more or less intermingled with blood-corpuscles. As a result there is seen either a well-formed pustule, a sebaceous concretion, or a crust upon the surface of the papule.

Usually the pustules are seated upon a reddish, copper-colored patch or papule. When the eruption is confluent it covers large surfaces with scabs.

Syphilitic ecthyma may be superficial or deep. The former variety occurs usually on the lower limbs, and appears as a large pustule with a thick dark crust. It leaves behind it ecchymotic stains.

Deep ecthyma at first appears as a collection of pus under a large elevation of superficial epidermis, as occurs in the variety already described. The pustule is regularly circular; the contents inspissate by evaporation, and form a

crust which increases by the addition of successive layers. These crusts in superimposed strata, greenish or brown in hue, imbricated like the shell of an oyster, dry, resistant, are also met with in rupia, having the same configuration and immediately suggesting syphilis. Under this crust, which continues to enlarge and thicken, the pustule itself extends in breadth and depth. The crust overlaps the border of the ulcer, or, when the latter is the larger, is set within it like a watch-crystal in its case. When it falls off there is disclosed an ulceration extending to the papillæ or even deeper into the skin. These pustules are sometimes spread singly over a large portion of the body, most frequently the inferior extremities; in other cases they are grouped in the form of circles or crescents.

The **diagnosis** of syphilitic ecthyma from scrofulous ecthyma is frequently difficult. The latter ulceration is often deep and with perpendicular borders, as in the syphilides; the crusts, however, in syphilis are drier, darker, and more imbricated, the cachectic lesion suppurating earlier and more freely, consequently permitting of less adhesion of the crusts. This is not an invariable distinction, as in certain cases syphilitic ulcerations are attended with the formation of large quantities of pus. When the eruption is distributed upon the face and body as well as upon the limbs, the diagnosis of syphilis should be made, as the ecthyma due to scrofula is observed only upon the inferior extremities.

The history and concomitant symptoms almost always lead to a recognition of the disease, as it is a persistent eruption, lasting for months or even for a year, and often reappearing with all its original characteristics. It necessitates a guarded prognosis on account of its persistence and of the continual suppuration caused by it, especially when it is widespread. It is formidable also because it indicates a grave form of syphilis, particularly when it appears soon after the initial lesion.

Rupia manifests itself at first by large elevations of the epidermis filled with a clear or bloodstained serum, soon becoming turbid and purulent. The bulla bursts, allows some of the liquid to escape, and as it desiccates is covered with a crust, which dries, accumulates new layers, and becomes imbricated with brown and greenish strata, as in the variety of ecthyma just described. Rupia is, of all the syphilides, the one attended with the largest, thickest, darkest, and most characteristic crusts, as it is also the one presenting the most extensive ulcerations. Under these crusts the papillary layer and the entire derm are undergoing suppuration, as in the last two eruptions considered.

In the **tubercles** and **gummata** of the skin are seen the latest and deepest manifestations of cutaneous syphilis.

Syphilitic tubercles and gummata have striking analogies. They appear at the same stage of syphilis, are of the same clinical import, and are caused by the same pathological changes; the chief distinction being that the tubercles are more superficial, only involve the derm, do not extend into the subcutaneous tissue, and give rise to a less abundant cellular infiltration.

Tubercular syphilides represent deep and enormously swollen papules, and are intermediate pathologically between the papule and the gumma. They appear as single, flattened pimples, attended with an induration of the entire skin, from the superficial epidermis to the deepest layer of the derm; they are sometimes solitary, sometimes in groups, and may be scanty or may be widely extended. Their favorite situation is upon the face, at the mucous outlets, upon the nose, ears, forehead, back, neck, and inferior extremities, especially the legs.

There are two varieties, the dry and the ulcerating. The dry tubercular

syphilide is usually copper-colored and covered with thick scales, almost crusts; there may be no ulceration, and healing may occur, with the production of a white or pigmented cicatrix, without any ulcerative process having taken place.

The ulcerative tubercular syphilides are more grave on account of the abundant suppuration caused by them. They may be isolated, but are usually in groups, often very extensive.

Histologically, gummata and tubercles consist essentially in the formation of embryonal cells, which in the former, the gummata, occupy a position deep in the derm, infiltrating all the tissues, and in some instances even involving the deeper structures, bone, cartilage, etc. The tubercles are similar in their histological structure, but are limited more particularly to the skin, not affecting the subcutaneous tissues.

The disease for which an ulcerating tubercular syphilide is most likely to be mistaken is lupus vulgaris, which is a cellular new-growth due to infection with the bacillus of tuberculosis, and results in various papular or tubercular patches which are usually followed by ulceration. It has no relation with syphilis, and should be carefully distinguished from it, as the treatment beneficial in one case is useless or absolutely harmful in the other. The main diagnostic points may be tabulated as follows:

Tubercular Syphilide.	Lupus Vulgaris.
Occurs chiefly among adults.	Occurs commonly in young persons; when in adults there is often a history of a similar eruption in childhood.
Considerable infiltration of skin.	Not so marked.
Tubercles opaque and of a deep brownish-red color.	Tubercles often translucent and lighter in color.
The characteristic ulcer produced in a month or two.	The same amount of ulceration would require several months or even years for its development.
Ulcers usually distinct.	Ulcers apt to be confluent.
Ulcers deep and extensive.	More superficial and involving smaller area.
Ulcers small, circular, punched out.	No regular form or perpendicular edges.
Secretion copious, sometimes offensive.	Secretion slight, inoffensive.
Crusts bulky, greenish.	Crusts thin and dark-colored.
Scales irregular in shape and attachment.	Scales arranged more regularly, attached in the centre and loosened at the edges.
Cicatrices soft, white, circular.	Cicatrices distorted, irregular, puckered.
History and concomitant symptoms of syphilis.	No such history except as a coincidence.
Local treatment ineffective. Internal specific treatment effects a cure.	Eruption disappears only under very active local treatment, as curetting, or under the influence of tuberculin.

Gummata of the skin make their appearance at variable intervals after the contraction of syphilis; sometimes very late—twenty or thirty years after the chancre—sometimes, on the contrary, very early, during the first year, or even in the first four or five months; this occurs in the grave and abnormal varieties of the disease; most frequently they develop three or four years after the chancre. The favorite localities are the face, scalp, shoulders, neck, arms, thighs, and legs, but they may appear in any region of the body.

Cutaneous gummata are inflammatory tumors of the subcutaneous tissue—the cellulo-adipose connective tissue—which terminate by discharging externally: they cause a loss of substance to great depths, more considerable in extent at the bottom than at the cutaneous orifice, the disintegrated tissue being slowly thrown off like the core of a furuncle.

In the development of a gumma there are *four periods*, which include the processes of *formation*, *softening*, *ulceration*, and *repair*. The first period

is of long duration, and, as the tumor is painless, the patient usually discovers it by chance as a rounded or slightly flattened nodule seated deeply beneath the skin, which latter is slightly raised The nodule is movable in the subcutaneous tissue, is hard, consistent, and gives rise to no subjective symptoms. The tumor grows slowly until it acquires a volume varying from one centimeter in diameter to that of a hen's egg. Ordinarily it has a diameter of from one-half to three-quarters of an inch. The skin over the surface of the gumma remains normal, until suppuration begins. After a time the tumor softens, becomes doughy, and then fluctuation takes place. Soon the skin reddens, grows thin at the most prominent point, and is finally perforated. The small circular opening gives exit at first only to a small quantity of purulent or gummy liquid; an open gumma not resembling in the least a discharging abscess. The gumma does not at once empty itself when it is opened. The inflamed connective tissue adheres by its deeper portions to the subcutaneous cellular tissue, which is thrown off in the form of small sloughs. Granulations forming at the bottom soon fill the cavity, the solution of continuity is repaired, and cicatrization takes place. The resulting cicatrix is depressed, often adherent to the deeper tissues or to the bone itself.

The **clinical characteristics** of the group of cutaneous syphilides may be stated as follows:

1. General or constitutional symptoms are usually absent, with the exception of the syphilitic fever which precedes or accompanies the early eruptions.

2. Additional evidences of syphilis will usually be found, and should be carefully searched for—the chancre, its cicatrix or its induration, the buboes, sore throat, baldness, mucous patches, etc.—if an early eruption be in question; osteocopic pains, nodes, and other bone-lesions in the later stages.

3. The eruptions, especially the early ones, are apt to be polymorphous, or to present at the same time a variety of forms of cutaneous lesion, macules, papules, and pustules being usually intermingled. This is due to the chronic, slow evolution of the disease, which permits of the development of new symptoms during the gradual fading of previous ones.

4. The patches of eruption are apt to have a rounded or crescentic form, due to the anatomical arrangement of the cutaneous capillaries, and when seated upon the extremities occupy the side of flexion—the anterior surface of the forearm, the palm of the hand, the sole of the foot, etc.

5. The characteristic color of the syphilitic eruptions is a yellowish-red, usually described as "coppery." Its peculiar dusky tint is due to the absence of the active hyperemia and arterial excitement which usually exist in the non-specific eruptions, the color of syphilides being the result of slow changes in the coloring matter of the blood which has exuded under pressure, and not the accompaniment of acute inflammation.

6. There is an absence of pain and itching which is very distinctive, and which is also due to the non-inflammatory character of the eruption. It is quite common to find patients who are not aware of the presence of an extensive syphiloderm until their attention is directed to it by the surgeon.

7. The early eruptions are superficial, general, and symmetrical, indicating by these characters the infection of the blood to which they are due. During their evolution the disease is transmissible by contagion.

8. The early eruptions are frequently scaly, the pressure of the cell-proliferation, which is always present, cutting off the supply of nutriment to the superficial epidermic layers, which accordingly dry, desiccate, and are exfoliated.

9. The scales are whitish, superficial, and usually not adherent, there being no plastic or inflammatory exudation to fasten them to the subjacent part.

10. The later eruptions are not contagious, are irregular in distribution, extend to the cutis vera or beneath it into the connective tissue, and are described as local lesions or as sequelæ following the acute or secondary stage, and due either to relapses in parts previously diseased or to new-growths resulting from changes effected by syphilis.

11. The later eruptions have thick, irregular, or imbricated crusts, often occur in groups, and leave scars even if no ulceration has occurred.

12. Ulcers resulting from the breaking down of syphilitic deposits have rough, abrupt edges, are irregularly crescentic or circular in shape, covered with an unhealthy greenish-yellow secretion, and, as a rule, are painless.

13. The cicatrices caused by syphilis are at first pigmented, then whitish, shining, rounded, or radiating, and depressed below the level of the surrounding surface; they often show very small apertures, the sites of pre-existing follicles.

14. The therapeutic test in all very doubtful cases is an extremely valuable one, although it should be necessary to resort to it only in extremely exceptional instances. The amenability of nearly all the cutaneous symptoms to well-directed specific treatment often renders this test very conclusive.

The tertiary lesions of the mucous membranes are characterized by growths occupying the deeper portion of the mucous membrane or extending beyond it, and by gummata identified with those just described. They are nearly always ulcerative, but are not covered by crusts, owing to the facility with which the accumulated secretions are detached from the surface. Thus, in cases where upon the skin there would be a scab, upon the mucous membrane there is found an ulcer discharging pus more or less freely. Like the deep syphilodermata, they are limited and localized, for, as the disease grows older, instead of being extended and superficial and symmetrical, it becomes limited to a special locality and deeply involves and destroys its tissues.

The most important mucous membranes affected by tertiary lesions are the tongue, soft palate, and pharynx.

Tertiary Syphilis of the Mouth.—The most important of the late manifestations of syphilis in this region are the gummata of the tongue, which may be either submucous or muscular in their origin.

The *submucous gummata* are of the size of a pea or a cherry-stone, single or multiple. They begin as small, hard tumors, and their softening, their discharge through a small aperture, their excavated appearance and characteristic base, do not differ from those of other gummata: this is also true of their duration and of their mode of healing.

The *muscular gummata* are larger: they may occupy either the lateral or median aspects of the tongue, or may affect its tip, its base, or its edges. They reach the size of a hazel-nut. They open by what is first a very narrow channel, which enlarges or extends in the direction of the muscular fibers.

In these affections of the tongue it is rare to find enlarged cervical or submaxillary lymphatic glands, and the same is true of gummata of the pharynx.

The *differential diagnosis* of syphilitic diseases of the tongue is one of some importance, especially in regard to non-syphilitic affections which simulate them. Gummata of the tongue may be mistaken only for tubercular ulcers or for epitheliomata. From tubercular ulcers it would be difficult, if not impossible, to make a diagnosis from the character of the ulcer alone. The sides and edges of ulcerating tubercles often show, however, a few small yellow points with opaque centers, which are tubercular granulations undergoing caseous degeneration. These latter are finally thrown off by ulceration, and are never seen in syphilis. The evolution of tubercles of the tongue is entirely different from that of gum-

mata. The gumma begins as a single mass, submucous or muscular in position, opening after a time by a contracted passage, ulcerating, and discharging like a furuncle and having a sloughing base. The tubercles, on the contrary, begin on the surface as small nodules. By the union of many of these a large, irregular ulcer is formed, slower in its evolution than a gumma. As it extends in depth there are successive eruptions of tubercles, too minute to be detected by the naked eye, and situated between the muscular fibers. The ulcer has jagged edges and usually suppurates less than the gumma. In cases of doubt the chest should be carefully examined, as pulmonary tuberculosis often exists at the same time. The family history may also aid in the decision.

Lingual epithelioma may always be detected by microscopic examination of the fragments of tissue from the cancerous ulceration, large pavement-cells and epidermic nests being found. In addition, the epithelioma never becomes stationary or recedes, that of the tongue being especially grave and rapid, often running its course and terminating in death in a year or eighteen months.

The diagnosis between ulcerating epithelioma of the tongue and ulcerating gumma of the tongue has been tabulated by Fournier, as follows:

Epithelioma.	Gumma.
Chiefly affects persons between fifty and seventy years of age.	Is apt to occur at an earlier period of life.
Often a history of cancer in near relatives or ancestors.	No such history, as a rule.
No history of syphilis.	Such history almost always obtainable.
The appearance which has been described as "lingual psoriasis" often precedes the cancerous disease.	Nothing which resembles this has been seen.
Is generally single and confined to one side.	May be multiple and bilateral.
Is sometimes found on the under surface of the tongue.	Never seen except upon the dorsum or side of the tongue.
Begins as a hard swelling upon the surface of the organ, and ulcerates rapidly and superficially; sometimes begins as a fissure or ulcer, without previous swelling or induration.	Begins as a rounded mass beneath the surface, and then opens like a furuncle, leaving a hollow, deep ulcer.
Induration follows cancerous ulceration.	Induration precedes ulceration.
No cavity resembling that of an abscess.	An excavation like an abscess-cavity.
Surface bleeds when touched or spontaneously.	Ulcer covered by an irregular slough which does not bleed.
Edges turned outward, with the border elevated, irregular.	Edges abrupt, perpendicular, "punched out," sharply defined.
Secretion profuse, offensive, irritating.	Secretion moderate, not so apt to be offensive.
Lancinating pain, often darting toward the ear, thought to be pathognomonic.	Painless or nearly so.
Great disturbance of deglutition, mastication, speech, etc.	Tongue much more mobile; functional troubles not so marked.
General cachexia supervenes.	No cachexia.
Microscopic examination shows the characteristic ingrowing of the interpapillary epithelium, the large squamous cells, pearly bodies, and other histological peculiarities of epithelioma.	The microscope shows an infiltration of the part by embryonal cells in various stages of granular degeneration.
Submaxillary lymphatic glands progressively enlarged and indurated.	Glands not involved, or, at the most, a little swollen and tender.
Specific treatment useless or harmful.	Specific treatment curative.

Gummata of the soft palate, or of the palatine arch, usually result in a perforation of the palatine bones, causing a communication between the oral and nasal cavities. These gummata are slow and insidious in their onset.

The patient experiences no pain or discomfort. The soft palate is red, thickened, and either nodular in its entirety or at one point. The induration and thickening may be felt with the finger.

If the patient be asked to utter sounds requiring the assistance of the soft palate for their production—*ah*, for example—whilst the throat is being examined, it will be seen that the palate is elevated incompletely or not at all.

The immobility of the palate is a valuable symptom, and, taken in conjunction with the induration, the thickening, and the prominence often presented by the gumma itself, permits of an early diagnosis, which it is especially important to make as soon as possible in order to avoid perforation. If the patient be left without treatment, the gumma ulcerates and discharges, and if it be of the kind above mentioned, involving both the anterior and posterior mucous surface, complete perforation of the palate will follow with great rapidity, often taking place in a single day or night.

A gumma of the soft palate does not invariably give rise to perforation, especially if mixed treatment (see p. 172) be at once commenced. It may affect only one surface of the palate, and then it will heal without interfering with function. There may be even a small but complete perforation at the moment of the evacuation of the gumma, which will entirely heal.

Syphilis of Muscles.—Muscular syphilis is rare; it may manifest itself by contraction due to myositis, which at first appears to be idiopathic, as it is not accompanied by tumors or changes in size or apparent lesions; in other cases gummata develop in the interior of the muscles.

Syphilitic contracture of the muscles is chiefly an affection of the muscles of the arm, and more particularly of the biceps. It appears about six months to a year after the chancre. The first symptom is a stiffness of the elbow. Gradually extension becomes more and more limited, and the forearm remains flexed upon the arm at an angle varying from a large obtuse angle to one quite acute. No tumors or inequalities of surface are discoverable: if the muscle be examined during forced extension, it is found prominent and like a tightly-drawn cord.

It has been denied that this affection has any essential relation to syphilis, and it has been attributed to rheumatism, to traumatism, and to other causes. The weight of evidence is, however, in favor of its syphilitic origin; nine out of ten cases observed by Mauriac had a distinct history of syphilis and were accompanied by unmistakable eruptions, chiefly papular and papulo-squamous. He believes it to be a subacute myositis. In every one of six cases reported by Notta syphilitic symptoms were present. In none of them was there any association with rheumatism.

Gummata of muscles have a more important significance than these simple contractures. They consist of tumors, often of considerable size, which may discharge externally, may give rise in various ways to serious results, and may even invade the cardiac muscles. The tongue appears to be the muscle most frequently affected, and those of the sides and nape of the neck are often involved. Murchison has recorded a case of gumma of the diaphragm. Sometimes, instead of distinct tumors, a general infiltration occurs. White has seen a case in which all the posterior cervical muscles, including the trapezius, were thus infiltrated. Mixed treatment effected a rapid cure.

Syphilis of the Bones.—Among the most important and most common late effects of syphilis are the osseous lesions, which are often of much gravity. Both in adults and in children affected with hereditary syphilis the order, the seat of the lesions, and even the anatomical condition of the diseased bones,

are so characteristic that the diagnosis of syphilis is rendered easy. Osseous syphilis is met with during any of the periods of the malady.

The determining cause of the osseous lesion and of its seat, in tertiary as in secondary syphilis, is generally some form of traumatism, which is usually slight, but frequently repeated at the same point. It is owing to this fact that the superficial bones, as the frontal bone, clavicle, sternum, radius, tibia, etc., are the most common seats of the disease. Only the lesions of adults are here referred to. In cases of infantile syphilis traumatism is not the determining cause; the active development of the bones sufficiently accounts for the localization of the disease.

The lesions of the bones from an anatomical point of view are very numerous, varying from simple periostitis and osteitis to gummata; their final consequences also vary from the development of exostoses to the formation of sequestræ in pus-cavities.

The following lesions may be successively described:

1. Simple osteo-periostitis.
2. Rarefying osteitis.
3. Intense rarefying osteo-myelitis or gummatous osteo-periostitis.

Then the consecutive lesions of these different states, which are: formative osteitis or eburnation, the exostoses, the necroses, and the sequestræ; and finally the osseous lesions of infantile syphilis. (See p. 180.)

1. **Syphilitic osteo-periostitis** does not differ materially from ordinary osteo-periostitis. Limited to the superficial layers of the bone and the periosteum, it most frequently occurs at the end of the secondary or in the tertiary period, attacking the tibia, clavicle, sternum, bones of the head, etc.

2. When the inflammation is more intense there occurs a **rarefying osteitis.** The subperiosteal inflammation extends into the Haversian canals; the subperiosteal tissue and the osseous marrow contain numerous small cells with transuded red blood-corpuscles. These elements are free, with a small amount of granular intercellular substance. The original bone is eroded or destroyed. This lesion, which is observed so often in diseases of the phalanges and short bones, is named *spina ventosa*. It is frequently a result of syphilis.

3. **Gummatous osteo-myelitis** and **gummatous osteo-periostitis** are nothing more than a rarefying osteitis in which the abundant subperiosteal embryonal tissue or the medullary tissue assumes the arrangement that is observed in the gummata. The lesions are seen in the form of tumors, varying in size and having a tendency to become caseous. Gumma of bone is thus merely a circumscribed osteo-periostitis with destruction of the osseous lamellæ by a rarefying osteitis. It is the localization and form of the lesion which give it its distinctive characters.

The histological changes of the osseous tissue, as met with in the various forms of syphilitic lesions of the bones, therefore resemble similar lesions due to other causes. In osteo-periostitis there is a proliferation of the cells within the Haversian canals or the medullary elements of the bone which causes an increase in the size of these canals, the marrow itself becoming embryonic in nature. A continuation of this same process in a more intense degree results in the absorption of the osseous tissue, an enlargement of the Haversian canals, an increase in the amount of embryonal marrow, or, in brief, a rarefying osteitis, which in syphilis constitutes a gumma; that is, a gumma of bone is a localized intense osteo-periostitis in which there is a destruction of the osseous trabeculæ by the formation of granulation or embryonal tissue, which later undergoes retrograde metamorphosis and absorption. The bone in which the gumma or rarefying osteitis has been developed after the absorption of the

gummatous tissue takes on reparative action, and there occurs a formative osteitis, in which there is a new formation of osseous tissue, the process resembling that of the physiological development of bone. This process continuing, there results a condensing osteitis of the part, in which the laminæ surrounding the Haversian canals are increased to such an extent as finally to obliterate the lumina of the canals and cause a sclerosis or eburnation of the bone. An exostosis is nothing more than a slow formative osteitis, which results in the gradual addition of new osseous layers to the original bone; if the process becomes active there is produced an eburnation of the new-formed bone, or if very intense there occurs that form of osteitis known as rarefying, and if still more active there may even be a complete destruction of the new osseous tissue. It is thus seen that the several lesions occurring in bones, and due to syphilis, are, to a great extent, the continuation or stages of one process which varies in its intensity and results.

Symptoms of Syphilitic Osseous Lesions.—The osseous lesions of syphilis are not always recognized during life, but in ordinary cases, when subcutaneous bones are involved, the symptoms are well marked.

The essential symptoms of syphilitic osteo-periostitis are pain and swelling. The pain is peculiar in that it is more intense during the night than during the day. It is very acute at times. It prevents sleep, and by its persistence may become of considerable gravity. The slightest touch to the tumor causes exquisite suffering. After two or three days' treatment with iodide of potassium it is usually relieved and often is entirely removed.

The symptoms of syphilitic osteitis are very variable, depending upon the bone affected and its connections. They differ, of course, very much with the variations in form of the lesions, which, as has been explained, may vary from a simple swelling of the periosteum and bone to the suppuration and necrosis with fistulous tracts met with in intense gummatous osteo-periostitis.

The most simple and most frequent cases are those of osteo-periosteal tumors of the superficial bones—the tibia, clavicle, sternum, frontal bone, etc. The nodular swelling, the single or multiple nodes of differing size, and the special pain upon firm pressure or upon percussion, are all characteristic. The pain occurs spontaneously during the early part of the night, before retiring.

The periostoses of the clavicle are readily seen on account of the position of the bone, and most frequently are oval in shape, with their long axes parallel to the long axis of the bone.

Osteo-periostitis of the anterior surface of the sternum and of the bones of the cranium, when recent, generally appears as a flattened swelling, varying in size and of the shape of the segment of a sphere. It is then elastic to the touch, and may disappear under mixed treatment. Later, when an osseous formation is developed around its circumference, it feels hard at the margins, while its central part is relatively soft.

As regards bones in general, the differences between syphilitic and tubercular inflammations may be stated as follows:

Syphilitic Osteitis.	Tubercular Osteitis.
Syphilitic osteitis occurs in persons in varying physical conditions.	Osteitis of tuberculosis occurs in persons who have other symptoms of this disease.
Begins most frequently in the periosteum.	Begins in the medulla.
Tends to the formation of new bone or to necrosis.	Tends to disintegration of the parts.
Is often unaccompanied with suppuration.	Generally terminates in the formation of pus.
Does not involve neighboring articulations.	Apt to do so.
Frequent in bones of the cranium.	Almost never found in this situation.

Syphilitic Osteitis.	Tubercular Osteitis.
Histologically, consists of a relatively large mass of granulation-tissue.	Made up of a varying number of tubercle-granulations and surrounded by isolated granules.
In the majority of cases can be cured, or at least arrested, if taken in time, by judicious specific treatment.	We know of nothing short of operative interference which materially affects the course of this disease.

Syphilitic dactylitis occurs at various periods of the disease, and in two varieties. One of these appears usually in the late secondary stage, and involves chiefly the periosteum and the fibrous and integumentary tissues surrounding a joint. It is characterized by slow, almost painless, swelling and discoloration of the affected member. This is due to a gummatous infiltration, which, upon subsiding, leaves the finger or toe temporarily stiff, but not permanently disabled.

The second form is a specific osteo-myelitis with accompanying inflammation of the periosteum, and appears from five to fifteen years after the infection with syphilis. It is chiefly limited to the bones and periosteum, the integument being but seldom involved; erosion of the articular cartilages often takes place; the ligaments and the capsule become thickened, and the function of the joint is sometimes entirely lost.

The absence of acute symptoms in the subcutaneous variety enables us to diagnosticate it from paronychia, whitlow, and gout. Rheumatoid arthritis begins in the joints, is associated with other symptoms, deformity of the fingers comes on early in the disease, and the sheaths of the tendons are involved.

The second variety might be taken for enchondroma or exostosis, but these swellings involve only a limited portion of the bone, increase very slowly, and present dense, circumscribed tumors.

Syphilis of the Nervous System.—The **dura mater** is frequently the seat of tertiary syphilis, chiefly owing to its intimate connection with the cranial bones, toward which it bears the relation of a periosteal lining. The internal surface of this membrane, in contact with the pia mater and with the surface of the brain, is frequently attacked at the same time—an accident which manifests itself by various cerebral symptoms: intense cephalalgia, trembling, dulness, intellectual torpor, loss of memory, and coma.

Besides these peri-encephalic lesions, the pia mater, and even the brain-substance and the spinal cord, may be the seat of sclerosis or of gummata.

The **pia mater** presents two varieties of lesions: A chronic inflammation, followed by fibrous thickening and by adhesions to the surface of the brain; and gummata, lesions much more characteristic than the foregoing.

Cerebral gummata may be found in two forms:

1st. As large gummatous masses developed on the surface of the brain within the convolutions and in the gray substance or encroaching upon the white substance, and usually attacking the base, the cerebral peduncles, the pons Varolii, and the optic tract. They are also found upon the cerebellum and upon the superior surface of the cerebrum.

2d. In the form of smaller nodules accompanying the cerebral arteries, and in particular the middle cerebral arteries.

These two varieties of syphilitic lesions do not differ materially as regards their structure; their evolution is slightly different. The latter are generally accompanied by endarteritis, which results in a limited anemic softening of the brain.

Symptoms of Cerebral Syphilis.—The symptoms depending upon the

different alterations of the meninges, of the brain, and of the vessels differ, it is needless to say, according to the region of the brain which is affected by them. The lesions of the dura mater, of the pia mater, and often those of the cranial bones, coincide with gummata or with more or less extended softening in such a manner that multiple manifestations have to be analyzed and explained. Despite these difficulties, the progress of these encephalopathies, a certain number of characteristics which appertain to them, and, in doubtful cases, the antecedents of the patients and trial of the iodide treatment, will ordinarily indicate their nature.

The most common initial phenomenon is headache, which is frontal, occipital, or parietal, very intense, often worse during the night, and accompanied frequently by vertigo and mental dulness, and sometimes by convulsions. This pain is at times intolerable, or, on the contrary, there may be a stupor resembling coma. The headache may last for a long time before any other symptom shows itself. If syphilis has been suspected from the antecedents of the patient, and iodide of potassium has been given with the result of lessening the pain or causing it to cease, the diagnosis is assured. During the headache the patients often experience a diminution of their intellectual faculties, forgetfulness of certain words or of their actions of the day before, etc. Different forms of paralysis supervene. They are at first very limited. The nerves at the base of the cranium are those most frequently attacked. The paralysis of muscles supplied by the common oculo-motor nerve produces, for example, external strabismus, diplopia, etc. The diminution of the sense of taste, and even its complete abolition, the loss of the sense of smell, the diminution or the loss of hearing, have also been noted. The disturbances of vision are exceedingly variable, and depend upon the seat of the lesion—whether it is localized in the cuneus, in the optic tracts before their intercrossing, at the optic chiasm, or upon the optic nerves beyond the chiasm. Subjective symptoms are observed, such as *muscæ volitantes*, circles of fire, etc., the perception of only a portion of objects, hemianopsia, or a partial or total loss of vision. These conditions are frequently cured by iodide of potassium.

The partial paralysis first shows itself in a limb—in the lower extremity of one side, for example—and is followed by amelioration if iodide of potassium employed in time has produced its curative action; if the lesion continues its progress, complete hemiplegia may supervene. This is generally progressive, slow at the commencement, with incomplete aphasia, especially if the paralysis is on the right side. These cases of hemiplegia are not accompanied, like those of copious hemorrhages or of apoplectiform softening, by a total loss of consciousness. Patients preserve, on the contrary, to a great extent, their consciousness, as is the case in certain forms of cerebral softening, and the paralysis affects only the power of motion. Finally, along with several other phenomena connected with the intelligence or the power of motion, convulsive symptoms often predominate—veritable attacks of epilepsy.

The **diagnosis of cerebral syphilis** is based less upon the symptoms taken singly or in groups than upon the progress of the affection and upon the therapeutic action of iodide of potassium. An intense headache of long duration, which is cured or benefited by the iodide, but relapses, and which is accompanied by loss of memory, hebetude, slight paralysis; then a paralysis very slow in progress, ending in hemiplegia, aphasia, and epileptiform convulsion,—such are the symptoms upon which the diagnosis is established. These symptoms are slow in showing themselves, and they grow more intense very gradually. At their commencement they are benefited or cured by the iodide of potassium. Each of them presents some characteristic peculiar to

syphilis in such a way that recognition of the cause is possible in the great majority of cases. The diagnosis from apoplexy and softening is generally easy. The sudden onset of an attack with absolute loss of consciousness and complete hemiplegia excludes the idea of syphilis. It is more easy to confuse it with chronic softening; but in syphilis there are the violence of the headache, the effects of the iodide, the epileptiform convulsions, and especially the presence of old syphilitic lesions. Cerebral tumors are easily confounded with syphilis, but the consideration of cerebral tubercle is unnecessary, as it is an affection of infancy. Sarcomata might be mistaken for gummata; however, they are exceedingly rare, and the symptoms which characterize them are progressive, without its being possible to benefit them by the iodide treatment.

The **prognosis of cerebral syphilis** is very grave.

Syphilis, when it affects **the spinal cord**, may involve the meninges by a specific pachymeningitis, or the cord itself may be invaded by gummata originating either in its substance or in the membranes. The symptoms are those connected with pressure upon or degeneration of the cord itself, and the diagnosis is to be made chiefly by the presence of concomitant lesions of syphilis or by the effects of treatment. The interesting question of the relation of locomotor ataxia to syphilis is not yet settled, but there is enough evidence to justify the following recommendations:

In every case of ataxia careful and minute search should be made for evidences of antecedent syphilis, either acquired or inherited. If this be found to have existed, the patient should be placed at once upon vigorous specific treatment, and should be directed to continue it through long periods. If only a fair presumption of previous syphilis exist, the same treatment should be employed, as it would, at the most, be useless, but not hurtful. If the disease be recognized in its earliest stages, and found to be associated with syphilis, and treated in this manner, a prognosis may safely be given of a more favorable character than at present seems justifiable in any other variety or under any other mode of treatment.

Unlike cerebral syphilis, in which the question of operative treatment is often discussed, **syphilis of the intestinal tract** in the adult has little interest for the surgeon. The involvement of the liver, and especially that of the spleen, in newborn children are of great diagnostic importance, but will be fully considered in the chapter on Hereditary Syphilis.

Syphilis of the respiratory tract is of greater surgical interest and importance, on account of its relation to the larynx, where it may simulate carcinoma or tubercle.

Some help in the diagnosis of tertiary ulcers of the larynx from those of pthisis and cancer may be found in the points which have been tabulated as follows:

Syphilis.	Phthisis.	Cancer.
Development of ulcer acute, occupying only a few days.	Development slow; follows throat symptoms after several months.	Intermediate in time; appearance of ulcers in a few weeks.
Considerable irregular inflammatory or œdematous swelling.	Uniform, pale swelling, looking like an infiltration.	Nodular excrescences and acute inflammation of neighboring mucous membrane.
Epiglottis affected, if at all, on upper surface.	Lower surface.	No uniformity.
Ulcer solitary; rarely more than two.	Numerous.	Solitary.

Syphilis.	Phthisis.	Cancer.
Proceeds from center to periphery, or from above downward.	The reverse is true.	Irregular in their course.
Deep, round, or oval.	Generally round.	Irregular in shape.
Diameter of 1 to 1½ centimeters.	2 or 3 millimeters.	2 or 3 millimeters.
No cachexia.	Phthisical appearance.	Cachexia.
Treatment usually highly beneficial.	Treatment has but very moderate effect.	No effect.

Syphilis of the Testicles.—Syphilitic lesions of the testicles may consist in gummatous nodules of the epididymis, which appear at the end of the secondary period, or later in orchitis, which may be either interstitial or gummatous. There is also a syphilitic interstitial orchitis of newborn children.

Gummata of the Epididymis.—Toward the end of the secondary period there is occasionally observed upon the epididymis a limited induration, generally at its head, varying in size from that of a bean to that of a walnut or larger, connected with the testicle, hard and indolent. More rarely it is situated upon the body of the epididymis. It may be uni- or bilateral. There is no accompanying affection of the tunica vaginalis or of the skin. The tumor very soon disappears under treatment by mercury and iodide of potassium.

Interstitial Orchitis.—Interstitial orchitis of the adult belongs to the period of the later tertiary lesions. It seldom occurs before the third year. It may affect one or both sides. The testicle is the seat of a chronic interstitial inflammation. The epididymis is seldom affected; if it be involved, it is its head that is changed. At the beginning of interstitial orchitis the gland is a little larger than normal, but its shape is retained. If the disease is not treated, the gland gradually atrophies, still remaining indurated. There is frequently a notable effusion into the tunica vaginalis, which is inflamed.

The following table clearly presents the main points of difference between syphilis, encephaloid carcinoma, and tubercle of the testicle:

Syphilitic Orchitis.	Encephaloid Carcinoma of Testicle.	Tubercular Orchitis.
Syphilitic history.	No history of any special condition.	Tubercular history.
Usually occurs at about twenty-five or thirty years of age.	Any age.	Not often seen after thirty.
Begins in the testicle.	Begins in the body of the organ.	Begins in the epididymis.
Is situated primarily in the connective tissue.	Begins by the deposit of small nodules in the seminiferous tubules.	Exists primarily in the tubules.
Tends to fibrous overgrowth.	Tends to formation of patches of softened, white, pultaceous material.	Tends to fatty, caseous, or purulent degeneration.
Slow in its progress.	Rapid in its course.	Slow in its progress.
Skin of the scrotum rarely involved.	Skin of the scrotum finally involved.	Skin involved only just before the formation of abscess.
Ulceration or suppuration rare.	Ulceration and fungus common.	Suppuration common.
Fistulæ uncommon.	Fistulæ common.	Fistulæ common.
A feeling of great weight, with only such pain as results from dragging on the cord.	Pain severe and lancinating in advanced stages.	Little pain.

Syphilitic Orchitis.	Encephaloid Carcinoma of Testicle.	Tubercular Orchitis.
Tumor very hard, uniform.	Soft and fluctuating.	At first hard, knotty, irregular.
Skin of scrotum purplish, but unaffected.	Network of large veins over surface of tumor.	Skin congested, but otherwise unaffected.
Of moderate size; rarely exceeds twice its normal diameter.	Attains great size.	Of moderate size.
Painless on pressure.	Painless on pressure.	Often painful on pressure.
Both testicles often affected.	Generally only one testicle affected.	Often both testicles affected.
Fungus rare.	Fungus always present in advanced stages.	Fungus common.
No discharge or bleeding.	Bleeds freely; offensive discharge.	Not so apt to bleed; discharge not so offensive.
Lasts many years.	Rarely extends beyond twenty months.	Lasts several years.
Curable.	Usually fatal.	Generally incurable.
No involvement of inguinal glands as a rule.	Inguinal, iliac, and lumbar glands and cord affected.	Usually no inflammation of glands.

TREATMENT OF SYPHILIS.

The prejudice which for many years existed against the employment of mercurials in syphilis has largely disappeared. A careful and impartial review of the testimony as to the results of the mercurial and of the non-mercurial treatment of syphilis will prove convincingly the far superior efficacy of the former method. Without denying that certain cases of syphilis do well without any treatment or with simple attention to hygiene, diet, etc., or even while admitting that in the majority of instances at the present day the disease tends to a spontaneous cure, it may still be considered as well established that, without detriment to health, the probability of that cure can be increased and the duration of the active stage of the malady lessened by a careful administration of some form of mercury. Similar, though not quite so conclusive, evidence exists in favor of a continuous as opposed to an intermittent plan of treatment, although various circumstances may render the latter desirable. The reasons which have been advanced for the employment of mercury in syphilis are—

1. The clinical evidence of its usefulness in the control of early symptoms and the prevention of later developments. 2. Its "tonic" action, which, by counteracting the anemic tendencies of syphilis, lessens the severity of the disease. 3. Its action as a physiological antidote to the syphilitic poison, which it destroys probably through its antibacterial or germicidal power. 4. Its properties as a promoter of destructive metamorphosis and fatty degeneration, through which it renders possible the absorption and removal of the new cell-growth which causes the secondary symptoms.

With regard to the beneficial influence of the iodides in the later stages, a therapeutic fact established beyond all possibility of contradiction, a similar diversity of opinion as to their mode of action prevails. A tonic effect is again claimed as one of the causes of the good results obtained by the administration of these preparations. The views held as to their modus operandi will depend upon the particular theory of the tertiary stage which is adopted. However this may be, the clinical evidence is quite sufficient to justify the employment of these drugs, and the proper methods of administering them may be epitomized as follows, beginning with the appearance of the initial lesion:

1. Do not employ mercurial treatment until either by confrontation or by the development of constitutional symptoms the diagnosis of syphilis is assured.

Mercury always retards the appearance of the secondary symptoms, and sometimes prevents it altogether. As no venereal sore can with absolute certainty be pronounced syphilitic, it is unwise to add an element of uncertainty to the case by delaying indefinitely the outbreak of unmistakable symptoms. There is sufficient evidence to prove that the subsequent course of the case is not materially affected by this delay. 2. When the time has arrived for the administration of mercury, it is well to explain to the patient the necessity for long-continued treatment and to point out the risks of neglect. Having done this, in the majority of cases the most satisfactory method of giving the drug will be by the mouth, a useful preparation being the protiodide of mercury in pill form, in the dose of $\frac{1}{4}$ to $\frac{1}{3}$ of a grain, three or four times daily:

℞. Hydrarg. iodid. vir., gr. xx;
Confect. rosæ, q. s.
M. et ft. pill. no. lx.

If these should disagree with the stomach and produce dyspeptic symptoms, or should give rise to colicky pains and diarrhea, from $\frac{1}{20}$ to $\frac{1}{12}$ gr. of opium may with advantage be added to each pill. At the same time a saturated solution of chlorate of potassium should be given as a mouth-wash, to be used twice daily as a prophylactic against salivation. 3. To ascertain the proper dose of the drug in each individual case, continue gradually to increase the dose until slight tenderness of the gums or of the posterior molars is noticed. Then diminish it to two-thirds, or even to one-half, of that dose, when its further administration for an indefinite period will be possible with no unpleasant results. 4. If the preparation selected agrees with the patient and controls the symptoms, and if there are no intercurrent complications, pursue this treatment continuously for two years. If, however, the protiodide gives rise to persistent bowel trouble, as it does in a small number of cases, substitute for it the bichloride in solution or in combination with a tonic:

℞. Hydrarg. chlorid. corros., gr. iss;
Tinct. cinchonæ co., f℥iv.
M. et sig. One teaspoonful in water after meals.

Hydrargyrum cum creta in one-grain doses four to six times daily is a very useful preparation in cases of gastro-intestinal irritability. A half-grain to a grain of Dover's powder added to each dose will often control any tendency to diarrhea. In some cases of irritable stomach, or when it becomes desirable to intensify the mercurial influence, *inunction* should be employed, and it is a useful addition to the routine treatment of every case of syphilis. If once in six weeks or two months the administration of mercury by the mouth be intermitted and a dram of mercurial ointment rubbed into different portions of the cutaneous surface once daily for a week, it intensifies the mercurial influence without affecting digestion or nutrition. The uncleanliness of the procedure and the almost certain eczematous irritation of the skin which it produces render it unsuitable for long-continued use. *Vapor baths* of mercury may be taken in various ways, the simplest being the volatilization by means of an alcohol lamp of a dram of calomel, the apparatus being placed beneath a chair upon which the patient sits, a blanket extending from his shoulders to the ground serving to retain the fumes in contact with his body. 5. By whatever method the mercurial influence is kept up, the dose should be temporarily raised whenever new

symptoms make their appearance, and, after they have vanished, should be dropped to the standard dose for the particular patient. 6. The local treatment of symptoms is of secondary importance, and altogether subservient to the constitutional treatment. It may, however, be useful as an adjuvant. Mucous patches should be treated with sulphate of copper or nitrate of silver if on mucous membranes; when on cutaneous surfaces they should be dusted with powder of starch and calomel or of calomel and lycopodium. The scaly and tubercular syphilides will be benefited by the application of a salve consisting of equal parts of citrine ointment and cosmoline, or by ammoniated mercury and cosmoline, two drams to the ounce, or by any other stimulating and absorbent ointment. Ulcers may be dressed with iodoform, or, when sluggish, touched with nitrate of silver or acid nitrate of mercury. Enlarged glands may be painted with iodine or let alone; they rarely run on to suppuration. 7. At the end of two years small doses of iodide of potassium should be added to the mercurial, and this "mixed treatment" should be persevered in for six months longer. If during this period any symptom of syphilis makes its appearance, the six months of mixed treatment should be dated from that time. In other words, some such formula as this:

℞ Hydrarg. biniodid., gr. ij;
Potass. iodid., ʒij;
Syr. sarsaparillæ co.
Aquæ, āā. fʒiij.
M. et sig. A dessertspoonful in water after each meal,

should be administered for the last six months of the treatment, and should be recommenced and continued for six months if any symptoms appear later. Great care should be taken to give the mixture largely diluted, and so to vary it as to do away as far as possible with any irritation of the intestinal tract. In obstinate tertiary conditions the dose of the iodide may with impunity be run up to twenty, thirty, or sixty grains, or even more, four times daily. If this be done, the cases which refuse to come under its control will be very rare. 8. At the end of two and a half years the patient should be kept under observation for another full year, and if during that time no symptoms are developed, he may consider himself as in all probability cured. If such symptoms do appear, however, he should recommence treatment, and should continue it for at least six months after their subsidence.

CHAPTER XVIII.

HEREDITARY SYPHILIS.

THE most important points bearing upon the general subject of hereditary syphilis may be enumerated as follows:

I. Is syphilis transmissible in all its stages (*a*) to the wife or husband, or (*b*) to the offspring? In other words, is it ever proper to consent to the marriage of a person who has had syphilis? If so, under what circumstances?

II. By what means or through what channels can the disease of the parents reach the child?

III. What are the pathology and symptoms of hereditary syphilis?

IV. What is the treatment—(*a*) prophylactic, applied to the parents, (*b*) curative? We shall take these up seriatim.

I. Is Syphilis Transmissible in All its Stages?—No more important questions can be submitted to the surgeon than those pertaining to the marriage of syphilitics. Involving as it does the welfare of many individuals, modifying or fixing the conditions of one or more lives, his opinion should be exceptionally definite and well grounded.

There are two distinct methods of arriving at an answer to the question under discussion: First, by considering the probabilities in regard to the essential nature of syphilis; and second, by carefully weighing the clinical evidence in the matter. It seems evident that belief in any particular theory of syphilis, assigning it to this or that class of disease, must have an important influence in determining the opinion which is held as to its curability, or, at least, as to its indefinite transmissibility.

In regard to the first, the main point is the recognition of the fact that modern syphilographers, as a rule, regard the tertiary or late symptoms as indicative of damage done during the active period—as relapses or sequelæ, and not as fresh outbreaks of a highly contagious and transmissible disease. Their time of appearance, their entire want of symmetry, their non-contagiousness, their non-inoculability, all favor this view, and much corroborative evidence may be obtained from clinical facts.

It is necessary to admit that there seems to have been but little doubt in the minds of many syphilographers that in rare instances syphilitic children have been born to parents who had long passed the limits of the secondary period. At least, the majority of writers upon this subject speak confidently of the exceptional occurrence of such cases, and assert that syphilis may be transmitted during any of its stages. If, however, we look for positive evidence in this respect, we shall find very little that is entirely satisfactory. Cases are reported, to be sure, in which eight, ten, twelve, or even fifteen or twenty years after the primary sore, syphilitic patients have become the parents of children who showed unmistakable indications of the disease. When we examine the history of these cases, we find usually that many important points have been omitted without which it is impossible to be certain of their true character. Were both parents originally affected? If not, has a recent case of syphilis occurred in the one who at first escaped? If they were both diseased originally, has either been subsequently re-infected?—a much more frequent accident than has been commonly supposed. On applying these tests it will be found that few if any are thoroughly convincing.

Fournier, whose immense experience and acuteness of observation entitle his opinion to the utmost consideration, says that in cases of paternal heredity the duration of the power of transmission never exceeds, at the maximum, three or four years. Of the many hundreds he has observed, in no case has he known a syphilitic father to infect a child—the mother being healthy—at a later period than the one mentioned. And he is equally positive that the gradual diminution and final extinction of the syphilitic reaction of the parents upon the children constitute a veritable pathological law, "absolutely demonstrated." Mr. Hutchinson says: "It is almost an acknowledged law that parents in the late tertiary stages do not transmit taint."

These quotations indicate what is now the prevailing view—viz. that the period of transmissibility of syphilis is more or less strictly limited even when the disease is allowed to progress without treatment. As to the fact that it becomes milder with time, so that with each succeeding year after the termination of the secondary period the chances of escape of the product of conception

increase in a rapidly augmenting ratio, there is no difference of opinion whatever. Neither is it seriously disputed that the length of time during which the disease remains active, as well as the degree of its activity, may be markedly influenced by treatment. Under proper medication patients who have married in the height of the secondary period have had children born healthy who never subsequently manifested any symptoms of the disease.

We may therefore assume safely that syphilis after a certain period, not extending much over four years where the disease is allowed to run its own course, and probably somewhat reduced by treatment, ceases to be a contagious disease, and at about the same time or somewhat later loses, in the majority of cases, its capability of being transmitted by parent to offspring. As there are probably exceptions to the rule that this power of transmission disappears spontaneously within any specified time, it is never safe to trust altogether to nature, but a vigorous and sufficient specific treatment must be employed.

Given, however, the lapse of a sufficient time—say from three to four years as a minimum—and the history of a proper and continuous plan of treatment, the risks of marriage are so reduced as to warrant a careful surgeon in permitting it. And, conversely, of course in any doubtful case where such a history can be elicited, and where all these precautions have been observed, it is improbable that any taint of syphilis has been transmitted. Beyond this in positiveness it is not safe to go. There may be exceptions to these as to most other hygienic or therapeutic rules, but they will be of excessive rarity.

Before considering the methods by which syphilis can reach the child from one or the other of its parents, it may be well to mention the modes in which the parents can infect each other.

The *man can derive syphilis from the woman* only in the usual way—*i. e.* by contagion through a breach of surface permitting of the direct absorption of the poison, the development of the disease being attended by the usual phenomena—chancre, lymphatic enlargement, skin eruptions, etc. The *woman* may—and in the majority of cases does—acquire the disease from the man in a similar manner. But the *mother* may also become infected through the medium of the child, which receives its syphilis directly from the father, the mother up to the time of conception having escaped contagion. More than this, it appears to be highly probable that no woman ever bears a syphilitic child and remains herself absolutely free from the disease.

No surgeon of large experience in this class of cases can fail to have seen some in which the husband, having had syphilis and having married after an insufficient interval or an imperfect course of treatment, has infected his wife with the disease, although at the time no discoverable symptom is to be found upon his body. An equally careful inspection of the woman will also in such cases be attended by negative results as regards the primary sore, and yet she will be found with unmistakable evidences of constitutional syphilis. There is a clue to all such cases which will immediately resolve the difficulty. In every instance, provided that no mistake has been made and that both husband and wife are really free, the one from any contagious lesion, the other from any evidence of a present or previous primary sore, it will be found that pregnancy has occurred; that the woman has either been delivered of a syphilitic child or has had an abortion or miscarriage at some time before the outbreak of the symptoms of syphilis. Another argument lies in the application to the case in question of the well-known "law of Colles," which, from the date of its first enunciation in 1837 down to the present day, has been found to be absolutely without exception. It may be given in his own words: "One fact well deserving our attention is this: that a child born of a mother who is

without obvious venereal symptoms, and which, without being exposed to any infection subsequent to its birth, shows this disease when a few weeks old,—this child will infect the most healthy nurse, whether she suckle it or merely handle and dress it; and yet this child is never known to infect its own mother, even though she suckle it while it has venereal ulcers of the lips and tongue." As to the absolute and unvarying truth of this law there is not a shadow of doubt. There can be but one rational explanation of these facts—viz. that the mothers who have thus acquired immunity have done so by first acquiring the disease through pregnancy.

We may conclude, then, that the husband may infect his wife—(1) In the usual manner or by direct contagion; (2) through the medium of the child, or at any rate by the production of conception.

There is no proof whatever that the *semen of a syphilitic man* is contagious or can transmit the disease in any way but that above discussed. On the contrary, it has been shown experimentally that it is entirely non-inoculable. All other theories as to methods of contagion are so entirely hypothetical and unsupported by trustworthy evidence that we can afford to disregard them.

II. We may now consider **the ways by which syphilis reaches the child.** These may be broadly classified into—

1. Descent from the father; 2. Descent from the mother; 3 Direct infection.

As a matter of course, the influence of the father upon the child, so far as regards heredity, ceases at the moment of conception, or, to be more exact, no subsequent condition of the male parent, no development or acquirement of disease, can exert any further effect. That the existence of active syphilis in the father may result in the transmission of the malady to the child cannot be doubted. The relative effect of paternal as compared with maternal influence may be considered after we have described the latter.

2. Descent from the mother may occur theoretically in consequence of—

a. Infection of the mother previous to conception; *b.* Infection of the mother at the moment of conception; *c.* Infection of the mother during the period of utero-gestation.

a. As to the first of these methods of transmitting the disease there is little if any difference of opinion. Even those who claim the most for paternal influence include among the conditions which may give rise to syphilis in the child disease of the ovule, and it may be stated as incontrovertible that recent or active syphilis in the mother at the time of conception will almost certainly be followed by syphilis in the child. The cases in which treatment of the father has resulted in healthy children, whereas without treatment he procreated syphilitic children, the mother being without either symptom or treatment, have been urged as evidence of the direct descent of syphilis from the father to the child without the intervention or participation of the mother. But it does not follow because the mother has latent or hidden syphilis that she must infect her child. In those cases in which she does not do so the treatment of the father will remove the only active source of syphilitic infection.

b. The second method, or that in which the mother becomes syphilitic at the moment of conception, is really, strictly speaking, an example of paternal heredity, as the resulting germ is syphilitic, not because the ovule of the mother was infected, but on account of the disease of the spermatozoid of the father.

c. There remains for consideration the influence upon the child of a syphilis acquired by the mother during some period of utero-gestation. That under

these circumstances the child can become infected has been and is still absolutely denied by some very respectable authorities. All that is necessary for proof of its occurrence is, however, (1) freedom of both parents from syphilis at the time of conception, or, in other words, syphilis must have been acquired by both—not alone by the mother—after the beginning of pregnancy; (2) that the syphilis of the child be unmistakably prenatal—that is, not acquired by some accident during or after birth. Several cases reported by acute observers seem to combine both these requisites, and, after reading them carefully, there seems to be no reasonable escape from the conclusion that in some manner the poison of syphilis may find its way from the mother to the child. The old idea that the latter was directly infected in utero from the semen of the father is, of course, altogether without foundation.

3. Direct infection of the child during birth does not properly come under the head of Hereditary Syphilis. There is no possible reason why, when the mother has contagious lesions of the genitals, acquired too late to infect the child in utero, this should not occur, but as a matter of fact no such case has ever been recorded. One explanation of this circumstance may be found in the protective covering of vernix and mucus which coats the infant's body and lessens greatly the risk of absorption. This hardly accounts satisfactorily, however, for the entire absence of such cases from medical literature, and it is fair to suppose that in all except those cases in which the primary sore is acquired during the last month of gestation—which for obvious reasons are excessively rare—the infant acquires some immunity which protects it from its mother, and is similar to that which, under Colles's law, operates in her favor. In other words, even though apparently free from syphilis at birth—a not uncommon event, as we shall see—it has a latent or modified syphilis which protects it from contagion. (Profeta's law, see p. 136.)

We may now briefly restate the conclusions at which we have arrived:

1. After a certain interval, not less than four years, and after thorough specific treatment, a person who has contracted a syphilis not especially severe or malignant in its type may be permitted to marry. The assent to marriage will then be based on a belief in the curability of syphilis or in a cessation of its contagiousness, its inoculability, and, in the vast majority of cases, its transmissive power, at the end of the secondary stage.

2. It may be inherited from either parent or from both, and the probability that this will occur increases in a direct ratio with the nearness of the time of conception to the date of their infection with the disease. The severity of the inherited disease in the child increases in the same proportion.

3. It is undoubted that, the father being healthy and the mother syphilitic, the child may, and in all probability will, have the disease.

4. It is probable, but less so than in the preceding case, that, the mother being healthy and the father syphilitic, the child will be infected.

5. It is highly probable that in all cases where a child becomes syphilitic through paternal influence the mother is also the subject of syphilis, which may, however, assume a latent form, the only evidence of its presence in a few cases being the protection which it affords against contagion through the medium of the child.

6. Syphilis may be transmitted from mother to child even when it is acquired by the former as late as the seventh month of utero-gestation.

III. **The Pathology and Symptoms of Hereditary Syphilis.**—*Syphilis of the placenta* is of especial interest in its relation to the abortions and stillbirths so frequent in syphilis. Under the influence of that disease cell-proliferation begins in the villi, which are, normally, only sparingly supplied with

cells, and extends to the connective-tissue stroma and the epithelium. This proceeds to such an extent that it leads to compression of the vessels, and finally obliterates them. The vascular spaces into which the villi dip become filled up and narrowed, and often disappear. In this way, and also by reason of the thickening of the epithelium, the interchange between the maternal and the fœtal blood is interfered with, and at last is prevented. If this process is spread over the whole placenta, the fœtus perishes before it is complete. If it is limited to circumscribed areas, it may continue to live for a shorter or longer period.

Syphilis in the parents will manifest itself in the children in one of several ways, which are determined chiefly by two factors—viz. first, the length of the interval between the infection of the parent and the date of conception; and, second, the thoroughness of the treatment of the parents during that interval. To these may be added as subsidiary, but still of definite importance, a third, the type of disease which has affected the father or the mother, whether mild or severe, benign or malignant.

From what has already been said in reference to the question of marriage, it will at once be understood that the danger to the offspring in untreated cases, and in those where conception has occurred during the early secondary period of the disease, is of extreme gravity. In such cases the usual result of pregnancy is abortion at from the first to the fifth or sixth month, the fœtus sometimes exhibiting the evidences of syphilis in the shape of large bullæ upon the palms and soles, or in the presence of characteristic visceral lesions, but quite as often showing nothing distinctive. It has generally undergone more or less maceration, and the skin, which is readily detachable, is of a congested, purplish color. At least one-third of syphilitic children are dead-born. As time goes on and other pregnancies follow, either the abortion occurs at a later period of pregnancy or the children are brought alive into the world. Even then, however, and although at birth they may show no evidences of the disease, their chance of escape is but small. One-fourth of them die within the first six months. If they survive that period, the chances for life are slightly in their favor, but those for health or for freedom from deformity and disease are still overwhelmingly against them.

The Primary Stage is never found in true hereditary syphilis. Of course in congenital or infantile syphilis, in which by direct contagion, either from the mother or from any one else, the disease was acquired by the child, the course would not differ materially from that observed in the adult, and the primary sore would be present. But as this stage of acquired syphilis corresponds to the period during which the poison is finding its way into the system through the lymphatics, it is not found in the child who is infected from the moment of conception or who receives the poison from the mother directly into the circulation.

The Secondary Stage.—For from one to three weeks the newborn infant often shows no symptoms of the disease. In 158 cases collected by Diday, 86 manifested symptoms before the expiration of the first month, and 60 of the remainder before the end of the third month. When to these are added the statistics of Roger, we find that of a total of 172 cases 159 showed syphilitic symptoms before the end of the third month. When these symptoms are present at birth, they consist largely in a general withered, atrophied, weazened appearance of the child; a hoarse cry, due to swelling, with subacute inflammation, or even ulceration, of the laryngeal mucous membrane; a coryza, due to a similar condition of the Schneiderian membrane; and

certain cutaneous eruptions, the most common of which at this early date is the large vesicular or bullous eruption known as syphilitic pemphigus.

Pemphigus.—With regard to the specific or non-specific character of this eruption there has been much difference of opinion, and, as it is often the earliest distinctive expression of syphilis, a diagnosis of which could hardly be founded on the general appearance of the child, or even on the hoarse cry and the coryza, it becomes important to have definite ideas upon the subject. Nearly a century ago it was denied that this eruption was a manifestation of venereal disease; and this view has found supporters down to the present day. The progress of clinical and pathological knowledge enables us now to assert, however, that although, as an exception, bullæ may sometimes be due to a profound cachexia not dependent on syphilis, yet in the large majority of cases they are specific in their character.

If we find an infant at or immediately after birth presenting on the soles, the palms, the fingers and toes, or on the limbs an eruption consisting of blebs more or less perfectly distended with a liquid which may be clear, cloudy, or bloody, circular or oval in shape, sometimes irregular, seated on inflamed, reddish skin, and surrounded by trifling areolæ, we may strongly suspect the presence of syphilis in an active and most menacing form. And this suspicion becomes a certainty if, in combination with such an eruption, the general cutaneous surface is yellowish or muddy in hue, is hard and dry, without elasticity or softness—owing to the absence of subcutaneous fat—and, for the same reason, is furrowed and wrinkled about the face, imparting an appearance of senility; if the child has a hoarse cry, and a discharge from the nostrils; and, of course, if there are at the same time other syphilodermata. This eruption is specially important, however, because upon the recognition of its specific character in cases of stillbirth or in those in which the child survives only a few days—not long enough for the development of further symptoms—will depend the opinion as to the cause of death, which, whether expressed or not, will determine the future treatment of both parents during the interval between pregnancies and of the mother during the next pregnancy.

Coryza is one of the most characteristic, and at the same time one of the most important, of the early symptoms of syphilis in its influence on the health of the child. It is due to the same condition of the mucous membrane lining the nasal fossæ which manifests itself simultaneously or soon afterward on the skin in the shape of erythema, roseola, or papules; in other words, it is a hyperemia with papillary infiltration. The excessive supply of blood to the parts induces a catarrhal condition which shows itself in a thin, watery discharge. As the child during suckling is compelled to breathe through the nose, this discharge is rapidly dried into crusts, causing the peculiar nasal, noisy respiration which has given the affection the popular name of *snuffles*.

Roseola is apt to present itself about the second or third week after birth. As in the adult, it begins upon the abdomen in the form of little oval, circular, or irregular spots, dull red in color and disappearing upon pressure. Later the color becomes deeper, the eruption extends to the trunk and limbs, and, as exudation and cell-proliferation succeed to simple capillary stasis, it ceases to disappear when pressed upon. It is often moist, and sometimes excoriated, owing to the thinness of the epidermis. Occasionally it is confluent, and covers large areas with an almost unbroken sheet of deep-red color.

The *diagnosis* in the early stage is often difficult on account of the resemblance to the simple erythema of infancy. As the disease progresses, however, maculæ form here and there; the cell-infiltration involves the papillæ, several of which coalesce, forming flat papules; the nutrition of the superficial layers

of the epidermis is interfered with, especially where it is thick, as on the palms and soles, and the eruption in these regions becomes scaly: and then the diagnosis is not difficult.

Papules and Mucous Patches.—In the ordinary evolution of the disease the next manifestation is usually the development of papules on the general cutaneous surface and of mucous patches on the tongue, lips, and cheeks; probably also on other mucous membranes not exposed to examination. The papules for the reason already mentioned—the thinness and moisture of the skin—are apt to be of the broad, flat kind, especially, as in the adult, in those regions where the elements of warmth and friction are superadded to moisture, as in the folds of skin about the genitalia, the neck, the flexures of the joints, etc. They are then moist, covered with a grayish secretion or a thin crust, and are in reality mucous patches. Mucous patches in the infant are among the most important of the early syphilitic lesions, as they are almost constantly present, and *thus constitute by far the most frequent vehicle for conveying the disease from the child to its nurse or to others with whom it may come in contact.* No child that has even been suspected of having a taint of hereditary syphilis should be permitted to nurse at the breast of any one but the mother, or to share its cup or nursing-bottle with other children, or to receive the caresses of relatives or friends; and in this last restriction we should include the father. The mucous patches should be actively treated both locally and constitutionally, and during their demonstrable presence a most rigorous quarantine should be observed.

Syphilitic condylomata are due to hypertrophic changes in the papules, which under the influence of heat and moisture in certain regions coalesce and become more elevated. They vary in size from an eighth to a quarter, or even a half, of an inch in diameter. Their surface is flat and covered by a crust or by an offensive secretion. They are found most commonly about the anus or at the angles of the mouth.

Pustular Syphilides.—A little later in the secondary period, usually at about the sixth week, but sometimes much earlier, the papules may become transformed into pustules, the change taking place slowly.

Iritis.—Another symptom of the secondary period, but of later development and of rarer occurrence than the syphilodermata which have been described, is iritis. In spite of its rarity, this is extremely important, because it is frequently overlooked until it has reached such a stage that occlusion of the pupil results, and also because when it is recognized it constitutes an almost pathognomonic sign of syphilis.

If the condition is observed, the *diagnosis* is not usually difficult. The pupil is irregular, especially under atropine; there are streaks of lymph, dulness, swelling, and change of color, and on very careful inspection a faint pink zone may be seen in the sclerotic. The conjunctiva and cornea are generally clear.

The *prognosis* depends on the stage at which the patient comes under treatment. The lymph, if recent, no matter in what quantity, will probably be absorbed under mercurial treatment, which will often be of great benefit even in those cases in which a certain amount of organization has occurred.

The foregoing symptoms are characteristic of the secondary period of hereditary syphilis, or that extending from birth, or more commonly from the age of three or four weeks, to about the end of the first year. They may be again enumerated as follows: coryza with snuffles; an erythematous, papular, or pustular eruption on the skin; mucous patches on the lips, tongue, cheeks, etc.; a marked tendency to general wasting; a hoarse cry or cough;

senility of aspect; iritis. The majority of syphilitic children born alive die during this stage.

Before its termination, sometimes even at birth, other lesions have been noticed (especially those affecting the liver), which, however, may be better described in connection with the special organ or organs involved.

Succeeding this stage—*i. e.* beginning in about a year or eighteen months—comes an **intermediate period,** which extends to second dentition, to puberty, or even much later, and which is characterized rather negatively—that is, by the absence of symptoms—than otherwise. The evidence of the general diathesis will of course be present in the shape possibly of malnutrition, stunted growth, or retarded development, perhaps shown in the weazened or withered face, the sunken nose, the pallor of the skin, the premature loss of the first upper incisor teeth, or the malformation of the others if they have erupted.

There is but little tendency to recurrence or relapse of any of the secondary symptoms; and in certain cases this stage extends through life, or, in other words, as is frequently the case with the adult who has followed a proper course of treatment, the disease appears to terminate with the secondary stage. In other cases, however, it recurs, and the symptoms which it then presents may be taken up in connection with the different organs or tissues involved.

Syphilis of the ear is for obvious reasons not often discoverable until the patient has reached an age at which interference with the function of hearing becomes a noticeable phenomenon. The only symptom likely to be noticed during the stage of inherited syphilis which we are now considering is a catarrh of the middle ear. This may lead to perforation of the membrana tympani, purulent infiltration of the mastoid cells, etc., and when accompanied by an otorrhea which attracts attention to the ear will be easily discovered by the surgeon.

The affections of the middle ear and Eustachian tube are said to be contemporaneous with the keratitis which appears in the neighborhood of puberty, while those of the auditory nerve are somewhat later in point of time, and are almost always conjoined with retinitis, choroiditis, and optic neuritis.

Syphilitic disease of the liver in newborn children is distinguished especially by increase in size and weight of the organ. This increase depends upon a proliferation of cells from the connective tissue between the acini, or from the adventitia of the interlobular vessels, this growth becoming transformed into connective tissue. The change is quite analogous to that which is taking place at the same time in the skin, the mucous membranes, and other tissues. It does not, however, go on to organization, but may be just as susceptible of absorption and resolution as are the papules or maculæ of the skin. A portion of the enlargement may be due to a passive congestion caused by the presence of this cell-accumulation.

As to the diagnosis of hepatic syphilis in infants, the symptoms are indefinite, or they are identical with those often observed in children who have poor or insufficient nourishment. The only physical sign which properly belongs to hepatic syphilis, when it exists at all, is increase in the size of the liver.

Bone syphilis in children is essentially of the nature of the syphilitic bone troubles with which we are familiar in the acquired form of the disease, consisting primarily and throughout of an unnatural accumulation of cell-elements, which in the later stages by their pressure produce various degenerations of surrounding structures, and which, as they occur during the process of bone-formation, are accompanied by irregular and abnormal deposits of lime-salts. They especially affect the junctions of the epiphyses and diaphyses, because at that time those points are the seats of great physiological activity.

The *symptoms* which obtain in this condition of syphilitic osteochondritis are as follows. There is a swelling at the diaphyso-epiphyseal junction of one of the long bones, which in the emaciated subjects of hereditary syphilis is often visible and can always be discovered by palpation. This consists of a ring or collar which more or less completely surrounds the bone, is apt to be smooth rather than irregular, and, when two bones situated near to each other are simultaneously affected, may conjoin them. A moderate amount of synovitis is often present. This affects chiefly the elbow and the knee, but may appear in any joint. It is readily influenced by specific treatment and well-regulated pressure. When the last stage is reached, or that of the formation of granulation-tissue, with degenerative changes of the cartilages and of the bones themselves, deformity often becomes more marked. There are unnatural curves or angles in the bones, with more or less complete separation at the point of junction.

The most important *differential diagnosis* to be made in these cases is between the rhachitis of young children and the form of syphilis in question. The points of resemblance are manifest, just as they are between a syphilitic and a variolous pustule, but they end in both cases when we come to study the evolution of the phenomena either from an anatomical or from a clinical standpoint. They may be expressed as follows in tabular form:

Osseous Lesions due to Inherited Syphilis.	Rickets.
The swellings, particularly those of the long bones, show themselves at or soon after birth.	Rarely appear before six months, generally still later.
A history of syphilis or evidence of existing syphilis in one or both parents.	No such history necessarily.
Preceded or accompanied by snuffles, coryza, and cutaneous and mucous lesions.	No such prodromata.
No such prodromata in most cases.	Pallor, restlessness, sweating, nausea, diarrhea, etc. constitute a combination of symptoms which often precede the bone disease.
Cachexia absent or moderate.	Cachexia marked.
Physiognomical peculiarities of syphilis present.	Not present as a group.
Circumscribed tumors on frontal and parietal bones, rarely on occiput.	Cranial bones thickened in spots, usually upon the occiput.
Ribs not markedly affected.	All or nearly all involved.
Disease of ribs, when existent, not ordinarily coincident with that of other bones.	Nearly always so.
Fontanels close at usual period.	Closure delayed.
Other syphilitic symptoms present—enlargement of phalanges, metatarsal bones, etc.	Syphilitic symptoms absent.
Often accompanied by sinuses, synovitis, abscesses, cutaneous ulcers, etc.	Little external or surrounding involvement.
Generally disappears by resolution, without leaving any permanent change.	Usually leaves some bending of shaft and distortion of the neighboring joint.
Mortality among children in whom many bones are involved is very great.	Much less.
Specific treatment useful.	Of no benefit.
In the first stage there is an exuberant calcification of the ossifying cartilage, causing necrosis of the new-formed tissue and a consecutive inflammation, which terminates in the separation of the epiphyses.[1]	This is less marked. There is formed, instead, a soft and non-calcified osteoid tissue.

[1] This table is founded on one published in the translation of Cornil *On Syphilis*, by Drs. Simes and White, and is compiled chiefly from the excellent work of Dr. Taylor on this subject.

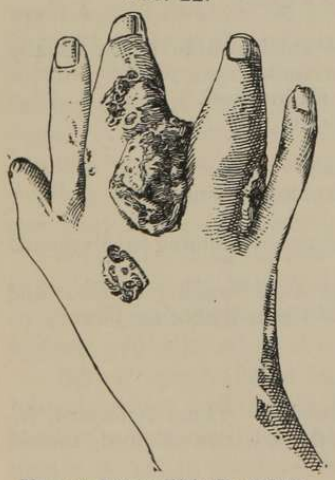
The bone lesions of hereditary exostosis can readily be recognized by the facts that they are stationary, appear later, and are of larger size, by the absence of syphilitic history or symptoms and by their resistance to specific treatment. The diagnosis from accidental separation of the epiphysis or from fractures may be made from the history of the case.

In cases of separation of the epiphysis, complicated with suppuration, sinuses, etc., the trouble may be mistaken for a similar condition due to non-specific inflammation. In all the recorded instances, however, the latter has occurred much later in life, is attended with much more acute inflammatory symptoms, lymphangitis, etc., and is of course without concomitant symptoms of syphilis. In both cases there is a decided osteo-periostitis, and, as so much depends on the early and vigorous use of specific treatment, it may be worth while to contrast the two forms of the disease.

Syphilitic Osteo-periostitis.	Non-specific Osteo-periostitis.
Occurs in infants under three months of age.	Seldom if ever occurs in children under one year of age.
History of syphilis in child and its parents.	No history of syphilis; sometimes a history of traumatism.
Implication of other bones.	Usually confined to one bone.
Coincident with the development of the shaft of the bone.	Coexists with the ossification of the epiphyses.
Other lesions of syphilis—nodes, skin eruptions, etc.	No such symptoms.
All the local symptoms comparatively mild.	Pain, redness, and swelling very marked.
Disease sharply localized.	Involves neighboring parts.
Lymphatics of limb unaffected.	Lymphangitis sometimes present.
Beneficial effect of specific treatment if employed early.	No such effect.

Syphilitic Dactylitis (Fig. 22) in the inherited variety of the disease, as in the acquired, consists of two varieties. The one of these which generally appears earlier affects chiefly the periosteum and the fibrous and integumentary structures surrounding a joint, usually a metacarpo- or metatarso-phalangeal articulation, involving a phalanx, and is characterized by slow, almost painless, swelling and discoloration of the affected member. This is due to a gummatous infiltration, which, after absorption under proper treatment, leaves the toe or finger temporarily stiff, but not permanently disabled.

FIG. 22.



Ulcerated Syphilitic Dactylitis (original).

The second form is a specific osteo-myelitis, with periostitis, coming on later, and often destroying the bone or the articulation involved.

The absence of acute inflammatory symptoms in the first variety distinguishes it from paronychia, whitlow, and gout. Rheumatoid arthritis begins in the joints and is associated with other symptoms; deformity of the fingers comes early in the disease, and there is a teno-synovitis with contraction.

The second variety might be taken for enchondroma or exostosis, but these growths increase much more slowly, involve only a limited portion of the bone, are of greater density, and are much more strictly circumscribed.

As a rule, especially in cases which are recognized early and treated actively, the *prognosis* is good.

Syphilis of the Teeth.—Syphilis of the teeth has its chief interest from its very important bearing on diagnosis. Manifesting itself at an age when the child is not apt to present the active and unmistakable cutaneous and mucous lesions of the disease, the recognition of which is therefore often extremely difficult, this diagnostic importance is greatly increased.

The teeth of the *first dentition*, although exhibiting the usual signs of interference with nutrition in their irregular development, opaque and chalky enamel deficient in quantity and unevenly distributed, soft and friable dentine, incongruity of size individually and relatively, and proneness to decay, do not often display any distinctive evidence of syphilis. The same conditions may, and often do, depend on other causes, and are commonly associated with various cachexiæ.

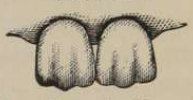
In the *permanent teeth*, likewise, the same condition may be due to the same causes. Stomatitis, however produced—by mercury, by gastro-intestinal derangements, by local irritation of any kind—is apt to result in imperfectly organized dental structures. Mercurial teeth, for example, are usually irregularly aligned, horizontally seamed, honeycombed, scraggy, malformed, of an unhealthy dirty-yellow color, separated too widely, and deficient in enamel. The diseases of childhood by temporarily arresting or greatly interfering with nutrition during the developmental period of the teeth often cause horizontal furrows across their crowns.

None of these conditions, however, are in the least degree characteristic of syphilis, the special expression of which in the mouth is to be found only in the *permanent upper median incisors*. It may be considered as well established that when these teeth are stunted, abnormally narrow at the cutting edge, crescentically rounded with the convexity upward, and the surface inclined upward and forward, instead of backward as in normal teeth, widely separated, but converging at their lower edges, they are pathognomonic of hereditary syphilis (Fig. 23). They are generally known as "*Hutchinson's teeth.*" They are often described as pegged, having been likened to a row of pegs stuck in the gums. This appearance is due to the facts that they are shortened, often projecting not more than half the normal distance from the gum, and are also widely separated; which abnormalities often affect the adjoining teeth, and sometimes the entire denture. A mistake which is frequently made is the confusing of the serrations of the cutting edges of recently-erupted normal incisors (Fig. 24) with the peculiar crescentic edges of syphilitic teeth.

FIG. 23.

Upper Median Incisors in Hereditary Syphilis (Cornil and Ranvier).

FIG. 24.



Serrations in Normal Teeth (Cornil and Ranvier).

Interstitial Keratitis.—The frequency of this form of diffuse inflammation of the cornea, and the diagnostic significance which has been so positively attributed to it—and as positively denied—render it of special interest. It begins, commonly, as a slight, diffused haziness situated in the substance of the cornea itself, usually not far from the centre, and at first affecting only one eye. This condition may persist for one or two months, after which the other cornea is nearly always attacked, and is similarly affected, although the disease is apt to pass through its different stages rather more rapidly than in the first eye. When the height of the disease is reached the corneæ are nearly opaque, a bare perception of light remaining. Then the cornea which was first involved begins to clear; this is soon followed by improvement in the other one, which in the course of a year or two results in a return to fairly good sight,

although in most cases there remain a slight haziness and an abnormal expansion of the cornea.

The *diagnosis* of this condition may generally be made with ease. The ground-glass appearance in the earlier stages and the dull pink or salmon color in the more vascular stage are very characteristic. The vascularity differs from that attending other chronic forms of keratitis, granular lids, etc., in which the vessels are large and superficial: in syphilitic keratitis they are much deeper and very closely interwoven, so that the effect is almost that of an ecchymosis. In non-syphilitic cases both eyes are not so apt to be affected nor is the tendency to spontaneous cure so marked. The absence of ulceration and the very slight degree of accompanying sclerotic or ciliary congestion are also valuable features. The chief point of interest, however, in the diagnosis of interstitial keratitis is its association with other symptoms of syphilis, upon which, for the general practitioner at least, the diagnosis will usually depend. There is such unequivocal clinical evidence in this direction that it is safe to say, as of the question of syphilitic teeth, that the burden of disproof rests with the doubters, and we may venture the assertion that interstitial, diffuse, or parenchymatous keratitis is a symptom of inherited syphilis, and that the unmistakable presence of the former disease is sufficient proof of the existence of the latter.

Syphilis of the Nerve-centres and Nerves.—Until a comparatively recent period our only guide to the course of the nerve diseases of inherited syphilis was to be found in analogy. We knew, for instance, that in acquired syphilis three forms of cerebral disease could be recognized in a general way: one characterized by a sudden attack of paralysis, in which the lesion was usually thrombosis from specific endarteritis; one in which the symptoms of brain-tumor were present, and in which gummata were the cause of the difficulty; and one in which pain, headache, and various functional or convulsive disturbances—chorea, epilepsy, paralysis of single nerves, etc.—were the customary phenomena, and in which periosteal, meningeal, or neuroglial thickenings constituted the pathological basis. The last two are often intermingled both symptomatically and histologically.

In spite of certain striking differences—more apparent than real, however—between inherited and acquired syphilis as regards cause, duration of stages, etc., the essential pathological changes are the same. When syphilis in its later periods attacks the brain or spinal cord or nerve-trunks or vessels of a fœtus, it proceeds just as in the adult, the same characteristic accumulation of cells taking place and setting up an arteritis or a meningitis, thickening the sheaths of nerves, or constituting a pericranial node or a gumma, according to their number and their situation. We find, thus, that in these patients meningitis, growths, and arterial disease constitute the three clinical divisions of the disease which have thus far been distinctly differentiated, and the reported cases, with or without autopsy, fall naturally into these classes.

Syphilis of the Spleen.—Disease of this organ in inherited syphilis is especially important from two points of view. It is a valuable aid to diagnosis, and by the size of the organ and the degree of persistence of the swelling gives an approximate indication of the severity of the case. Enlargement of the liver, although it ought to be noted because it is often present in hereditary syphilis, has but little value as a confirmatory symptom: first, because the liver is disproportionately large in infancy, and it is difficult to state the limit of what is actually normal; and, secondly, because other causes besides congenital syphilis lead to its enlargement. With regard to enlargement of the spleen the case is different. Gee's observation, that in the early stage of infantile syphilis some

enlargement of the spleen occurs in a large number of cases, has been abundantly confirmed. The importance of this sign is greatest when noted early, as, for example, when the child is from two to three months old, for at that period the enlargement of the spleen due to rickets can hardly come into question. The condition of the spleen during this period of enlargement seems to be simply that of hyperemia, or at the most of hyperplasia.

The *cause* seems to be in all probability the well-known effect of syphilis on the glandular system in general and on the lymphatic system in particular, to which the spleen is now usually assigned. The analogy between this slow, persistent, painless enlargement preceding the cutaneous symptoms, unaccompanied by inflammatory symptoms, unattended by any breaking down of tissue, subsiding slowly but evenly under specific treatment, and the behavior of the buboes of acquired syphilis, is certainly very striking.

In most cases of hereditary syphilis there are evidences of disturbance of the **gastro-intestinal tract.** Vomiting, diarrhea, colic, anorexia, and emaciation are well-known, but of course not at all characteristic, symptoms.

It has been supposed that the mucous membrane of the entire tract is probably, during the early period at least, and coincidently with the cutaneous eruption, in a condition of hyperemia and irritation comparable to that of the skin. Whether this is so, or whether it is due to associated involvement of the glandular apparatus, has not yet been determined.

Syphilis of the Larynx.—The hoarse cry of the newborn infant, so characteristic of hereditary syphilis, depends upon the presence of hyperemia, of mucous patches, or even of extensive ulceration, in the larynx. The first is probably the most common, as, if it were otherwise, cases of death from œdema glottidis or other forms of laryngeal obstruction would be oftener met with. When ulceration does exist it is generally, but not invariably, secondary to pharyngeal ulcers.

Bronchial catarrh, giving rise to cough, and sometimes to considerable embarrassment of respiration, is a not infrequent complication of laryngeal syphilis. Later troubles of the larynx in connection with inherited syphilis have not yet been studied carefully enough to warrant us in drawing any distinction between them and the usual symptoms seen in the acquired disease.

Syphilis of the testicles is found to consist of a true interstitial orchitis, very closely resembling that seen in the syphilitic testicles of adults. The disease usually occurs at from two months to three years of age; both testicles are generally involved, and are enlarged, hard, inelastic, and frequently nodulated. Mercurial treatment generally causes a marked improvement unless the inflammation has already resulted in the development of a new fibroid formation, in which case it will be likely to remain unaffected by treatment. Inunctions with diluted mercurial ointment, iodoform, etc. are useful adjuvants.

The Diagnosis and Prognosis of Inherited Syphilis.—In reviewing the general course of a case of inherited syphilis it seems evident that the differences between it and the acquired disease which have been so much dwelt upon are apparent rather than real. The primary stage is of course missing, and on any theory of the essential nature of syphilis this is readily comprehensible. Whether the chancre is the first symptom of a constitutional disease, or is the simple accumulation at the point of original inoculation of the cells affected by the syphilitic virus, it would naturally be in the first case undiscoverable, in the second non-existent.

The secondary stage, characterized in the acquired form chiefly by lymphatic engorgement and symmetrical, widely-spread, polymorphic cutaneous and mucous eruptions, and pathologically by a marked tendency to the proliferation of cer-

tain new small round nucleated cells, upon the presence of which depend all the manifestations of the disease, is in inherited syphilis strictly analogous. The lymphatic engorgement either exists in the infant as in the adult, or has its analogue in the enlargement of the spleen and of the liver, especially the former.

The tertiary stage, except in the fact that its phenomena may appear unusually early and may be commingled with those of the secondary period, does not widely differ in the hereditary form from that of the acquired disease.

In considering the question of diagnosis, therefore, we have an excellent guide in the facts that the disease conforms in most respects to the general laws of acquired syphilis, and that our knowledge of the latter affection will be a valuable aid to recognition of the former.

The chief elements of diagnosis and prognosis of inherited syphilis in its various stages may, then, be summarized as follows: A history of syphilis in either parent is important just in proportion to the shortness of the interval between the time of infection and the date of conception. If both parents were syphilitic at or before the time of conception, the probability that the disease will be transmitted, and in a severe form, is much increased. There is no sufficient evidence that inheritance from one parent results in a graver variety of the disease than when it is derived from the other.

A history of abortion or miscarriage on the part of the mother should have weight in the determination of any given case, and if such accidents have been very frequent their diagnostic importance is greatly increased.

Upon examining the product of abortion or stillbirth the most easily observable symptoms will be those of the skin. Maceration of the epidermis and its elevation into bullæ are in themselves hardly characteristic, though both of them—and especially the latter—may be regarded as suspicious. If the cutaneous lesions are, however, distinctly papular or pustular or ulcerative, or if the bullæ have all the characteristics of syphilitic pemphigus, the diagnosis is assured.

The most distinctive symptom—one which may really be considered pathognomonic—is, however, the inflammation of the diaphyso-epiphyseal articulations, with or without their disjunction. Distinct enlargement of the spleen or of the liver and arachnitis with hydrocephalus are valuable diagnostic points, and the presence of gummata, which are not very infrequent, would of course be conclusive.

At birth the syphilitic child may be small, stunted, emaciated, weazened, senile in appearance: this would properly give rise to suspicion, but might be associated with any disorder of nutrition on the part of either child or mother. It may also disclose cutaneous or mucous eruptions evidently specific in character. In any event, marked symptoms at birth render the prognosis highly unfavorable.

It is quite common, however, for the subject of hereditary syphilis to give no evidence of the disease at birth, but even to appear healthy and well nourished. In such cases the first symptoms of the disease appear, on an average, in from six weeks to two or three months, and consist principally of coryza, snuffles, hoarseness of voice, and syphilodermata.

Mucous patches on the tongue, cheeks, tonsils, and pharynx are common, often extending to the larynx, increasing the hoarseness, and to the nasal cavities, aggravating the snuffles. Both of these occurrences, by interfering with the respiration of the child and rendering its nursing interrupted and insufficient, greatly add to the gravity of the case. Enlargement of the spleen

(common), enlargement of the liver (less so), and iritis (rare) may be mentioned among the phenomena of this stage often associated with the skin eruptions.

About the time of the subsidence of the rash there may be developed the specific inflammation at the junction of epiphyses and diaphyses which produces a swelling of the long bones near their ends. The child will be noticed to cry a little when, for example, the wrist or elbow on one side is washed, and not to use these joints as much as the corresponding ones on the other side. The parts are slightly tender, and as yet there is but little swelling. Later, the droop and disuse of the affected limb become more noticeable and simulate infantile paralysis. There is, however, no wasting, no alteration of reaction by faradism, no real loss of power, so that the term pseudo-paralysis is an appropriate one. In a week or two similar symptoms will occur in the bone on the opposite side, and finally the ends of all the long bones will be affected; ordinarily the elbows, wrists, knees, and shoulders are the joints involved. Suppuration is rare, disjunction of the epiphysis from the diaphysis common. Recovery is apt to take place spontaneously within a month. The associated changes are chiefly endosteal at the junction of the shaft with the epiphysis, but there is also a little periostitis or perichondritis, which is the principal cause of the external swelling. Moderate deformity may ensue.

Similar changes occurring in the cranial bones give rise to what has been called the natiform skull. During the first year it is very common for syphilitic children to develop a number of lenticular swellings on the cranium, which appear symmetrically around the anterior fontanel, but at a little distance from it—*i. e.* one on each frontal and one on each parietal bone. They are said to be "bossed." They are originally circumscribed, and in a child nine or ten months old often measure from three-quarters of an inch to an inch in diameter. They are at first circular, afterward more irregular, and finally tend to organize, becoming diffused and massive and causing a permanent thickening of the skull.

The symptoms which have been described are the prominent ones occurring during the first six, eight, or twelve months of life. If they do not manifest themselves before the eighth month, it is highly probable, even in a case with a syphilitic parental history, either that the child will escape altogether or that the secondary stage has been very slight and altogether intra-uterine and unattended with noticeable phenomena. If during this first year the child's cachexia is marked, if there are any intercurrent diseases, if the symptoms show themselves early, if the nasal or laryngeal affection is severe, if the eruptions are markedly bullar or pustular or ulcerative, if the enlargement of the spleen is great or the osseous lesions are precocious or grave, and if, especially, there is any intermingling of tertiary symptoms, gummata, nodes, etc., the prognosis will be unfavorable.

From adolescence through adult life the diagnosis of inherited syphilis will depend on the following points: First, of course, the history of parental or of infantile syphilis, or of both. Then a group of physical and physiognomical peculiarities, which are not definitely characteristic, and are of little value when taken separately, but of considerable importance when all or a majority are present in any given case. These are low stature or puny development proportionate to the severity of the intra-uterine and infantile symptoms; a pasty, leaden, or earthy complexion, a relic of previous syphilodermata, probably also a result of malnutrition; a prominent forehead, bulging in the middle line at and within the frontal eminence, and due either to thickening of the skull or to a previous arachnitis and hydrocephalus before the ossification of the fontanels; a flat, sunken bridge of the nose, due to the coryza of infancy ex-

tending to the periosteum of the delicate nasal bones, and either interfering with their nutrition or partially destroying them; dryness and thinness of the hair, with brittleness and splitting of the nails; synechiæ and dulness of the iris (rare); ulcerations of the hard palate; and periosteal thickenings or enlargements of the shafts of the long bones near the ends, or slight angular deformity, the result of the osteochondritis of infancy.

A much more valuable group of symptoms, however, are the following, which are mentioned in the order of their importance, any one of the first three being almost or quite conclusive:

Dwarfed permanent median upper incisors, broader at the top than at the cutting edge, which is crescentically notched, separated by an undue interval, and converging toward each other.

Evidence of past or present keratitis—a dusky and thin sclerotic in the ciliary region and slight clouds here and there in the corneal substance, there being no scars on its surface; or of disseminated choroiditis; patches of absorption, especially around the periphery.

A radiating series of narrow cicatricial scars extending across the mucous membrane of the lips, or a network of linear cicatrices on the upper lip and around the nostrils, as well as at the corners of the mouth and on the lower lip.

Periosteal nodes on one or many of the long bones; sudden, symmetrical, and complete deafness, without otorrhea and unattended by pain or other subjective symptoms.

Late or tardy hereditary syphilis is rarely dangerous to life. The prognosis is almost unvaryingly favorable unless some grave visceral complication, such as interstitial pneumonia, gummata of the brain, liver, or kidney, or meningeal and periosteal inflammation within the cranium, should occur.

Treatment.—The prophylactic treatment, or that directed to the health and sexual relations of the parents previous to conception, has already been sufficiently considered. That of the mother during pregnancy, after having conceived from a syphilitic husband, or having had antecedent syphilis, or having contracted it by direct contagion subsequent to impregnation, is simply that of acquired syphilis in either adult or child. Mercury in its full physiological dose is the drug indicated. It may not be amiss to combine with it iodide of potassium in moderate doses, but the practice of employing the latter to the exclusion of the former is both theoretically and clinically unsound. Care should especially be taken to give it in such a manner, either by inunction or vaporization or so guarded with opium, that it shall not produce any irritating effect on the intestinal canal, the sympathy between which and the uterus may, in the event of a strong purgative action being set up, lead to an abortion.

As we have seen that the pathology, the stages, and the general course of hereditary syphilis are all closely related to or identical with the same phenomena in the acquired disease, and so know that they both depend upon the same ultimate cause, it follows that the same principle should govern us in the treatment of the one as in that of the other.

We know from clinical experience that mercury exercises an almost controlling influence over the secondary manifestations of acquired syphilis. We know also that iodide of potassium, probably by virtue of its powerful stimulating influence on the lymphatic system, has an equal power over the tertiary growths. In hereditary syphilis, however, there are two elements which should modify the treatment somewhat, and must be taken into consideration. These are—1st. The existence of a more or less profound cachexia influencing all the nutritive and formative processes, and in itself, entirely apart from any definite specific involvement of vital organs, threatening life. 2d. The not infrequent

occurrence during the secondary period of symptoms—notably gummata—belonging to the tertiary stage.

The first indication is met by making the treatment from first to last not only antisyphilitic, but also supporting or even stimulating; and with this object in view especial attention should be paid to nutrition. It may be stated, axiomatically, that for every reason, whenever it is within the bounds of possibility, the nurse of a syphilitic child should be its mother. To her it is harmless; to every other woman, not already syphilized, it is in the highest degree dangerous. If neither mother nor wet-nurse can be had to suckle the child, it must be fed by cow's, goat's, or ass's milk or by artificial alimentation; but its prospect of life will be immeasurably reduced. In addition to careful feeding, a little tonic treatment should be employed from the first, in conjunction with the specific remedies, iodide of iron, cod-liver oil, and preparations of the phosphates being the most useful drugs.

The existence of the second condition which exercises a modifying influence upon treatment—the early appearance of tertiary symptoms—is probably due, in many cases at least, to an overwhelming of the lymphatic system by the new cell-growth. This leads us to combine with the mercury from the beginning, at least in all cases where bony or periosteal involvement, suppuration, or the existence of gummata point to this condition, small doses of iodide of potassium or of some other soluble and easily-decomposed iodine salt.

The principle of treatment being recognized, the routine procedure may be thus described: Give mercury as soon as the diagnosis of syphilis is assured—preferably by inunction. Sir Benjamin Brodie's opinion, expressed many years ago, still represents that of the profession: "I have tried different ways of treating such cases. I have given the child gray powder internally and given mercury to the wet-nurse. But mercury exhibited to the child by the mouth generally gripes and purges, seldom doing any good, and given to the wet-nurse it does not answer very well, and certainly is a very cruel practice. The mode in which I have treated cases for some years past is this: I have spread mercurial ointment, made in the proportion of a dram to an ounce, over a flannel roller and bound it around the child once a day. The child kicks about, and, the cuticle being thin, the mercury is absorbed. It does not either gripe or purge, nor does it make the gums sore, but it cures the disease. I have adopted this practice in a great many cases with signal success. Very few children recover to whom mercury is given internally, but I have not seen a case where this method of treatment has failed."

When, for any reason, as irritation of the skin, this cannot be employed, probably the best form of giving mercury by the mouth is in the following formula:

℞. Hydrarg. cum creta, gr. j–vj;
Sacch. alb., gr. xij.
M. et div. in chart. No. xij.
Sig. One powder three times a day, to be taken soon after nursing.

Iodide of potassium may be given separately in a syrupy solution in doses of a half-grain to a grain, or, if there are any marked tertiary symptoms, even in much larger doses, three or four times daily. The treatment of course should be continued long after the disappearance of syphilitic symptoms, and it would probably be well to continue the mixed treatment intermittently until after puberty.

The cases of visceral syphilis in very young children are generally fatal. Those that recover do so in response to the active use of the above remedies.

Later, the prognosis is more favorable, the treatment the same. Of course moist eruptions should be dusted with some astringent or absorbent powder; mucous patches should be cauterized or stimulated; and great attention should be paid to avoidance of sources of cutaneous irritation, by frequent changing of diapers, etc., but the general methods are the same as in the adult.

CHAPTER XIX.

TUMORS.

A TUMOR is a new growth or neoplasm which produces a localized enlargement of a part or an organ, has no tendency to spontaneous cure, has no useful function, in most cases tends to grow during the whole of the individual's life, its development and growth, except in rare instances, being uninfluenced by drugs or by the greater or less general vigor of the individual. The exceptions to which the above definition does not apply are—first, such new growths as tubercle, lupus, etc.; second, certain epitheliomata and the withering scirrhus of the breast, which do not produce enlargement; and third, cysts not the result of new growth. Lymphadenoma or lympho-sarcoma, a malignant disease of the lymphatic glands, in a few instances temporarily, or more rarely permanently, seems to have undergone cure from the use of arsenite of sodium given internally in increasing doses.

All tumors *originate from the pre-existing tissues* (except when of metastatic origin), and are composed of tissue-elements resembling those of these tissues either in their fully-developed or in their embryonic state. When limited to the tissue in which it starts, the tumor merely displaces the tissues, and is, almost without exception, constituted of fully-developed cells similar to the tissue from which it started, as fat, fibrous, or muscular tissue: to this class of tumors, which are generally benign, the term *homologous* has been applied. When the new-growth no longer remains confined to the tissue in which it starts, but infiltrates the surrounding tissues, its component elements tending to be more embryonic in their type, it is usually malignant; such growths have been termed *heterologous*. Nearly all secondary tumors—*i. e.* those forming in parts distant from the primary growth, as in the lymphatics or the viscera—are therefore heterologous. Both innocent and malignant growths may be multiple. Multiple malignant growths are usually the result of lymphatic or vascular embolism, but cases are not uncommon where more than one primary focus has been observed; thus two or three portions of the lip or of the tongue may be simultaneously attacked.

Tumors Originate from Many Causes.—Some, as nævi, are congenital, or the tendency to their development in later life is inherited. Of the causes initiating those occurring in later life, the following are regarded as most effective and unquestioned. While inflammatory new formations cannot be regarded as tumors, there is little doubt that inflammation—especially that following a contusion—stands in frequent causative relation to many new growths, notably the sarcomata. Anything which acts chemically or mechanically so as to maintain a constant but slight degree of undue vascularity of a part, such as the irritation of soot (scrotal cancer), the hot, rough stem of a clay pipe (labial epithelioma), a jagged tooth (carcinoma linguæ), favors the development of a malignant growth. Abnormal conditions of parts where the epithelial elements are in excess, as certain benign growths, such as warts (cutaneous papillomata), pigmented moles, and leucoma of the tongue (a

chronic inflammatory affection involving the surface of that organ), predispose to the formation of malignant growths. Age and sex predispose to tumor-formation. Thus carcinoma is a rarity under thirty years of age; the mammary gland of the female is infinitely more liable to carcinoma than that of the male, owing to their differing functional activity; while, on the other hand, the œsophagus, lip, and tongue in the male seem to be more liable to be attacked by malignant disease than the same organs in the female. The depressing emotions long continued, such as sorrow or anxiety, generally considered as predisposing causes, can act only, as does age, by lowering the vitality of the tissues, inducing as it were premature senescence: their action is therefore doubtful.

Since malignant growths present some slight apparent resemblances to certain phenomena of the infectious diseases, observers have of late years sought to ascribe their origin to bacteria. Still later, microscopic appearances simulating those presented by certain parasitic protozoa have led enthusiastic observers to the belief that the spheroidal or irregular bodies found in and between the epithelial cells are in reality developmental forms of certain sporozoa, and that their presence is not accidental, but causal. The arguments in support of this view rest upon the morphological resemblances of these bodies to psorospermiæ and to the corpuscles of molluscum contagiosum. The diversity in size, form, and staining qualities of the supposed parasites, the lack of evidence that these bodies are either growing or developing, and the failure of all culture methods, have caused most authorities to believe that the alleged sporozoa of carcinoma are really degeneration-products of the epithelial cells. The possibility that carcinoma may yet prove to be of parasitic origin is not denied, but certainly no positive evidence in support of this view has been adduced.

Growth.—This is dependent upon its structure primarily, and to a less degree upon the part in which the tumor starts. *Cæteris paribus*, the more embryonal the structure, the more rapid the increase and the more malignant the tumor, but tumors of similar structure pursue widely differing courses according to the organ in which they originate. This is partly due to their lymphatic and vascular connections, partly to the importance to life of the part involved or of neighboring parts which may become diseased by contiguity, or mechanically rendered partially or wholly useless; thus a small carcinoma of the pylorus will terminate life by starvation; a tumor of the larynx will early endanger life by suffocation.

Clinically, tumors are divided into the *benign* and the *malignant*. A **benign** tumor is usually composed of tissues resembling those in which it originates, and is circumscribed, because usually encapsulated, whence its mobility among the circumjacent tissues. Its vascular supply is small; hence generally it grows slowly. It is painless; it never infiltrates surrounding tissues, but displaces them; it does not recur when thoroughly removed, does not give rise to enlargement of the lymphatic glands intervening between it and the venous circulation, and consequently does not affect distant parts. A **malignant** tumor usually consists of tissues widely different from those in which it originates; its growth is rapid, and therefore often painful; it infiltrates all the surrounding tissues, however resistant, even bone, because it is almost never encapsulated; it thus early becomes immovable; the superjacent skin is apt to become adherent, especially when the breast is involved; sooner or later it usually infects the group of lymphatic glands intervening between it and the venous circulation, and from these new centres or directly through the veins gives rise to secondary deposits in the internal organs.

Diagnosis.—In general terms this must depend upon the history, age, sex, situation, rate of growth, fixity to the surrounding parts and overlying skin, or the reverse, lymphatic or visceral involvement, and the physical characters of the growth.

The *liability of tumors to degenerations* resulting from disease or injury—since morbid growths are no more exempt from such influences than normal tissues—should be clearly recognized and constantly kept in mind. Thus the vascular supply determines the occurrence of ulcerative inflammation in both benign and malignant growths. For instance, an ordinary sessile fatty tumor (lipoma) is no more liable to be attacked by ulceration than any other portion of the normal fatty tissue of the body, but when such tumors become pendulous, with narrow pedicles, the blood-supply is often interfered with—especially the venous return—and ulceration is prone to occur from trivial causes. Again, epithelial carcinomata are chiefly formed of masses of cells the majority of which are distant from any direct blood-supply; thus they readily undergo fatty degeneration and break down early; the overlying skin inflames, gives way, and ulceration is initiated. This process is often so active that the major part of the growth ulcerates or sloughs away, while at the periphery the disease extends into the adjacent tissues. Very rarely, from injury, gangrene of the whole growth ensues, resulting in its total destruction and the cure of the disease. One most important class of malignant neoplasms—viz. the sarcomata—are liable to such developmental transformations into structures resembling normal tissues, as to give rise to errors both in diagnosis and in prognosis. It must, then, never be forgotten that any of the structures normally developed from connective tissue may form either the bulk of some of the most malignant growths or isolated portions of them: thus cartilage, bone, or fibrous tissue may form the mass of a malignant growth; but these changes into tissues of a permanent type in no way modify the malignancy of the remaining tissues of the embryonal type. Such benign growths as fibromata may undergo calcification; cartilaginous tumors may soften (undergo mucoid change).

Treatment.—The only effectual treatment is removal or destruction of the growth. Benign growths should be removed if much inconvenience or deformity is present, or if disturbance of health or danger to life—present or prospective—is undoubted. It is needless to say that all malignant growths should be promptly removed, including, when possible, the whole of the organ attacked and the neighboring lymphatics and glands, as the entire breast with the axillary contents in cancer of that organ; the whole tibia by amputation in sarcoma of that bone. Special therapeutic indications will be considered when treating of each particular class of growths.

Classification of Tumors.—Tumors are best classed according to their supposed origin and their histological structure; thus—

I. *Mesoblastic or Connective-Tissue Tumors.*

A. Those conforming to the types of fully-formed connective tissues:

1. Fibrous Tumors (Fibroma, plural Fibromata);
2. Fatty Tumors (Lipomata);
3. Cartilaginous Tumors (Chondromata);
4. Osseous Tumors (Osteomata);
5. Mucous Tumors (Myxomata).

B. Those conforming to the types of the higher connective tissues:

1. Muscular Tumors (Myomata);
2. Vascular or Erectile Tumors (Angeiomata);
3. Lymphatic (vessel) Tumors (Lymphangeiomata);
4. Nerve Tumors (Neuromata).

C. Those conforming to the type of embryonic connective tissue:
   1. Round-celled Sarcomata;
   2. Spindle-celled Sarcomata;
   3. Myeloid Sarcomata.

D. Tumors intermediate between the sarcomata and the carcinomata: The Endotheliomata.

II. *Epiblastic and Hypoblastic Tumors—i. e. those conforming to the type of Epithelial Tissues:*

A. Warty or Villous Tumors (Papillomata).

B. Glandular Tumors (Adenomata).

C. The Acinous or Spheroidal-celled Carcinomata:
   1. Hard Spheroidal-celled (Scirrhous, or Chronic Carcinomata);
   2. Soft Spheroidal-celled (Encephaloid or Acute Carcinomata);
   3. Colloid Carcinomata.

D. Epithelial carcinomata:
   1. Squamous-celled Epitheliomata;
   2. Cylindrical- or Columnar-celled Epitheliomata.

III. *Tumors composed of Epiblastic, Hypoblastic, and Mesoblastic Elements:*

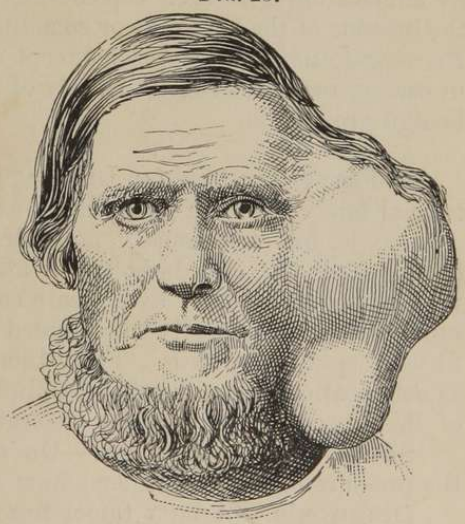
Teratomata, tumors containing bone, hair, teeth, etc., situated in the ovaries or testicles.

I. Mesoblastic or Connective-Tissue Tumors.

A. Tumors conforming to the types of fully-formed connective tissues:

1. Fibrous Tumors, or Fibromata (Fig. 25).—Consisting of fibrous tissue, they may be as dense and firm as a tendon or as soft as the subcutaneous areolar tissue. They commonly possess a distinct capsule; when completely removed they neither recur locally nor become generalized, and consequently are absolutely innocent tumors. They rarely consist solely of pure white fibrous tissue, but the firmer varieties are composed of a dense mass of interlacing bundles of this tissue, intermingled with a few yellow elastic fibers and connective-tissue corpuscles. The bundles may form concentric circles around the blood-vessels in some fibromata, but usually they present no definite arrangement. On section they are smooth, glistening, firm, and of a grayish-white color. Usually the blood-supply is scanty, the vessels being small and thin-walled, but some naso-pharyngeal polypi are excessively vascular, being traversed by large cavernous blood-spaces. The softer varieties consist of a more or less loose, succulent, fibrous tissue permeated with numerous large blood-vessels, and according to the proportions of the different forms of fibrous tissue which enter into their composition they will appear more or less yellowish, glistening, semi-transparent, or gelatin-

Fig. 25.



Fibro-cystic Tumor of Parotid Region (original).

ous; a serous fluid can be expressed from their cut surfaces. When superficial they often become pedunculated.

Fibrous tumors are prone to undergo certain secondary degenerative changes —viz. calcification, mucoid change, and ulceration.

Seats of Predilection.—Fibromata may occur wherever fibrous tissue is found in any of its forms, but the commonest seats are the periosteum, especially that of the jaws, for the harder forms, when the tumor is called a fibrous epulis; in the uterus; in the neurilemma of nerves—then miscalled neuroma (false neuroma); in the subcutaneous tissue on terminal nerve-filaments, termed painful subcutaneous tubercles; in the rectum and naso-pharynx, forming fibrous polypi. Hard fibromata are also found in the testis or may spring from the sheaths of tendons. The softer forms originate chiefly from the intermuscular septa or the subcutaneous and submucous tissues, and are oftenest found in the scrotum, labia majora, or scalp. The soft fibroma was formerly called fibro-cellular: the ordinary nasal polypus is a typical example of this variety. Fibromata attack adults chiefly, but have been observed at all ages; they are usually single, but may be multiple when springing from the nerves (false neuromata), the skin (molluscum fibrosum), and the uterus. Pure fibromata and fibro-lipomata sometimes form large renal tumors.

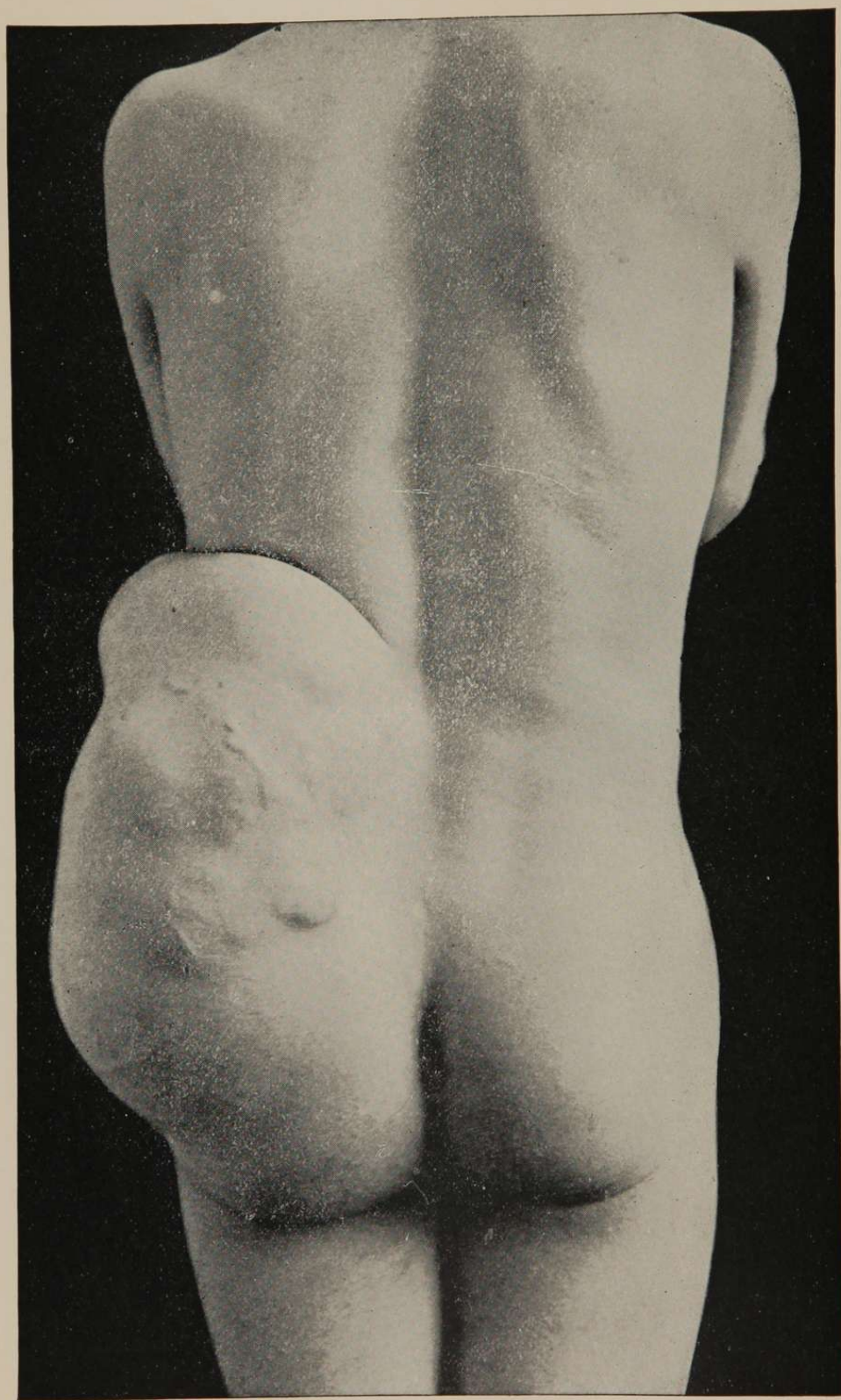
Diagnosis.—In general terms, fibromata are ovoidal, hard, nodular, or bosselated, of uniform consistence, of slow growth, painless—except when involving nerves—movable, those in the breast and subcutaneous tissues being unattached to the skin or circumjacent tissues. In these situations, or when arising from the jaws or other bones, in their earlier stages it is difficult to distinguish them from the harder sarcomata, the latter being often encapsulated. The slow growth, the regular contour, and the non-involvement of the overlying tissues in the case of fibrous growths are the chief points of distinction. Cartilaginous and bony tumors present the same characteristics, but are much harder and more nodular. The softer fibromata are smooth, globular, elastic, soft, and painless.

Treatment.—When possible, they should be completely removed, either by enucleation with their capsules, as in most of those occurring in the breast, the interior of the jaw, etc., or sometimes by a dissection, which may be tedious. Recurrence never takes place except where a sarcoma—portions of whose mass in certain instances consist largely of fibrous tissue—has been mistaken for the benign growth.

2. Fatty Tumors, or Lipomata, consist of adipose tissue identical with normal fat. They are innocent, grow slowly, may reach a large size, are usually single, but occasionally multiple, are almost never painful, occur chiefly during adult life, and do not recur after removal. Composed of masses of fat-vesicles bound together by delicate connective tissue in which the blood-vessels ramify, they are usually surrounded by a thin capsule which is attached by fibrous septa to the skin. Fatty tumors may undergo such secondary changes as calcification, mucoid softening, inflammation from pressure, and, as a result of this in some rare instances, ulceration.

Seats of Predilection.—On the shoulders, back, nates—possibly from the pressure of the suspenders, from sitting, etc.

Diagnosis.—A fatty tumor forms a circumscribed, usually painless, lobulated, soft, pseudo-fluctuant, inelastic, flattened growth—if subcutaneous, causing dimpling of the skin when this is pinched up, due to the passage of the fibrous septa from the skin to the capsule. It is best distinguished from chronic abscess—with which it may be confounded—by its dimpling and by



Enormous chondroma of ilium.

the slipping away of the edge of the tumor from beneath the finger when pressed upon: possibly the grooved needle may be requisite. Certain variations should be noted. Thus there is a diffuse form, producing symmetrical swellings at the back of the neck, or beneath the chin, forming so-called "double neck" and "double chin." Again, the presence of more fibrous tissue than usual may render lipomata unusually firm. They may be deep-seated, springing from the intermuscular septa or even from the surface of a bone. Moreover, they occasionally become pedunculated. Lastly, some of the most typical cases of "painful subcutaneous tubercle" are composed of fat. The average case can be readily diagnosticated from a cyst, a chronic abscess, or a bursal enlargement by the symptoms given above, while the deeper-seated can hardly be mistaken for any other than soft fibrous or myxomatous growths—an error of no practical moment, since both should be removed.

Treatment.—For the circumscribed variety a free incision, opening the capsule, should be employed, when the tumor will usually shell out; if more adherent, some dissection with the knife may be necessary: all portions of the growth must be removed, since occasionally, although rarely, the portions left have formed the starting-point of a new tumor. Multiple growths, unless painful ones, seldom require removal. The diffused form should not usually be attacked with the knife. The prolonged internal use of liquor potassæ in 10-minim doses, t. d., has in certain instances caused their disappearance.

3. Cartilaginous Tumors, Chondromata or Enchondromata (Pl. VII.), are composed of some variety of cartilage, forming hard, elastic, slowly enlarging growths, often nodular or lobulated. They may consist of a single mass or of a number of small masses each enclosed in its capsule, all bound together by connective tissue and blood-vessels. They are homogeneous or coarsely granular on section, presenting a translucent, bluish-gray or pinkish-white surface, sometimes marked out into irregular lobules. Histologically, they are usually composed of hyaline- or fibro-cartilage. Where unattached to bone their fibrous capsule serves as a perichondrium, and when exposed to friction a bursal sac often forms between them and the superjacent parts. Fatty or mucoid secondary changes may render some of the nodules centrally diffluent, producing cyst-like cavities containing synovia-like fluid, thus so completely metamorphosing the tumors that they sometimes are hardly recognizable as chondromata; while, on the contrary, some become calcified or ossified. This latter change is especially apt to affect chondromata springing from the juxta-epiphyseal region of the long bones, the change progressing so far that only a thin layer of cartilage caps them, forming what are termed cancellous exostoses. Chondromata are apt to be single, but they are often multiple and symmetrical, as those attacking the phalanges. While pure cartilaginous growths are benign, sarcomata are often partly, or even chiefly, composed of cartilage, especially those found in the testicle and the parotid. Multiple chondromata of the hand, if of rapid growth, should be viewed with suspicion as possibly cartilaginous sarcomata. Occurring at any age, they are more common in the young, especially those springing from the long bones near the epiphyses. Sometimes the tendency to their formation seems to be inherited, the tumors being similarly located in both parents and children. While they often attain a large size, they grow slowly, so that unusual bulk with rapid growth would justify a strong suspicion of the intermixture of sarcomatous elements. Mixed tumors containing cartilage have been already referred to.

Seats of Predilection.—The bones, especially on or in the phalanges of

the fingers or toes; the lower juxta-epiphyseal region of the femur; the upper ends of the tibia, fibula, and humerus, the scapula and ilium, on or in the jaws, especially the upper; the salivary glands, notably the parotid; the testicle; in or around joints attacked by rheumatoid arthritis; and the subcutaneous tissues.

Diagnosis.—This must depend on the hardness yet elasticity of the tumor, its nodular circumscribed outlines, and its slow continuous growth; later, on the development of softened spots indicative of cystic degeneration, and on the location of the tumor, as upon a young bone near an epiphysis. A *cartilaginous sarcoma*—the growth with which chondromata are most likely to be confounded—presents less definite outlines—*i. e.* infiltrates somewhat, is apt to be of unequal consistence from the outset, and grows with much greater rapidity.

Treatment.—Complete removal of a pure chondroma will secure future immunity, and should always be adopted when possible. Mixed chondromata containing sarcomatous elements commonly recur. In the parotid gland and subcutaneous tissues they can usually be enucleated with their capsules, and sometimes this can be done when the phalanges are involved, but more often in the latter event and when the testicle is attacked the whole part or organ must be sacrificed: usually those springing from the surfaces of the larger bones can be removed without sacrificing the bone, with but small chance of their recurrence.

4. Osseous Tumors, or Osteomata, are formed of true bone, and are generally composed almost solely of either cancellous or compact bone. The cancellous have been just described as resulting from the ossification of chondromatous growths springing from the juxta-epiphyseal portions of such long bones as the tibia, femur, humerus, fibula, etc., where they form exostoses. The ungual surface of the distal phalanx of the great toe is often the site of such a tumor, producing a subungual growth. The compact osseous tumors rarely grow from any other bones than those of the cranium. Certain exostoses, called from their hardness "ivory exostoses," are said to differ from other bony growths by the absence of Haversian canals, and are composed of "layers of bone lamellæ laid concentrically over a central point or pedicle." They rarely attain a greater size than that of a small walnut, are so dense that they can hardly be cut by any instrument, and it is difficult by the exercise of great force to fracture their pedicles, even when comparatively slender. The ivory exostosis springs from the exterior of one of the cranial bones, while the more ordinary forms of compact osteomata originate in the cranial or nasal sinuses, grow slowly, and thrust aside or cause absorption of adjacent structures, thus producing marked deformities. Although usually single, osseous tumors in some patients may be multiple, being found by the score, in such cases commonly commencing at a very early age, being then hereditary and often symmetrical.

Seats of Predilection.—These have been mentioned above in describing these growths.

Diagnosis.—This is usually easy, depending on the evident connection of the tumor with bone or cartilage, for tumors growing apart from these structures in the connective tissue are probably tumors of some other class which have undergone osseous change, or are structures, such as tendons, muscles, etc., which have undergone calcification or ossification. The pedunculated form when the osteoma occurs as an exostosis, the dense, hard, irregularly nodulated surface when the tumor is non-pedunculated, and its slow growth, serve as distinguishing points. The more rapid growth and unequal consistence of the calcifying or ossifying sarcomata serve to distinguish this variety of malignant growth from the benign osseous tumors.

Treatment.—Although operation alone can remove these growths, not every one should be meddled with, but only those should be attacked which are steadily growing and are painful or produce great deformity or loss of function, and the proposed operation on which will not unduly risk the life of the patient. Thus, most of the exostoses of the flat and long bones and certain osteomata of the upper and lower jaws should be removed, for valid reasons, such as those just given. Those of the facial and cranial bones, which are ill defined and often extend so deeply as to involve the base of the skull, should not be touched. It was formerly taught that it was inadvisable to attempt the removal of non-pedunculated, sessile exostoses of the long bones, which are usually covered by thick masses of muscle, because of the risk of profuse and deep-seated suppuration; but with modern methods of operating such complications ought to be avoided, so that if good reasons exist for their removal such tumors should be subjected to operation.

With the exception of the cancellous exostosis of the ungual phalanx of the great toe, a pure osteoma when removed does not return, even when some of the surface from which it has sprung is allowed to remain. An ossifying sarcoma, for which osteoma has sometimes been mistaken, will of course return. In the exceptional case mentioned the distal portion of the phalanx should be removed with the tumor to obviate any risk of recurrence.

5. Mucous Tumors, or Myxomata, resemble both to the naked eye and to the microscope the Whartonian jelly of the umbilical cord and the vitreous humor of the eye. They grow slowly, and may attain a large size, but are innocent tumors, not returning when pure and if completely removed. Sarcomata may undergo an analogous change—*i. e.* mucous softening—and of course such tumors are apt to recur. Mucoid softening also attacks fibromata, chondromata, and other connective-tissue tumors, so that many tumors called myxomata are chondromata, fibromata, or sarcomata undergoing mucoid (myxomatous) change.

Structurally, a true myxoma is soft, gelatinous, semi-translucent, encapsulated, and intersected by septa of fibrous tissue. Their cut surfaces are pinkish- or yellowish-gray, and exude large quantities of glairy fluid containing much mucin. Microscopically, they are seen to be composed of numerous anastomosing stellate cells, with branching processes which form a delicate stroma in which the gelatinous basis-substance is contained: some round and spindle cells are also found. Inflammation, fatty degeneration, ulceration, and the formation of blood-cysts from rupture of capillary vessels are the secondary changes to which these tumors are liable.

Seats of Predilection.—The nasal cavities, in which they form gelatinous polypi; the mammary gland; the intermuscular spaces; the submucous and subserous tissues; more rarely the periosteum, the bone medulla, and sheaths of nerves.

Diagnosis.—Before removal their close physical resemblance to fatty and fibro-cellular tumors renders certainty impossible, since they present the same soft, elastic feel, and may even seem to fluctuate, thus simulating a chronic abscess: in such cases the hypodermatic needle would settle the diagnosis.

Treatment.—This should be removal when practicable. This is usually readily effected, the growth shelling out of its capsule; but careful dissection is required when they spring from large nerves, since these not uncommonly pass through the center of the tumor, so that sections of the nerve have been accidentally removed when excising such growths.

B. Tumors conforming to the types of the higher connective tissues:

1. Muscular Tumors, or Myomata.—Only those of congenital origin seem to be composed of *striated* muscle-elements (*rhabdo-myoma*), but even in such tumors the bulk of the neoplasm is not usually composed of muscle-cells.

New growths made up in part of smooth, *non-striated* muscle-cells (*leio-myoma*) frequently occur in the uterus, forming such considerable portions of most fibromata of that organ as to induce many writers to term them myomata of the uterus. In like manner most enlarged prostates are composed in great part of unstriped muscle. Prostatic enlargements are more apt to be due to fibro-myomatous growths involving the whole organ or an entire lobe, although distinct pedunculated growths are not uncommonly found; while those of the uterus, often very large, consist usually of an aggregation of separate tumors. Uterine fibromata also often assume the polypoid form, from the extrusive efforts of the organ excited by the presence of the growth. Situated elsewhere, myomata rarely attain a great bulk. Wherever situated, they grow slowly and are quite innocent, although from their size or position they often cause the utmost inconvenience or even danger to life. They are firm, sometimes smooth, but more often nodular, their cut surfaces closely resembling those of a fibrous tumor, owing to the presence of varying quantities of true fibrous tissue; glandular structures form part of prostatic tumors.

Diagnosis.—As they are at the outset so situated as to be inaccessible to sight or touch, the reader is referred to the sections on Diseases of the Prostate and the Uterus. When the œsophagus, stomach, or intestines have been the parts affected, the nature of the tumors has rarely been diagnosticated.

Treatment.—When accessible, they should be removed. Not seldom this may require total hysterectomy.

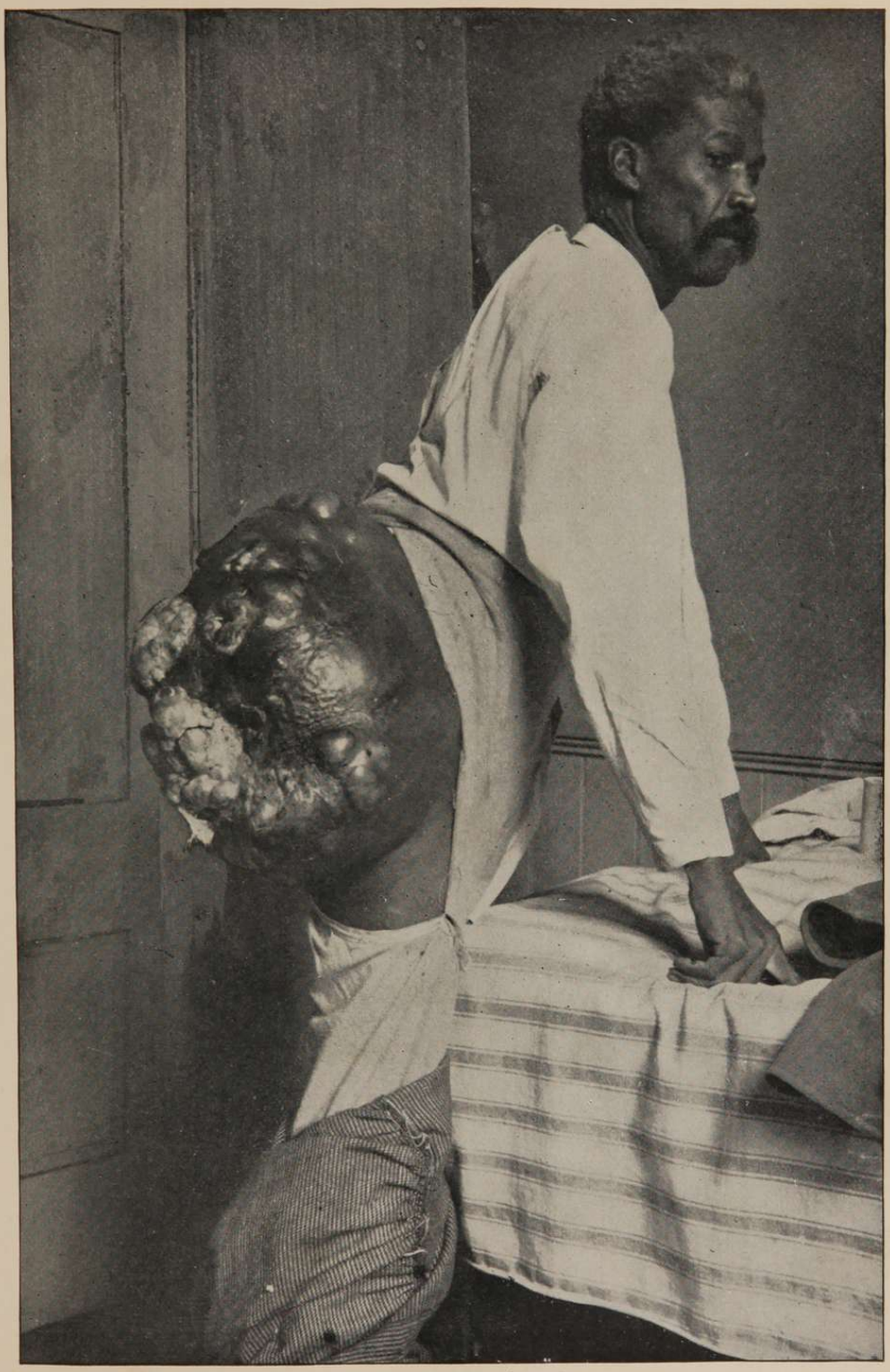
2. Vascular or Erectile Tumors, or Angeiomata.—Under this head are classed all neoplasms the chief constituents of which are blood-vessels, either arteries, veins, or capillaries, or in which the blood is contained in cavernous spaces not true vessels. Many sarcomata, and some fibromata and carcinomata, are permeated with enormous quantities of blood-vessels or channels of large caliber, but the essential element composing each tumor is not the vascular tissue, but the sarcomatous, fibrous, or carcinomatous element.

3. Both Angeiomata and Lymphangeiomata will be more thoroughly discussed in the chapters on Diseases of the Blood-vessels and Lymphatics, where their treatment by excision, cauterization, ligature, or electrolysis is described.

4. Nerve Tumors, or Neuromata.—Such growths are of rare occurrence, whether composed of medullated or of non-medullated nerve-fibres. To avoid repetition, the student is referred to the section on Injuries and Diseases of the Nerves.

C. Tumors conforming to the type of embryonic connective tissue.

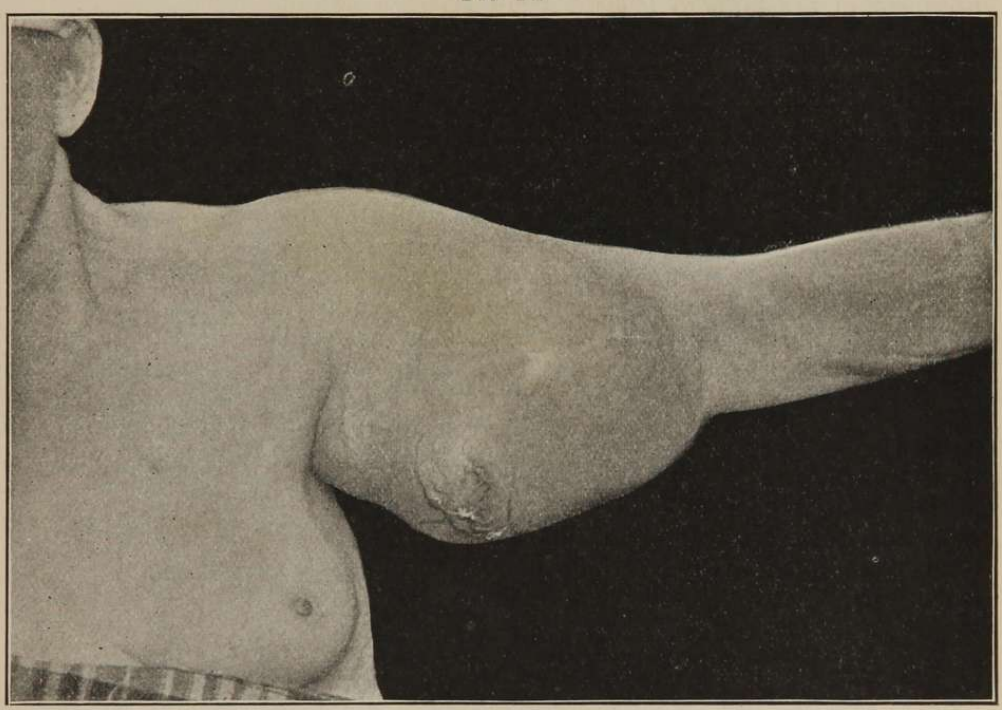
These neoplasms, called **Sarcomata** (Pl. VIII and Fig. 26), closely imitate in their structure normal embryonic or immature connective tissue, and to this class belong the fibro-nucleated, fibro-plastic, myeloid, recurrent fibroid, and many of the encephaloid cancers of the older authors. While normal embryonic connective tissue goes on to the formation of fibrous tissue, cartilage, bone, and so on, the sarcomata always retain the embryonic character at their circumference—*i. e.* their growing, advancing



Enormous sarcoma of buttock.

border, and therefore their youngest and least mature part—even in cases in which the older portions may have developed almost normally into fibrous tissue, cartilage, or bone. Therefore any rapidly-growing tumor of the connective-tissue type must have its periphery especially subjected to careful microscopic examination to determine whether sarcomatous elements exist there. While the sarcomata vary much in their structure and clinical course, they all present the following *characteristics*. The component cells contain one or more nuclei, the masses of protoplasm of which they are formed not being surrounded by any distinct cell-wall, and the cell-body is large as compared with the nucleus. The cells are "in constant relation with the stroma"—*i. e.* the intercellular cement, that which corresponds to stroma, surrounds each cell, varies in amount, and has no definite arrangement, no alveoli being formed as in carcinoma. The blood-vessels ramify among the cells, not, as in the carcinomata, running in the stroma, because of the absence of any such structure, and are very thin-walled. Indeed, they often

FIG. 26.



Sarcoma of the Arm.

appear to be nothing more than mere spaces bounded by the cells of the growth themselves. A consideration of these peculiarities of structure and of the distribution of the blood-supply readily explains the frequent occurrence of hemorrhage into the substance of sarcomata. The fact that dissemination takes place almost invariably by the blood-vessels, and not by the lymphatics, as is the case with carcinomata, is also explainable by the peculiar relation of the vessels and cells. Again, for the same reasons, the lungs, being the organs first reached by the blood after fragments of the growth have been swept away by the current, are the organs most often the seat of secondary deposits. The metastatic deposits are usually similar in structure to the primary growth. Since sarcomata grow by infiltrating the surrounding tissues, they are exceedingly apt to recur locally, doubtless because some infiltrated tissue has been left. Secondary lymphatic glandular involvement, except when the tonsil or testis is implicated, is the rare

exception—as is alleged, because of the absence of lymphatic vessels in most sarcomata: if the organs just mentioned are attacked, glandular involvement is the rule. Their growth is not slow and steady as in the carcinomata, but spasmodic, now fast, now slow. While carcinoma attacks old or senescent tissues, sarcoma most frequently occurs in organs or tissues which are developing, are in active function, or are at least in their prime; hence it is a disease of youth or early middle life. Another point in which it differs from carcinoma is that scraping a freshly-cut section does not yield a milky juice like that obtainable from the latter form of malignant growth. Not infrequently sarcomata result from an injury, such as a blow or a fracture.

So closely does one of the varieties of sarcoma—the round-celled—resemble ordinary granulation-tissue that they cannot be distinguished from each other microscopically. They both consist of small round cells similar to the white cells of the blood, separated from one another by a very small amount of homogeneous intercellular material permeated by delicate capillary vessels arranged in the form of loops. The sarcomata exhibit nearly every step in the development of the connective tissues, from this round-celled, immature tissue to bone. Thus, the cells become elongated and spindle-shaped, while the intercellular substance may show an attempt at fibrillation; or further developmental changes may ensue, converting the major part of the growth in some instances almost wholly into fibrous tissue, cartilage, or even bone, although, as has been already said, sarcomatous elements are always discoverable at the growing margins, while its malignancy, as shown by invasion of the surrounding tissues and dissemination throughout the internal organs, is in no way lessened. Calcification is often mistaken for true ossification, which is seldom met with except in bone sarcomata, and while it is true that bone may form part of any variety of sarcoma, yet it is most common in the spindle-celled and the mixed forms. Where the new bony spiculæ, in any tumor connected with a long bone, grow at right angles to the shaft of that bone, they will usually be found to be surrounded by some soft tissues, which upon microscopic examination will prove to be of a sarcomatous nature: this arrangement of the bony spiculæ is the exact reverse of that commonly prevailing in the structure of true osteomata, where they pursue a course parallel to the long axis of the bone and are surrounded by cartilage or periosteum.

Sarcomata may be grouped in three main classes—viz. the *round-celled*, the *spindle-celled*, and the *myeloid* or *giant-celled*.

1. The Round-celled Sarcomata usually form soft, vascular, and very rapidly growing tumors, often becoming very large, and early giving rise to metastatic deposits in distant parts and in the viscera. Microscopically, they consist of round cells of varying size closely resembling leucocytes, imbedded in a small amount of granular or homogeneous intercellular basis-substance. On section they so much resemble brain-matter in consistence and vascularity that the old terms encephaloid and medullary seem not inappropriate. Many of those tumors formerly called encephaloid cancer or fungus hæmatodes were really round-celled sarcomata. A variety of round-celled sarcoma, where the cells lie within a stroma formed of delicate meshes closely resembling that of lymphatic tissue, is often described as *lympho-sarcoma*. Such tumors must be distinguished from irritative enlargements of lymph-glands and the adenoid hyperplasias of leukemia and Hodgkin's disease. It has been thought to have been palliated, or even to be curable in rare instances, by the internal use of arsenic. Mucoid softening, fatty degeneration, and ulceration are common secondary changes, together with the extravasation of blood

into their substance, resulting in the formation of cysts (sarcomatous blood-cysts).

Seats of Predilection.—They attack most frequently the periosteum, bone, lymphatic glands, subcutaneous tissue, testicle, eye, ovary, uterus, lungs, kidneys, and more rarely the skin, although they may originate wherever fibrous tissue exists.

Sub-varieties.—(*a.*) *The glioma.* This form grows from the connective tissue (neuroglia) of nerve-centers, and its basis-substance resembles that structure; the cells are apt to be small. It occurs in the retina and brain. (*b*) The *lympho-sarcoma*, growing in lymphatic glands, is composed of cells usually of large size, lying in a reticulum resembling lymphoid tissue. (*c*) The *psammoma* or *nest-celled sarcoma* is of rare occurrence, attacking only the pineal gland. (*d*) The *alveolar sarcoma* is so called because the basis-substance encloses each cell in a separate space or alveolus. (*e*) In the *melanotic sarcoma* both the cells and the intercellular basis-substance are pigmented. Both the alveolar and the melanotic form may be of the spindle-celled variety. The melanotic form is found as a primary growth only in parts normally containing pigment, as the skin and the choroid coat of the eye, becomes rapidly disseminated—the secondary growths being usually also pigmented—is probably the most malignant of the sarcomata, and by the older writers was called *melanotic cancer* or *melanosis*. *Warts* are sometimes pigmented, and thus look like this form of sarcoma, but warts are firm, often pedunculated or lobulated, and of slow growth: in rare instances pigmented warts undergo epitheliomatous change, when their rapid growth excites the suspicion that they are pigmented sarcomata, but in the epithelial growths the glands early become implicated.

2. The Spindle-celled Sarcomata are formed of cells varying much in size, some tumors being composed of very small oat-shaped cells, others of greatly elongated bodies with long, fine, tapering extremities. Often the cells are arranged in the form of trabeculæ, which so closely imitate fibrous bands that the tumor may be diagnosticated as a fibrous or even a muscular growth.

The **sub-varieties** are the *melanotic*, just mentioned, and the *small-celled* and *large-celled*. When portions of these tumors have undergone developmental changes they are sometimes called chondro-sarcoma, osteo-sarcoma, etc.

Seats of Predilection.—The skin and subcutaneous tissue, the fasciæ and intermuscular septa, the periosteum and the interior of bones, the eye, the antrum, the breast, and the testicle.

Sarcomata consisting of an admixture in varying proportions of round and spindle cells, or of cells of many different forms and sizes, are sometimes called *mixed-celled sarcomata*. To the naked eye they present the same characteristics as the round- and spindle-celled forms, and they may undergo the same developmental and degenerative changes.

Seats of Predilection.—Chiefly the bones.

3. The Myeloid or Giant-celled Sarcomata consist chiefly of large elements formed of masses of protoplasm, containing two or more nuclei—up to twenty, or even fifty—with a varying number of round, spindle, or mixed cells. They usually spring from the interior, cancellous tissue of bones, and vary in consistence from that of jelly to almost that of muscle. A section appears smooth, shining, succulent, but presents no appearance of fibrillation, and is of a greenish or of a livid red or maroon color, varied by pink or darker red spots, due to extravasations of blood. They have been compared in color to the muscular tissue of the heart.

Seats of Predilection.—The lower jaw, the lower end of the femur, and the head of the tibia; although they may occur elsewhere.

The **courses** pursued by the several forms of sarcomata are partly dependent upon their structure, partly upon the organ or tissue which they attack. For example, the commonest form attacking the mamma, the spindle-celled, occurs most frequently between thirty and forty years of age, is at first encapsulated—therefore freely movable—hard and nodular, grows with great rapidity, and sooner or later, from softening or the development of cysts, is apt to present points of unequal consistence, some of the consequent bosses actually feeling fluctuant. The tumor remains for a considerable time isolable from the mammary gland proper, thrusting this to one side. The skin does not usually become adherent, even when intracystic growths fungate, after having caused ulceration; although, if the tumor is left to pursue its natural course, in time not only the skin but also the subjacent parts will be infiltrated, and death will ensue from sloughing or involvement of the lungs, liver, or other viscera; the axillary glands remain uninvolved.

Examine the other extreme as exemplified by the course pursued by a giant-celled sarcoma, usually occurring in an adult over forty years of age, and attacking the body of the lower jaw, slowly expanding the bone into a smooth tumor, involving both its inner and its outer surface, the bony walls of which are often so thin as to crackle under pressure, yet growing so slowly that years may elapse before it attains the bulk of a walnut; the growth does not become adherent to the surrounding tissues, and consequently rarely ulcerates; involvement of the lymphatic glands seldom occurs.

From the preceding remarks it will be seen how difficult the diagnosis of sarcoma often is, varying as the symptoms do with the organ attacked. Occurring at all ages, sarcoma is more apt to attack the young—*i. e.* the tissues during the developmental period. Although it is the rule for sarcomata to grow rapidly, especially the secondary growths, yet some of the primary ones develop slowly, the rate of growth and bulk attained depending largely upon the tissue attacked. Those of the eye or brain are apt to be small, while those of bone often reach a huge size. While those which attack the subcutaneous tissue, the fasciæ, and the intermuscular planes are usually surrounded with a capsule, there is none for those springing from the surfaces of bones, nor for those arising in the interior of such organs as the lymphatic glands, the tonsil, etc., which are soon entirely infiltrated by the growth.

Infiltration of the surrounding tissues, even those external to its capsule (when such exists), is a peculiarity of sarcoma: this is especially true of the small spindle-celled variety (recurrent fibroid of Paget), which occurs chiefly in the subcutaneous tissue and sometimes in the breast, recurring in the course of many years a dozen or more times, while distant parts and the lymphatic glands never become infected. Attention has already been called to the early implication of the glands in sarcomata of certain organs, as the testicle, etc. The subperiosteal sarcomata are very apt to give rise to secondary tumors in other bones, the skin, the subcutaneous tissue, and the viscera, lymphatic involvement being the rare exception. Finally, certain of the softer sarcomata by hemorrhage into their substance become completely broken down and converted into cyst-like tumors filled with blood, partly fluid, partly coagulated. These if punctured bleed profusely, the hemorrhage being often difficult to control; without a microscopical examination it may be impossible to distinguish such a growth from a true hematoma (blood-cyst).

Diagnosis.—This is often difficult, and must depend on a careful consideration of the foregoing facts, together with those now to be given. The

consistence of the tumor varies much in different parts; cysts are of frequent occurrence, especially when affecting the bones, breast, or testicle; moreover, these develop, as does the growth, with a rapidity unknown in benign cystic growths; sarcomata are more apt to ulcerate than benign tumors—this is peculiarly true of recurrent growths; the ulceration, whether the giving way of the skin be due to infiltration, as is the rule, or merely to advancing pressure, is apt to be preceded by a reddened, tender, hot skin, thus presenting such symptoms of inflammation as will embarrass the diagnosis in doubtful cases. In any given case the questions to be considered are—Is it an inflammatory trouble, or is it a malignant growth? If a malignant growth, is it sarcoma or carcinoma? The first question can probably be answered by the history, by the absence of the systemic indications of an acute suppurative inflammation, and, above all, by the marked differences of consistence exhibited by different portions of the tumor. The second query, as to the class of malignant disease to which any given growth belongs, can, with the exception of primary growths attacking the tonsil, the testicle, or the lymphatic glands themselves, be settled by the early involvement of the lymphatic glands in carcinoma and their immunity in sarcoma, and by the frequent presence of cysts, the greater mobility, the freedom of the overlying skin, the enlargement of the superficial veins, and the greater rapidity of growth in the latter disease. Retraction of the nipple in a case of tumor of the breast points to carcinoma rather than to sarcoma. The peculiar features assumed by sarcoma as it affects each organ often afford valuable information, and for this the student is referred to the appropriate sections of this work.

The **prognosis** varies with the site of the disease; thus, a myeloid (giant-celled) sarcoma of the lower jaw is not uncommonly curable by operation, while a sarcoma of the tonsil or lymphatic glands destroys life with great rapidity. As has just been pointed out, recurring small-celled sarcoma of the subcutaneous tissue may be repeatedly removed, the system remaining free; or amputation, if a limb be involved, will probably cure the disease. It also varies with the variety of the disease: the more embryonic the form the greater the malignancy. Thus the round-celled variety is by far the most malignant form, the spindle-celled less so, and the myeloid the least.

Treatment.—This depends partly on the variety, partly on the organ attacked. While it is true that a myeloid tumor of the lower jaw may after thorough enucleation never recur, it is far safer to remove at the same time as much of the surrounding tissue as can be done with safety. When the long bones are the seat of sarcoma, amputate high up—if possible, through the joint above: this is likewise good practice when sarcomata of the soft parts of the extremities recur, especially if they are of the round-celled type. If the upper jaw is attacked, the whole maxilla of that side must be removed, but the prognosis will be bad. Sarcomata of the lymph-glands or of the tonsil are so little influenced for good by operation that, except as a mere palliative, removal, as a rule, should not be attempted. Tumors of the subcutaneous tissue or intermuscular fascia should be removed as often as they recur, or amputation may be resorted to when a limb is concerned. It has been long known that occasionally an attack of erysipelas will cure a sarcoma. Lately, the treatment of inoperable sarcomata by hypodermatic injections of the toxins of erysipelas, instead of the streptococcus itself, has been revived, especially by Coley. The toxin of the bacillus prodigiosus added to that of erysipelas increases the reaction. A few cases of apparent cure have been reported by Coley, Mynter, and others, but most other surgeons have met only with failure.

Emmerich and Scholl have recently used the serum of a sheep immu-

nized by inoculation of erysipelas toxins in the treatment of inoperable carcinoma and epithelioma with apparent success.

D. The Endotheliomata.

These, as yet, little-known tumors, occupying apparently the border-land between sarcomata and carcinomata, must be briefly considered, since it appears probable that some sarcomata of the testicle are of this nature, and, developing at least in part from the endothelium of the lymphatics, give rise to that early infection of the glands so characteristic of testicular sarcoma, and yet so contrary to the natural history of the disease as it occurs in nearly every other situation.

When arising in the pia mater, structurally and from their mode of origin many of these endotheliomata are alveolar sarcomata, while those originating in the pleura or peritoneum are carcinomatous, consisting of nests and clusters of epithelial cells presenting at their periphery a columnar appearance, these cell-masses being surrounded by a dense fibrous stroma: the cells follow very exactly "the course of the lymphatic vessels." They present themselves in the form of "multiple flattened nodular growths, white in color, and either isolated or connected by neoplastic bands, the intervening serous membrane being more or less thickened;" metastasis is common, giving rise, when the pleura, for instance, is the seat of the primary tumor, usually to secondary growths in the peribronchial fibrous tissue, the bronchial glands, and the thoracic muscles. Attacking as they do chiefly the pleura and peritoneum, nothing definite can be said concerning their diagnosis or treatment, and they have been mentioned here because of their apparent etiological relations to other malignant growths, and because, although rare, recorded cases are becoming more frequent.

A. Warty or Villous Tumors, or Papillomata, closely resemble in their structure hypertrophied papillæ of the skin or mucous membrane, some of the varieties receiving other special names, as condylomata, mucous tubercles, and "benign villous tumors." They are often due to some form of irritation, as in the case of those which develop on the glans penis from the action of acrid discharges, or those on the hands from dust and dirt. Rarely attaining a large size, and attacking only the skin or the mucous membranes, they are innocent growths, although during the cancerous period of life they are apt to degenerate into epithelioma, and the villous tumor of the bladder may destroy life by the hemorrhage to which such a growth often gives rise. Structurally, they are composed of a varying amount of connective tissue surrounding one or more central blood-vessels, and are covered in by one or several layers of epithelial cells resembling those of the skin or mucous membrane from which they are developed; but the cells never transgress their connective-tissue limit—*i. e.* they do not infiltrate, as epithelioma does.

Warts or *warty growths* either occur as circumscribed growths, or more rarely form cauliflower masses, large relatively to the size of the part, such as those occurring in the larynx. The enlarged papillæ are covered by a layer or layers of horny epithelium, and their vascular supply, as a rule, is small.

Mucous tubercles and *condylomata* consist of flattened elevations composed of enlarged papillæ; their connective tissue, of rapid growth, is infiltrated with numerous small round cells, and their epithelial covering is moist and sodden. They are most commonly due to syphilis.

Villous tumors, when springing apparently from the vesical mucous membrane, where papillæ do not normally exist, originate from the subepithelial con-

nective tissue and owe their papillary form to the concentric arrangement of the connective tissue and epithelium around the blood-vessels. These can, however, best be described here. Such growths assume the branching, dendritic form of the villi of the chorion, and are very vascular, the vessels being often dilated and thus liable to give way, producing the frequent and serious hemorrhages common to this affection of the bladder. Their epithelial layer is thin, and often removed mechanically, being passed in the urine, where it can be detected by the microscope.

Seats of Predilection.—*Warts* and *warty growths* occur most frequently on the skin, especially of the hands and genitalia, and on the mucous membrane of the larynx. *Mucous tubercles* and *condylomata* are most commonly found about the anus and genitals or in the mouth and throat. The *villous growths* attack the bladder, rectum, and larynx.

Such secondary and degenerative changes as pigmentation, ulceration, and atrophy are common, while with advancing years the epithelial elements may infiltrate the connective tissue, resulting in epithelioma.

Diagnosis.—The signs and diagnosis of tumors attacking such diverse organs cannot be profitably discussed here, and can be best studied in the articles on the Skin, Bladder, Rectum, Larynx, and Syphilis.

Treatment.—As this varies with the parts involved, it can only be said, in a general way, that these growths should be removed by such means as sulphuric or nitric acid, etc., which will destroy the base from which they spring; or this base, after their excision by the knife or scissors, must be destroyed by a caustic or by the actual cautery in some form.

B. Glandular Tumors, or Adenomata, are innocent growths, and originate only from pre-existing glandular tissue, which they closely imitate. As of normal gland-tissue, so of these tumors there are two types, the *acinous* and the *tubular*. The *acinous* are composed of acini lined with spheroidal epithelium, intercommunicating by duct-like channels: mammary adenomata are of this type. The acini are bound together by a varying amount of connective tissue in which the blood-vessels ramify. Pure adenomata are rare, the interacinous tissue usually being replaced by a considerable amount of fibrous tissue (adeno-fibroma), mucous tissue (adeno-myxoma), or sarcomatous cells (adeno-sarcoma); again, the admixture of fibrous tissue with the sarcomatous elements, or of mucous tissue similarly disposed, results in other growths (adeno-fibro-sarcoma, adeno-myxo-sarcoma); still further, from obstructive pressure the acini or ducts may become dilated, forming cysts into which proliferating growths (intracystic growths) may project: such growths receive their names from the character of the interacinous and intertubular tissue, being termed adeno-cystoma, cysto-sarcoma, etc.

The *Tubular Adenomata* consist of tubules lined with cylindrical epithelium, and therefore spring from mucous membranes the glands of which are similarly constructed, as from that of the intestines. Closely resembling carcinomata in many respects, unlike them the epithelial elements do not infiltrate the connective tissue.

Seats of Predilection.—The *acinous* occurs chiefly in the mammæ—generally in the form of adeno-fibroma—in the lip, ovary, testis, prostate, thyroid, parotid, lachrymal gland, the cutaneous and sebaceous glands: the *tubular* variety occurs in the intestine, especially the rectum. Secondary degenerations, such as mucoid softening of the stroma and fatty degeneration of the epithelium, frequently produce cystic changes by obstructive pressure on the acini or duct-like portions of these growths.

II. Epiblastic and Hypoblastic Tumors, or those conforming to the Types of Epithelial Tissues—the Carcinomata.

The malignant tumors of this class are composed of cells of the epithelial type "in constant relation with one another"—*i. e.* no visible intercellular matrix is discoverable—forming nests surrounded by more or less fibrous stroma. This alveolar arrangement of the cells is due to the fact that the cells, having broken through their "connective-tissue limit," now occupy the interstices of this tissue—*i. e.* the radicles of the lymph-system—forming *intercommunicating columns of cells, which in cross-section, surrounded with their fibrous stroma, present the appearance of true alveoli.* Unlike adenomata, the cell-groups are not limited by any basement membrane, while the vessels differ from those of sarcomata by having walls of normal thickness and construction; moreover, they ramify in the *stroma*, not among the *cells* themselves. Two points should be noted—viz. that although the individual cells differ somewhat from one another, they retain the type of the parent epithelium, being more or less spheroidal when originating from a gland, squamous if derived from the skin, squamous or more often columnar when springing from a mucous membrane. Still further, the cells of the secondary growths usually closely resemble those of the primary tumor. The normal connective tissue of the part, which at first forms the stroma, is infiltrated with numerous cells, which later, by development into fibrous tissue, produce the denser stroma characteristic of some forms of carcinomata.

The development of this fibrous tissue, studied in connection with the disposition of the blood-vessels, explains the differing behavior of the rapidly-growing tumors and those of slower growth. In the former the vascular supply is rich and tolerably evenly distributed throughout the growth, while there is relatively little stroma, what is present probably being not much more than the normal connective tissue of the part incapable of active contraction and consequent obliteration of the blood-vessels. In the tumors of slower growth the blood-supply is more scanty originally, and is found chiefly at the periphery of the growth, having been obliterated in the more central older portions by the contraction of the large amount of newly-formed fibrous tissue. Hence the fatty degeneration of those portions, resulting in their breaking down, with loss of substance, when occupying a free surface or after giving way of the skin in more deeply situated growths: this is the so-called *ulceration of new growths.* Owing to the abundance of blood-vessels and the lack of support afforded by the scanty stroma of the rapidly-growing carcinomata, hemorrhage into their substance is not uncommon, with free bleeding from the surface when ulceration has taken place. Carcinomata possess no capsule at any stage of their development, growing by endogenous cell-division and by infiltration of the surrounding tissues, as a rule sooner or later breaking down and ulcerating. As the cells proliferate in the lymphatic spaces of the connective tissue, or, as is alleged for the breast, originate in what are said to be spaces in direct continuity with the lymphatic vessels, the nearest lymphatic glands early become involved, then those next in order, and finally the viscera. In external carcinoma the general health does not usually suffer until after ulceration, with its consequent purulent and bloody discharges, or secondary implication of one or more of the important viscera, has occurred, when what is known as "the cancerous cachexia" sets in, characterized by a peculiar sallow, earthy hue of the skin, anxious, careworn facies, and more or less marked emaciation. Death finally results from the combined effect of the

purulent and hemorrhagic discharges, from the impairment of nutrition through involvement of important viscera, and from pain, anxiety, and loss of sleep. In internal carcinoma, especially of the digestive organs, this cachexia soon sets in, inasmuch as the general nutrition of the body is disturbed very early in the disease. Possibly also the absorption and diffusion of secondary products of the carcinoma may have some influence in causing this cachexia.

Carcinomata are divisible into *two main classes*, with certain sub-classes:

(C) The acinous or spheroidal-celled:

1. The hard spheroidal-celled (scirrhus);
2. The soft spheroidal-celled (encephaloid);
3. The colloid, probably a degenerative form of one of the preceding varieties.

(D) The epithelial:

1. The squamous-celled;
2. The cylindrical- or columnar-celled.

(C) **Acinous or Spheroidal-celled Carcinoma** originates only from the epithelium of the acinous glands or from that lining the tubular glands possessing glandular epithelium. The essential difference between the two chief divisions of this class is in the relative amounts of stroma and cells, the hard form containing large amounts of fibrous tissue, while in the soft carcinomata the cells preponderate. The term **Scirrhus** has been applied indiscriminately to the harder forms of spheroidal-celled carcinomata and to the whole class.

1. Hard Spheroidal-celled Carcinoma, or Scirrhus, appears as a hard, irregular, tuberous growth of moderate size; if originating in a glandular structure, it is continuous with it; at the outset freely moving with the gland, but later by infiltration losing this mobility because adherent to the skin, fascia, muscles, etc. Implication first of the nearest group of lymphatic glands, and next of the viscera, and finally ulceration of the superjacent tissues, complete the natural history of the growth. The carcinomatous ulcer is irregular in outline and depth, has hard, nodular, everted margins, while the base is indurated and irregular, sometimes more or less covered with sloughs, and but rarely presents any evidences of granulations, although in very exceptional cases these exist with slight attempts at cicatrization. The duration of life in this affection is about two years, but occasionally patients live for many years, even twenty, during much of which time ulceration may exist. Of course these remarks apply only to external tumors. Owing to the large amount of newly-formed connective tissue in the hardest forms of scirrhus, in some instances the tumor, instead of growing larger as time goes on, becomes smaller, the surrounding tissues being irregularly puckered and drawn in toward the small central shrivelled lump which forms the tumor; this is the so-called *withering* or *atrophic scirrhus*, best seen in the breast, where after it has existed for years nothing but an irregular mass resembling a cicatrix is to be found, blending into one inseparable growth what formerly was skin, mammary gland, and chest-wall. Unfortunately, the malignant tendencies of the growth are not abolished by its shrinkage, for secondary tumors develop in the viscera, destroying the patient. (See *Diseases and Injuries of the Breast.*)

On section, hard carcinomata are firm, of a white color, often traversed by fibrous septa, and creaking under the knife; the cut surface is cupped. The section is succulent, yielding on pressure or scraping a milky fluid, the so-called *cancer-juice*. Howsoever circumscribed the tumor may appear, it is one of the rarest of pathological curiosities to find it encapsulated. Islets of normal tis-

sue or fat can often be detected at the periphery of the new growth surrounded by carcinomatous tissue; indeed, no definite tumor is discoverable in certain cases, the neoplasm being disposed throughout the affected organ in the form of nodules and cord-like bands.

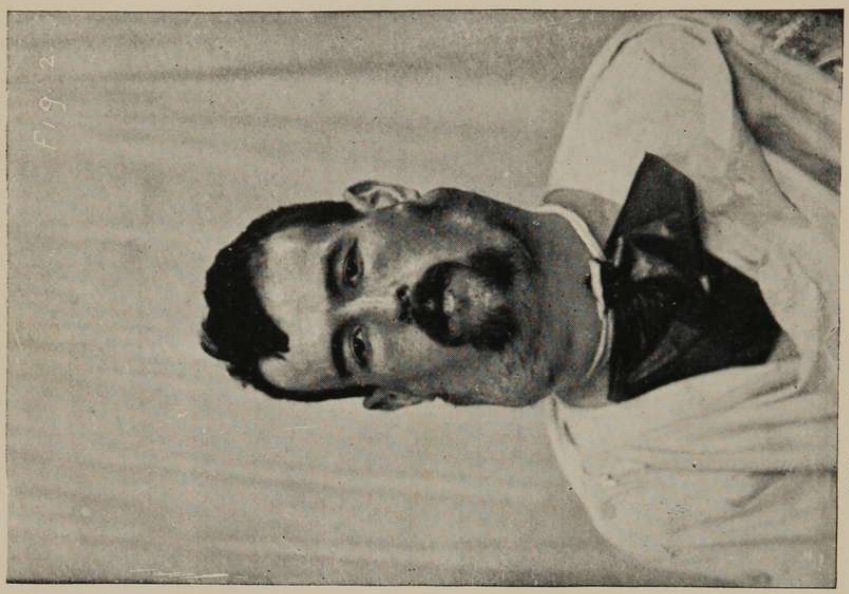
Seats of Predilection.—The mammary gland, the alimentary tract, especially the pyloric end of the stomach, and, in a few instances, the glands of the skin.

2. Soft Spheroidal-celled (Medullary or Encephaloid) Carcinoma.—Differing, as already said, from the preceding variety merely by the amount of fibrous tissue, in its typical form soft carcinoma on section closely resembles brain-tissue both in appearance and in consistence. Clinically, the chief points wherein it differs from the hard form are the greater softness of the growth—so soft as at times to simulate and be mistaken for abscess—the greater bulk attained, the short time required to reach this size, and the rapidity with which it runs its course. In form the soft carcinomata differ according to the organ attacked. Thus those of the testicle form large, bossellated masses, while mammary growths tend to form a large globular mass or one composed of an aggregation of rounded masses. When ulceration has taken place a fungating, readily-bleeding mass often forms; hence the old name of "*fungus hæmatodes.*" The secondary and degenerative change which these carcinomata undergo is softening at their central older portions, due chiefly to fatty degeneration, but partly to giving way of the blood-vessels, which often results in the formation of such large fluctuating areas that, as has been said, they have not infrequently been mistaken for abscesses. Such tumors on section show that their central portions are converted into a soft, diffluent mass, while the periphery of the growth presents the ordinary grayish-white or cream-colored, brain-like surface, blotched here and there with blood. This softening also results in cyst-like cavities of considerable size, giving to the tumor the appearance of a true cystic growth. In some carcinomata of the testicle, the mamma, and other glands true retention-cysts form.

Locally, carcinomata extend by infiltration of the circumjacent tissues; this accounts for the clinical phenomena of adhesion of the tumor to neighboring parts, its decreasing mobility as it grows, and its final absolute fixation. With occasional exceptions, as in some carcinomata attacking the eye, the antrum, or the pylorus, early secondary lymphatic involvement is the rule, the secondary growths usually resembling the parent one. Occasionally they are of the soft form, even though the primary tumor is of the hard variety, thus demonstrating the essential unity of both forms. The organs and viscera most apt to be affected by metastatic deposits are the skin, the bones, especially the vertebræ, the liver, the lungs, the kidneys, and the brain. Even when, after operation, no local recurrence takes place, the possibility of this visceral implication must never be lost sight of, especially if pains in the lower limbs are complained of, if so-called "spontaneous" fracture of a long bone occurs, preceded or not by pain or tumor, if obscure symptoms of vertebral disease or if peculiar cerebral symptoms appear. Among surgical rarities is the secondary carcinomatous involvement of the medulla of many bones without the formation of distinct tumors in any, but so reducing their strength that numerous fractures occur, either from the application of trifling force or, as it is said, "spontaneously."

Seats of Predilection.—The testicle, liver, bladder, kidney, ovary, fundus oculi, and more rarely the breast.

3. Colloid Carcinoma.—This is really one of the preceding varieties



Malignant lymphoma (Hodgkin's disease).

Ulcerated epithelioma of chin and neck.

the cells of which have undergone mucoid or colloid degeneration and so distend the alveoli that these can be seen by the naked eye. The colloid material is a semi-translucent, glistening, jelly-like substance, in some parts of the growth being even diffluent: generally here and there a few spheroidal cells are found; it pursues a course similar to, but somewhat slower than, that of other carcinomata.

Seats of Predilection.—The stomach, intestine, omentum, ovary, and occasionally the mammary gland.

Diagnosis of the Carcinomata.—They are exceedingly rare before thirty years of age, and are common after forty years; early lymphatic involvement is the rule—contrary to what is true of the sarcomata. Innocent growths occur, as a rule, in younger patients, do not grow so rapidly, do not infiltrate the organ or neighboring parts—*i. e.* do not become adherent—and almost never ulcerate; and when ulceration does occur, the characteristics of the resulting ulcer differ widely from those of the ulcer attendant upon carcinoma. It is said that carcinoma never attacks the testicle in the child, but that at any age a malignant tumor of the testicle which on section contains either cartilage or bone cannot be carcinomatous, but is sarcomatous. While it is usually easy to make the diagnosis of carcinoma, yet at times this is difficult or impossible, competent surgeons having removed breasts, believing them to be carcinomatous, when the disease was simply cystic or merely a chronic abscess. There is no means of distinguishing that very rare condition, encapsulated carcinoma, from a benign tumor—*e. g.* a fibroma. Between chronic mastitis or abscess and carcinoma the association of pregnancy or lactation in most instances when the mamma is the organ involved will assist in the diagnosis, while the greater density of carcinoma and its unequal consistence in its different parts when undergoing softening will often remove all doubt. Unfortunately, the skin over a chronic abscess and that over a softening carcinoma are not so dissimilar in appearance as to preclude all chance of error, especially as the glands may be enlarged in both affections. The decided elasticity of a cyst, even if fluctuation cannot be detected, its circumscription, and its free mobility, serve to distinguish this class of tumors from carcinoma. It is far better, in any case of doubt whether the tumor is really an abscess, a cyst, or a softening carcinoma, either to explore with a hypodermatic needle or at the time of operation to make first an exploratory incision directly into the tumor.

(D) The Epithelial Carcinomata.—1. The SQUAMOUS-CELLED EPITHELIOMATA always spring either from free epithelium-clad surfaces, as the skin or mucous membranes, or from the glands of the same, since the hair and sebaceous glands in certain instances have been observed to take the initiative in the carcinomatous process. These growths appear with great frequency at the points of junction of mucous and cutaneous surfaces (Pl. IX, Fig. 1), probably because there subjected to more frequent and varied forms of mechanical and chemical irritation. Structurally, they are composed of pegs or columns of squamous cells, which infiltrate first the subjacent connective tissue, then every underlying structure, including bone, in their track. The epithelial ingrowths contain globular masses of flattened cells, the so-called "*cell-nests*" or *epidermic pearls*. The surrounding fibrous stroma is usually infiltrated with small cells. Epithelioma commences either as a wart-like growth, a flattened tubercle, or a fissure, ulceration in all these forms setting in early. In many instances this proceeds with such rapidity that the tumor-formation barely keeps pace with it, the resulting disease resem-

bling—and being often mistaken for—an ulcer, the indurated base and margins either escaping detection or being looked upon as inflammatory. The other extreme is often met with where tumor-formation is in excess, only superficial ulceration obtaining until the growth is of considerable size. Epitheliomata are not encapsulated, although upon section their margins appear sharply defined from the surrounding tissues, while the cut surface is white, dense, homogeneous, poor in juice, but if compressed laterally giving vent to milk-white, twisted, thread-like masses which have been likened to the "comedones" that can be pressed out from the sebaceous glands of the skin. The consistence varies much, but is distinctly greater than that of the surrounding tissues, and the part feels dense and inelastic. Although an epitheliomatous ulcer may resemble that resulting from any other form of carcinoma, yet sometimes it is a mere fissure with indurated margins, a relatively indolent ulcer with the same peculiarities, or has superadded numerous papillary projections, producing a warty or cauliflower-like growth. When originating from an old wart—a not unusual occurrence—ulceration is apt to be the first symptom, with subsequent induration of the base of the growth. The same remarks are applicable to many cases of epithelioma of the tongue, where an indolent ulcer may last for weeks before the characteristic induration of its base and margins can be detected. The rate of growth varies with the vascularity and looseness of texture of the tissues. Thus, when attacking the lower lip the progress is slow, lasting sometimes for a year or more before the tumor attains a size greater than that of a cherry, while relatively bulky tumors will form in a few months in carcinoma linguæ.

"Spontaneous fracture" or gradual bending of the tibia is not uncommon from the infiltration of that bone by cancerous tissue, either when an old ulcer undergoes a malignant change (Marjolin's ulcer), or when a scar, after long-indolent ulceration, commonly starting at its center, becomes similarly diseased. In like manner complete solution of continuity of the lower jaw may result from epithelioma of the lip extending to the gums and thence to the bone. Local recurrence is common after operation when the removal has been imperfect, and death usually results from the exhaustion incident to ulceration and hemorrhage. Secondary lymphatic involvement occurs with most squamous-celled epitheliomata, but usually late in the disease, when the antrum, the interior of the larynx, or the skin of the eyelids, nose, and other parts of the face is attacked. In these latter situations, indeed, the disease being apt to be superficial and of that form called "rodent ulcer," the glands are rarely affected. The exception in the case of the intrinsic parts of the larynx is the more striking because epithelioma of the extrinsic parts affects the glands certainly and early. Visceral involvement is rare, the liver, lungs, kidneys, bone, and skin suffering most frequently.

Seats of Predilection.—Any cutaneous or mucous surface covered with squamous epithelium. When the disease attacks the skin, the parts most commonly involved are the nose, the lower lip, the penis and scrotum, the vulva, the anus, and more rarely the hands and feet. The mucous surfaces most commonly affected are those of the tongue, palate, gums, tonsils, larynx, pharynx, and œsophagus down to the cardiac orifice of the stomach, the bladder, and os uteri.

Diagnosis.—The disease is very uncommon under thirty years of age; it is quite common after forty: it is limited in some of its forms, as epithelioma of the lower lip, almost exclusively to men, and, wherever occurring, attacks men much more frequently than women. If, then, a man of from forty to seventy years of age develops a small tumor in the lower lip which ulcerates early, giving rise to an indolent, slowly-extending sore, with indurated base and margins, no evidence of surrounding inflammation being detectable, the ulcer per-

haps presenting the peculiar warty, cauliflower surface mentioned, and especially if the submaxillary glands are enlarged, the disease may be safely considered carcinomatous. Or, again, an obstinate fissured ulcer, often scabbed over, forms in the same situation, discharging a watery matter, with induration extending in all directions for full one-fourth to one-half of an inch, involving not only the mucous and cutaneous tissues, but all the structures of the lip; perhaps in addition the patient states that the disease first appeared as a wart which had been picked off or cauterized—*i. e.* had been irritated, not destroyed. Epithelioma of the tongue may appear at an earlier age, and in from three to six months will often reach a considerable size in the rarer form, where the disease appears as a hardened, non-inflamed mass on the free border of the tongue—not uncommonly near a broken tooth—its surface eventually becoming fissured, ulcerated, and painful. Or, again, there may be merely an indolent, slowly-extending, unhealthy ulcer with indurated base and margins situated as just mentioned. Although the diagnosis between carcinoma and tubercle or syphilis of the tongue is often difficult, coexisting syphilitic lesions or old scars of the tongue, with antisyphilitic treatment, will usually settle the question, while signs of tubercle elsewhere ought to arouse grave doubt of the carcinomatous nature of the ulcer. Further diagnostic points are given in the section on Syphilis.

Warts on the hands or scrotum, or elsewhere, in elderly chimney-sweeps or in coal-tar- or paraffin-workers should be viewed with suspicion, especially if they are growing and if their bases are becoming indurated, because in such cases, sooner or later, an unhealthy ulcer, discharging foul matter, usually forms, presenting all the clinical evidences of epithelioma. It hardly needs to be said that epithelioma is evidently induced by persistent irritation, since the localities where it occurs are subjected to frequent slight traumatisms, and the occupations which give rise to it supply constant sources of mechanical and chemical irritation.

Local recurrence is common after operation as a consequence of imperfect removal of the disease, and death in these cases, as well as in those not operated upon, results from the exhaustion incident to ulceration and hemorrhage rather than to dissemination, which, as has been already pointed out, is of rare occurrence.

2. Cylindrical- or Columnar-celled Epithelioma.—This is a less common form of carcinoma than the spheroidal-celled or the squamous-celled varieties, and originates from either the cylindrical surface epithelium of a mucous membrane or that of its glands, closely imitating these structures in microscopical appearance; no "cell-nests" are found. These growths form indurated, infiltrating masses in the walls of the organs attacked, and vary much in the rapidity of their course, producing considerable stenosis of the lumen of such hollow viscera as the rectum and small intestines, which may terminate life by producing more or less intestinal obstruction; ulceration occurs early. Dissemination throughout the liver, lungs, and other organs occurs, as a rule, only after infection of the intervening lymph-glands. (See Diseases of the Intestines and Rectum.)

Seats of Predilection.—The rectum, uterus, and intestinal tract.

Diagnosis.—This is to be made by attention to certain secondary results, which will be found detailed in the sections on Diseases of the Intestines and Rectum.

Treatment of the Carcinomata.—The first question to be answered is, Can this case be treated radically, or does it admit only of palliation? If it can be treated radically, the *whole organ* should be excised, including as much

as can safely be removed of the surrounding *apparently* healthy tissues, *before lymphatic involvement has occurred*, if possible: after this involvement has taken place the primary growth must be removed with an unsparing hand, while the lymphatic glands and peri-adenoid tissues must be thoroughly cleared out. Indeed, if this last all-essential requisite cannot be secured, removal of the primary growth is indicated only for the relief of pain, or, if ulceration has set in, to get rid of a disgusting sore. For instance, in a case of mammary carcinoma, if axillary glandular involvement is present, and there is any question as to the possibility of clearing the axilla, as a preliminary to further operative interference an incision should be made into the armpit to determine whether all diseased tissue can be removed. If this cannot be done—unless the breast tumor is ulcerated, when removal may be indicated as a palliative measure—the wound should be closed and the breast allowed to remain, since its removal would add a risk with no compensating advantage. (See Diseases of the Breast.) Amputation of the limb high up, with extirpation of any diseased glands, is always indicated where epithelial carcinoma has invaded the bone from an overlying tumor, as, for instance, the tibia. Malignant disease of such parts as the penis and the tongue is properly treated by amputation of these organs, even when secondary glandular disease is beyond removal, merely as a palliative measure to secure urination in the former case and painless swallowing in the latter.

Epitheliomata of the lips, nose, and eyelids can often be successfully removed by the knife even when extensive, and the defects can be repaired by plastic operation or by Thiersch's method of skin-grafting. The more superficial forms can often be effectively handled by freezing with rhigolene spray, thoroughly curetting, the application of pyrogallic acid, and an after-dressing with an ointment of the same (grs. x @ ʒj), until healthy granulations are formed, when ordinary measures will secure healing or Thiersch's skin-grafting may be used. Potassa fusa or the actual cautery may be employed as the destructive agent, and, after separation of the slough, the defect may be left to Nature's efforts or skin-grafting may be resorted to. The chances of cure vary with the part involved, but even with extensive glandular complications, where complete extirpation is possible, some carcinomata of the lip, tongue, and breast do not recur either locally or in the viscera. Carcinomata of the testicle, œsophagus, or tonsil are rarely benefited by operation, except for the palliation effected. When operation is contraindicated, opium to relieve pain, local applications of lead-water and laudanum, extract of aconite and belladonna rendered of a proper consistence by glycerin, or other similar remedies, with attention to the general health, constitute the treatment in non-ulcerated carcinomata. For ulcerated carcinomata measures to control pain, to lessen discharge or hemorrhage, and to arrest fetor are the main indications. Iodoform with morphine in proper amount dusted over the surface, cocaïne in solution applied either by spray or by painting, solutions of carbolic acid, Labarraque's solution, or a solution of chloral may be used, as far as possible employing dry dressings or those which favor rapid drying of the discharges—*i. e.* lessen putrefactive changes. Esmarch's arsenical powder also serves an admirable purpose. No internal remedies of the many recommended having as yet proved of any real value, none need now be mentioned. Finally, the profession should clearly understand, and endeavor to educate the public in the belief, that *early and radical operations will cure a considerable proportion of cases*, and render life endurable in many more where a cure is impossible.

III. Tumors composed of Epiblastic, Hypoblastic, and Mesoblastic Elements, and containing bone, hair, teeth, etc. (Teratomata), situated in

the ovaries and testicles. These are considered with these organs, especially with the ovaries.

Cysts.

A cyst may be defined as a cavity bounded by a distinct envelope composed of fibrous tissue lined with endothelium, and called the cyst-wall; or it may be covered by epithelium and contain secreting structures: the cyst-contents may be either fluid or semi-fluid; intracystic growths may nearly or completely fill the cavity. A cyst may result from the increase of the normal secretion of an already-formed space or cavity by extravasation into it, or the cavity may be of new formation.

I. *Cysts formed by the Distention of Preformed Cavities or Spaces:*
   (*a*) Exudation cysts;
   (*b*) Retention cysts;
   (*c*) Extravasation cysts.

II. *Cysts of New Formation:*
   (*a*) Simple cysts;
   (*b*) Blood cysts.

III. *Cysts of Congenital Origin.*

IV. *Cysts due to Parasites.*

I. Cysts formed by the Distention of Preformed Cavities or Spaces.

Exudation Cysts result when excessive secretion takes place into closed cavities, such as bursæ, cysts, bronchoceles, etc.

Retention Cysts.—These possess a distinct fibrous wall lined with epithelium, and are caused by obstruction of the duct of a gland or portion of a gland, the continuous secretion producing dilatation of the duct or gland-acinus. In most instances, as a result either of inspissation of the contents or of the mingling with them of exudation-products from the cyst-walls, the normal character of the secretion is totally altered. According to their origin, three sub-classes are usually described—viz. (1) *Sebaceous* (atheromatous) cysts, formed by the dilatation of sebaceous glands; (2) *Mucous* cysts, due to the dilatation of mucous glands; and (3) Cysts formed by the *distention of large ducts—i. e.* the salivary, lacteal, hepatic, renal, etc.

(1) Sebaceous (atheromatous) Cysts present themselves as smooth, flattened ovoidal, sometimes semi-fluctuant tumors, usually movable on the deeper parts, but often adherent to the skin. At times the orifice of the obstructed duct can be seen, indicated by a small black spot.

Seats of Predilection.—The scalp and face chiefly, but they may be found on any part of the body, and are often multiple. When situated in the scalp they are sometimes apparently hereditary. Unlike dermoid cysts, the pultaceous, cheesy contents—often of an offensive odor—contain no hairs, while the cyst-wall possesses neither papillæ nor hair-follicles. Certain secondary changes may greatly alter their appearance and obscure the diagnosis. Thus by inflammation a sebaceous cyst may be converted into an abscess: after spontaneous opening the thinned coverings may ulcerate, abundant fungous granulations may form, and the margins and base of the sore may become indurated and elevated, closely resembling epithelioma. These fungous sores may also undergo actual epitheliomatous change: a portion of the coverings ulcerating, the secretion may be gradually forced out, drying as it protrudes, thus in time

forming a cutaneous horn, sometimes inches in length; finally, calcification of the cyst-wall may take place.

Diagnosis.—They are most apt to be mistaken for fatty tumors or chronic abscess. From the former they can be distinguished by the fact that the edge of a cyst does not slip away from the finger when pressed upon, by the absence of dimpling of the overlying skin, and when present by the black punctum indicating the duct-mouth; from the latter, by the absence of symptoms of inflammation and by the use of the grooved needle. When suppuration has occurred, one of the degenerative changes already mentioned, the symptoms of suppurative inflammation, the increase in size, and the exploring needle if requisite, will demonstrate the condition. In those rare instances where a fungating ulcer follows suppuration of a cyst, proper therapeutic measures will cause it to heal in a reasonable time, thus demonstrating that it is not epitheliomatous. If healing cannot be secured, the ulcer has probably undergone epitheliomatous change in whole or in part. When such change has attacked the ulcer before the surgeon sees the case, the diagnosis must depend upon the presence of the characteristics described as indicative of this disease, together with the history.

Treatment.—When situated upon the face, if the orifice of the obstructed duct can be discerned, it may be dilated with a small probe and the contents of the sac pressed out, this procedure being repeated from time to time, thus avoiding any scar; but final success is rarely attained, and the method is of very little value. Complete removal of every portion of the cyst-wall is usually the best treatment, and this can be most readily done by transfixion of the cyst and overlying integument with a curved bistoury, pressing out the contents, and then grasping the edges of the cyst-wall with two pairs of forceps, twisting and pulling out each half. If too adherent for this, careful dissection will be required.

2. Mucous Cysts arise from dilatation of mucous glands, their walls being comparatively thin and their contents a viscid mucoid fluid in which cholesterin is sometimes present. They form in the mouth one variety of *ranula:* so-called dropsy of the antrum is sometimes due to cystic dilatation of one of the mucous glands of its lining membrane.

Seats of Predilection.—The lips, mouth, antrum, labia, and indeed wherever mucous glands exist.

Treatment.—Excision of a considerable portion of the cyst-wall, and applications to the interior which will destroy the secreting surface. (See Diseases of the Mouth and Antrum.) Descriptions of cysts formed by the dilatation of such ducts as those of Wharton (forming *ranula*), of the breast (*galactocele*), etc. will be found in the sections on the diseases of those organs.

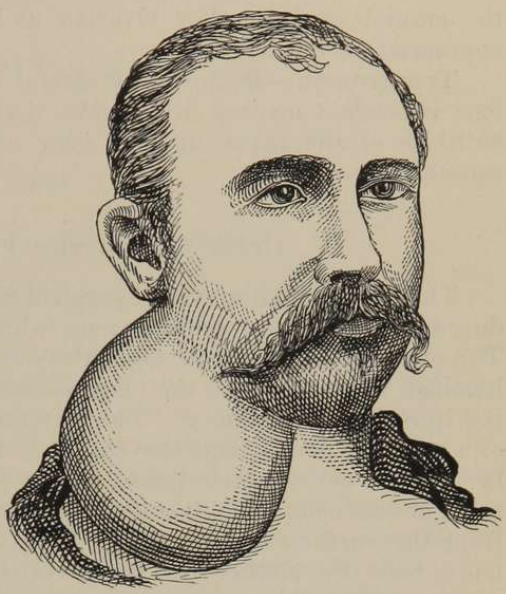
3. Extravasation Cysts result from hemorrhage into closed cavities, as that of the tunica vaginalis testis (hematocele). Some authors describe extravasations into softened portions of solid tumors, or into the cellular tissue which condenses around the effusion, as extravasation cysts.

II. Cysts of New Formation.

(*a*) Simple or Serous Cysts (Fig. 27) possess a thin wall lined with endothelial cells, and contain a serous or thick mucoid fluid. They originate from effusion, which takes place into the lymph-spaces of the connective tissue from the local irritation of pressure, and push aside the bundles cov-

ered with endothelial plates until they are condensed into a cyst-wall covered more or less completely with endothelial cells: this is the method of formation of an adventitious bursa. Simple cysts of the breast are similarly produced, and possibly some of the neck, although most of these are of congenital origin, while those occupying the median line of the neck arise from effusion into some of the normal bursal spaces of that region—*i. e.* antethyroid or infrahyoid bursæ.

Fig. 27.



Serous Cyst of the Neck (original).

(*b*) Hematomata, or Blood-Cysts.—There are two varieties, the first being usually found in the cervical region, and consisting of thin-walled cavities containing pure blood: their mode of origin is doubtful, but they appear to have some direct communication with the veins, because if tapped or incised they often bleed profusely. The second variety arises from the mechanical and inflammatory condensation of the tissues around an extravasation of blood, which may eventually be absorbed or undergo so-called organization; or the blood may remain liquid, disintegrate, and be absorbed; or suppuration may ensue. This form results from injury, and is situated most commonly beneath the scalp, especially in newborn infants. (See Cephalhematoma.)

So-called *compound proliferous cysts*, such as those found in the breast and ovary, are merely instances of primary cystic change in these organs, where, as a result of secondary developmental changes, ingrowths occur arising from the cyst-walls.

III. Cysts of Congenital Origin.

These result either from inclusion of a portion of the epiblastic layer within the mesoblast, or from the distention of the cavity of some persistent fœtal structure which should normally have become obliterated; for instance, broad-ligament cysts developing from the parovarium, and, dermoid cysts, as alleged, by the inclusion of a blighted ovum in either the testicle or the ovary. Since all except **dermoid cysts** of the external parts will receive special mention elsewhere, only this variety of cyst will be here described. The cyst-wall contains hair-follicles and sebaceous glands, while the contents are formed of the secretion of these structures, of disintegrated epithelial cells, and of hairs which have been shed. They often have absolutely no connection with the skin, and, occurring about the face and head where in the embryo fissures exist, are probably the result of inclusion of a portion of epiblast. Similar tumors of the ovary and testicle which contain bone, cartilage, and, in the case of the ovary, teeth, as before said, have been ascribed to inclusion of a blighted ovum, but this is at least non-proven.

Seats of Predilection.—The outer angle of the orbit, over the root of the nose, the ovaries, and the testicle.

Diagnosis.—This must depend upon the detection of a globular, tense, smooth tumor, usually situated at the outer angle of the orbit, unattached to the skin, generally freely movable upon the deeper parts, if overlying the bone often causing its partial or complete absorption, and of congenital origin. Processes of these cysts sometimes extend deeply into the orbit, or even into the cranial cavity. (For Ovarian and Testicular Dermoid Cysts, see the appropriate sections.)

Treatment.—Removal by careful dissection, making the necessary incisions in such a manner, if possible, that they shall coincide with the natural wrinkles of the parts, or that some other structure, as the eyebrow, shall conceal the scar.

IV. Cysts due to the Presence of Parasites.

The only parasitic cyst of surgical importance—the hydatid—is that produced by the Tænia echinococcus, which infests the intestines of the dog. The ova reach the human alimentary tract with the food or water, are there hatched, migrate, reach the blood-current, and lodge in some organ, developing into a hydatid tumor. The external layer of the cyst-wall is composed of a "highly elastic, lamellar cuticle;" the internal layer consists of "granular matter, cells, muscle-tissue, and a water-vascular system" (Sutton). A more or less complete adventitious fibrous capsule isolates the true cyst-wall from the surrounding tissues. Upon attaining the diameter of an inch or more, from the mother-cyst small vesicles or "broad capsules" form, which develop retractible heads or "scolices," each about 0.3 mm. long, having four "sucking-disks and a circlet of minute, blunt hooklets." Daughter-cysts form from the "blood-capsules," and possibly from the "scolices," the rapid enlargement seen where pressure does not interfere resulting from the increase in number of these capsules and daughter-cysts. Sometimes even large cysts contain neither capsules nor vesicles, being then sterile, but are recognizable by the characteristic lamellation of the cyst-wall. Multilocular hydatids consist of aggregations of innumerable small vesicles—usually sterile—varying in size, few larger than a pea, which are not contained in a mother-cyst. The bones and spinal cord are the usual sites for this variety. Hydatids eventually cease to grow, die, shrivel, and become calcified, leaving only the hooklets to enable the microscopist to determine the nature of the mortar-like mass. Rapid growth of daughter-cysts may produce necrosis of the mother-cyst with rupture. When related to the trachea, stomach, or intestines, pressure-absorption may permit osmosis of gas, fluid, or air; the hydatid dies, septic germs gain access, and suppuration ensues. Hydatids may also rupture into some one of the hollow viscera, a termination to be dreaded, as possibly productive of instant death or secondary changes ultimately lethal, although cure sometimes results.

Seats of Predilection.—Liver, kidney, omentum, bones, thyroid gland, spinal canal, brain, lungs, and connective tissue.

Treatment.—The cyst, when possible, must be removed entire. If total removal is not feasible, incise, evacuate; when possible remove the cyst-wall, leaving the capsule, and carefully drain. Never aspirate or merely puncture *except for diagnostic purposes.*

BOOK II.

SPECIAL SURGERY.

CHAPTER I.

SURGERY OF THE VASCULAR SYSTEM.

SECTION I.—DISEASES OF THE HEART AND PERICARDIUM.

THE diseases of the heart which may demand surgical interference are those which are accompanied by over-distention of the ventricles or by effusion into the pericardial sac. In order to understand how to relieve these conditions by surgical means it is necessary to study the anatomy of the heart and of its covering. In the healthy chest the heart is contained in a space extending obliquely in front from the third to the sixth costal cartilage, and horizontally generally from half an inch to the right of the right border of the sternum to a point half an inch to the right of the left nipple. Posteriorly it occupies the space corresponding to that between the fourth and eighth dorsal spines. The auricles are on a level with the third costal cartilage. The pulmonary artery covers anteriorly the left auricle. The right ventricle is partly behind the sternum and partly to the left of it. The left ventricle, except at its apex, is behind the right ventricle.

The pericardium is a fibro-serous sac in which the heart is contained. The base of the sac is at the diaphragm, and the apex is above and by its fibrous layer is connected with the deep cervical fascia.

OVER-DISTENTION OF THE HEART occurs in cases of pulmonary congestion of an acute character. The operation of *tapping the cavity of the heart* has been suggested with the view of relieving the dangerous condition under which the heart labors. The right auricle is the place selected for puncture, because the position of that cavity is less subject to alteration in its relation to the surrounding parts, and because the antero-posterior internal diameter is greater than that of the ventricle, the walls of which are also much thicker than those of the auricles.

The best place to perform *paracentesis auriculi* is the third intercostal space at the right edge of the sternum. The needle should be thrust directly backward. The operation should be performed as quickly as possible, and in order to abstract a sufficient quantity of blood with celerity it is necessary to introduce an aspirating needle about three times the size of a hypodermatic needle. The needle should be rendered perfectly aseptic before it is thrust into the auricle, and the end of the needle should be attached to the tube of an aspirator, because the blood-pressure is not sufficient to force the blood out through a canula. The needle must pierce the skin and fascia, the edge of the right lung and the pleural sac covering it, as well as both layers of the pericardial sac, before it penetrates the auricle. Tapping the cavity of the heart is fraught with extreme danger, and cannot be commended except in special and unusual cases, and even then should be resorted to only after consultation.

Effusion into the pericardium occurs as a result of acute and chronic pericarditis, both of which conditions may arise from various causes, including traumatism. Usually the effusion is moderate and undergoes absorption. Occasionally, however, the quantity becomes excessive and gives rise to alarming symptoms; under these circumstances tapping of the pericardial sac is indicated.

The **symptoms** denoting great effusion in the sac are precordial oppression, syncope, dyspnea, aphonia, feeble and irregular pulse, difficulty of deglutition, and dilatation of the veins of the neck, in addition to the signs of pericarditis during the different stages. An inspection of the chest shows that the pericardial sac is dilated and that the respiratory movement of the left side is impaired.

The physical examination, if made before the pericardial surfaces are separated by the fluid, demonstrates the presence of a pericardial friction-sound, which must not be mistaken for an endocardial murmur. The distinguishing feature of the pericardial friction-sound is that it does not possess the same regularity of rhythm as an endocardial murmur, and is not propagated beyond the limits of the precordia. Percussion reveals the presence of flatness over an enlarged precordial space both laterally and vertically. The flatness maps out a quadrilateral or a pyriform area with the base below and extending to both sides of the heart-apex. Auscultation demonstrates the absence of vocal resonance and of fremitus, and shows muffling of the heart-sounds. The apex-beat is pushed upward and to the left on account of the effusion, and in some cases it is lost.

Paracentesis pericardii should be employed when the symptoms threaten life. For purposes of positive diagnosis and with a view to ascertaining the character of the fluid an aseptically clean hypodermatic needle can be introduced before tapping, after which an aspirating needle can be used, or even a trocar, according to the consistency of the fluid. The best point for introducing the needle is at the fifth intercostal space, two inches to the left of the left border of the sternum. This will puncture the pericardium external to the internal mammary artery. The direction of the needle should be backward. The fluid should be withdrawn very slowly, and the effects of the removal of the effusion carefully watched. The operation should of course be done under the strictest antiseptic precautions.

Incision and *drainage* of the pericardium has been employed in cases of empyema of the pericardial sac. The incision, irrigation, and drainage of the sac should be resorted to only in the purulent form of the exudation. The operation should be performed at the same point as paracentesis pericardii. If necessary, part of a rib may be resected. Although this operation has as yet been done but seldom, the great mortality of empyema of the pericardium warrants its performance.

SECTION II.—INJURIES OF THE HEART AND PERICARDIUM.

Rupture of the heart has followed complete obstruction of one of the branches of the coronary arteries, the obstruction having been caused by a thrombus or by an embolus in the artery. Mechanical distention of the heart has caused rupture, as when its cavities have suddenly been filled with blood escaping from a bursting aneurysm, or when an abscess of the cardiac walls has burst into the ventricles. Rupture of the heart has also been a cause of death in tetanus.

Wounds of the heart are not infrequent. These may result from severe

injury of the chest-wall, or from penetration by a fragment of a fractured rib, or by a stab or a gunshot wound. A wound of the heart is not necessarily fatal, as is shown in the case where a needle was removed by Callender from the substance of the heart. Other cases of like nature have been reported by Hahn, Agnew, Stelzner, and others.

The **symptoms** of wound of the heart are not characteristic. Hemorrhage is usually present, but a stab wound may occur with little or no hemorrhage. The absence of hemorrhage is due to the anatomical arrangement of the muscular fibers of the heart. Pain is present as a constant symptom, and attacks of syncope occur at frequent intervals. If hemorrhage has taken place into the pericardium, the percussion note is flat and its area is increased, owing to the presence of the fluid, and the heart-sounds are less distinct than normal.

The cause of sudden death in wounds of the heart may be syncope from pressure on the heart due to over-distention of the pericardium with blood; or the inability of the heart to contract, owing to the wound of the cardiac wall, may produce fatal cerebral anemia. Shock and pulmonary anemia also have caused death in cardiac wounds. Death is not always sudden, but may be deferred for hours (Agnew).

Traumatic Carditis and Pericarditis.—The results of inflammation of the walls of the heart have been observed in cases of injury of the organ where the patients have died after a fortnight. In these cases the substance of the heart was studded with inflammatory exudates.

Inflammation of the pericardial sac is a more frequent result of traumatism than inflammation of the heart itself. The physical signs of a pericarditis of traumatic origin are substantially identical with those of an ordinary pericarditis.

The **treatment** of wounds of the heart and of traumatic carditis and pericarditis includes constitutional as well as local measures. The patient should lie with the head low, in order to prevent syncope from cerebral anemia. Absolute quietude should be insisted upon, and opium should be administered with a view to control subsequent inflammation, to tranquillize the circulation, and to relieve pain. Artificial warmth should be applied if indicated by the presence of collapse. It must not be overlooked that a certain amount of collapse is a favorable condition through its influence in checking hemorrhage and inflammation, and that over-stimulation must be carefully guarded against. In some cases violent reaction follows and necessitates the administration of cardiac sedatives.

If a patient survives beyond the period of reaction, the stage of inflammation ensues. This condition must be treated in the same manner as a pericarditis depending upon idiopathic causes.

SECTION III.—DISEASES OF THE BLOOD-VESSELS.

PART I.—DISEASES OF THE VEINS.

Before discussing diseases of the veins it is necessary to review some points in the anatomy of the vessels. A vein, like an artery, has three coats. The internal coat of the veins is the same as the internal coat of the arteries, and its continuation forms the only coat which the capillaries possess. The middle coat is composed of longitudinal and circular elastic fibers, interlacing with which are involuntary muscular fibers that are not so abundant in the veins as in the arteries. The external coat is composed chiefly of white fibrous tissue. The coats of the veins differ from those of the arteries in the thinness of the mus-

cular coat and in the presence of valves in the internal coat of the superficial and a few of the deep veins; they correspond with those of the arteries in the presence of a common external fibro-cellular tunic and the internal endothelial coat. The thinness of the muscular coat of the veins prevents them from having that rotundity, elasticity, and contractility which are so characteristic of the arteries; it also permits the temporary distention or bulging of the vessels when there is some mechanical impediment to the free return of venous blood to the heart. To serve this purpose the veins possess an inherent capacity of limited distention which is never required in the case of the arteries. It is important to remember this fact when the subject of wounds of veins is considered. Notwithstanding the thinness of the walls of the veins, they are relatively as strong as those of the arteries.

The presence of valves is a peculiarity of veins. These valves support the column of blood mechanically. They are found in the superficial venous system, and especially in the lower extremities. In the portal and hemorrhoidal systems there are no valves; and this fact has an important influence upon the development of certain diseases in connection with these veins.

I. Inflammation of Veins, or Phlebitis.—Inflammation of a portion of a vein produces changes in its coats in the same manner as inflammation of the coats of an artery alters the arterial coats. The disease is much more common than arteritis. Phlebitis may be acute or subacute.

Acute Phlebitis is diffuse, and is the result of some irritation of a vein, as puncture or any other injury accompanied by infection; sometimes it follows the ligation of a vein in its continuity or after an amputation. It especially follows any septic traumatism, and is then very dangerous, leading generally to pyemia.

Subacute Phlebitis is circumscribed, and is not ordinarily so dangerous as the acute diffuse form. The subacute variety generally supervenes upon some chronic disease of the coats of the vein which has led to their thickening by deposit of fibrinous matter, thus occluding the vein. An abscess may develop, and must be opened as an ordinary abscess. There is no hemorrhage from the vein, as it has been blocked up by external pressure or by an intravenous inflammatory product; hence its lumen does not communicate with the abscess. Should the fibrinous deposit break down, micro-organisms and their ptomaïnes get into the vein, and acute diffuse phlebitis is engrafted upon the chronic variety and pyemia results.

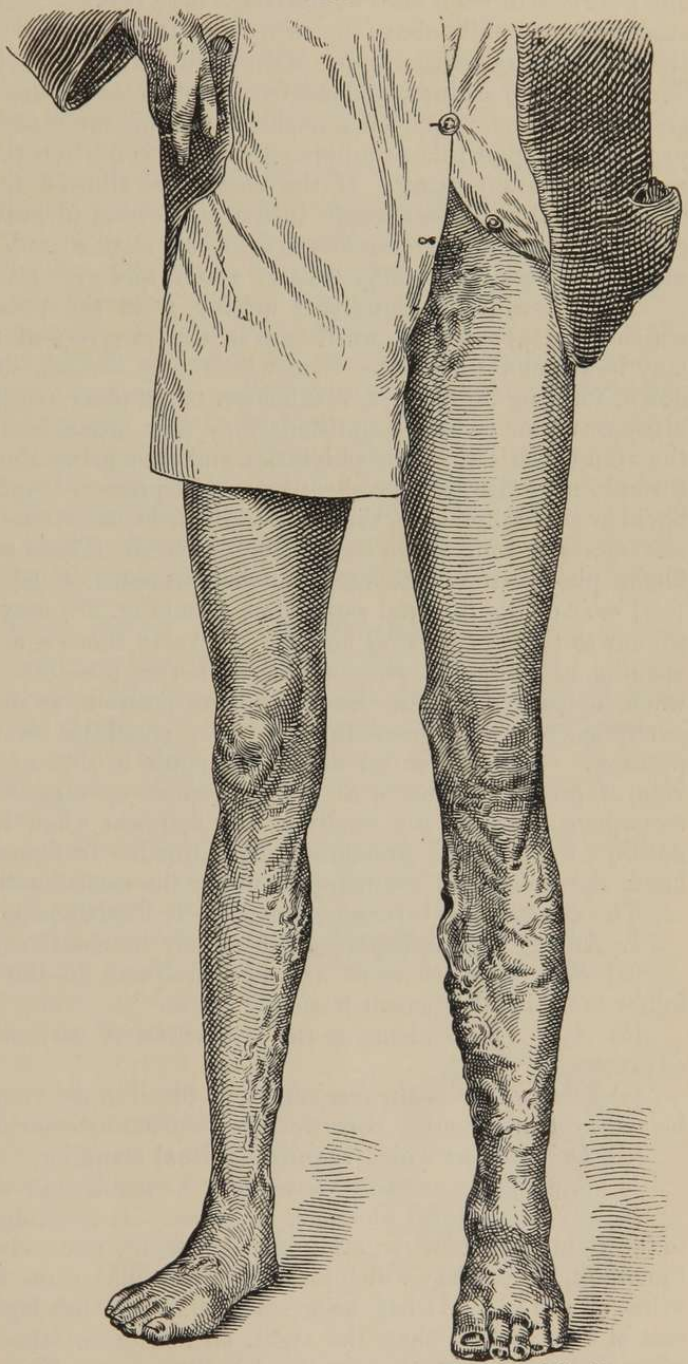
The symptoms of phlebitis are pain and tenderness along the course of the vein, with discoloration of the skin and acute œdema below the obstruction. There are present also symptoms of a constitutional nature, such as rapid and irritable pulse, rigors, elevation of temperature, dry and brown tongue, and pain in the joints if pyemia has developed.

Treatment of Phlebitis.—The patient should be kept perfectly quiet, the affected limb elevated, so as to favor the return circulation, and leeches applied in certain cases along the inflamed veins. Goulard's extract or a lead-and-opium wash should be used, or hot antiseptic fomentations, if a circumscribed abscess is forming. Opium is indicated to relieve pain. Abscesses should be opened, for if they are not incised the micro-organisms and the ptomaïnes may break down the plug in the vein and the softened thrombus obtain access to the general circulation. The patient's general condition must be kept up with nourishing food and stimulants, as there is a great tendency to exhaustion following certain forms of phlebitis.

II. Varix, or Varicose Veins.—By this is meant an enlarged, elongated,

tortuous, knotty condition of the veins. The term "varicose veins" is restricted in general use to the veins of the extremities, and especially to those belonging to the lower extremity. The internal saphenous vein is the one most frequently affected (Fig. 28). The disease begins by a slow dilatation of the vein, which gradually becomes thickened and tortuous. The inner lining membrane, or endothelial coat, of the vein is altered, and the valves are shortened, and thus rendered insufficient to support the column of blood. Besides these alterations in the inner coat of the vein, the outer coat becomes thickened on account of the connective-tissue infiltration and of the inflammatory new formation (periphlebitis).

FIG. 28.



Varicose Veins of the Legs and Left Thigh (original).

The varicose condition affects, as a rule, chiefly the superficial veins. When these are largely dilated the circulation becomes sluggish and is carried on by the deep veins. Occasionally it happens that the deep veins are primarily affected. Instead of the outer coat of the vein being thickened, this coat sometimes becomes excessively attenuated, and separates at places, so that the internal coat protrudes through the slit and forms a protrusion which may even become pedunculated. This pathological condition is, however, rare. When the varicose veins begin where the venous radicles arise from the capillary system, the varicosity appears as a fine capillary injection with an

arborescent appearance. This condition is more frequently found in women. When the large trunks are affected, the veins are dilated, tortuous, and knotty. They rise above the level of the skin, and if pressure is made over them the presence of blood in the vessels becomes at once manifest. When the disease has existed for a long while, they may burst from excessive thinness of the coats, and a serious or even fatal hemorrhage may result. Again, instead of the veins standing out boldly above the skin-level, there may be a passive exudation into the surrounding cellular tissue of the limb, which causes it to become œdematous. This is not the ordinary œdema from obstructed venous return, but a solid non-resisting œdema, which has a marble-like appearance and does not pit upon light pressure. Upon this peculiar œdematous condition there is often engrafted a most obstinate eczema. If the eczema is allowed to progress without any treatment, it will degenerate into a superficial ulceration which will become chronic and may extend down into the tissues and give rise to "varicose ulcer." These ulcers may involve a vein and give rise to fatal hemorrhage.

There is another condition arising from the presence of varicose veins which does not appear until late in the progress of the disease. *Thrombi* may be formed within the vein, which may become disintegrated and break down, forming an abscess, if infection takes place (suppurative thrombo-phlebitis), or under certain conditions they may organize and completely occlude the vein (plastic thrombo-phlebitis), and thus bring about a radical cure. The thrombi may also become shrunken and contracted, and frequently laminæ of fibrin are deposited upon them. Small hard concretions which have been called *vein-stones* or *phleboliths* have been observed. These are formed of laminated fibrin, phosphate of calcium, and the sulphates of calcium and potassium.

Varix of the internal saphenous vein (Fig. 28) may give rise to symptoms similar to those of femoral hernia. In varix there is a tumor at the saphenous opening at the place where a femoral hernia presents. The varix disappears when the patient assumes the recumbent position, as in femoral hernia. Both swellings reappear upon the patient's coughing or assuming the upright position. The differential diagnostic point is that in varix of the saphenous vein, if pressure is made at the saphenous opening while the patient is in a recumbent position, the swelling will reappear when he assumes the upright position, even though pressure is maintained. In femoral hernia, on the other hand, the tumor will not reappear under the same conditions.

The **causes** of varicose veins are—I. Predisposing, and II. Exciting.

I. Among the predisposing causes may be mentioned—

(*a*) *Sex.* Varicose veins are most frequent in the female, and are apt to follow uterine enlargement from any cause.

(*b*) *Age.* The tendency to the production of varicose veins increases as age advances.

(*c*) *Obstruction* to the free return of blood in the veins, as tight garters worn below the knee or other constrictions obstructing venous circulation.

(*d*) *Occupations* which require habitual standing.

II. Among the exciting causes may be mentioned—

(*a*) *Tumors* in the abdomen or pelvis. It is evident that any obstruction to the return venous circulation has a tendency to develop varicose veins; thus, tumors of any variety which press upon the iliac veins will give rise to varicose veins of the leg. It has been stated that the left leg is more frequently the seat of this disease than the right, on account of the sigmoid flexure, which when distended presses upon the left iliac vein. The cæcum, however, when distended, would press nearly as much upon the right iliac vein, and as a clinical fact the right leg is affected with equal frequency.

(*b*) *Diseases of the Heart and Lungs.*—In these conditions there is found an important exciting cause. If the heart is feeble in action, the power to drive the blood back is lessened, and as a consequence the column of blood moves very slowly and becomes stagnant in places. The development of the ascites (hydroperitoneum) often incidental to heart affections also forms by pressure upon the veins a barrier to the free return of the venous blood.

(*c*) *Pregnancy* by pressure of the gravid uterus upon the iliac veins. In a first pregnancy the veins of the extremities are not much altered pathologically, and if attention is paid to this incipient stage of the disease, which is amenable to treatment, subsequent pregnancies will not be so likely to produce an incurable condition of varicose veins.

Treatment.—I. *Palliative*, and II. *Radical.*

Palliative treatment is to be directed to the removal of the causes of the obstruction and also of their effects, as far as possible, without an operation. This object is best fulfilled by attention to the condition of the bowels, to the state of the liver, to the affections of the heart and lungs; by enforcing quiet and rest in a recumbent position, which favors venous return circulation, and by attention to the general health, and often by out-door exercise in a suitable climate. The local palliative treatment consists in the application of an elastic bandage or a perfectly-fitting silk elastic stocking which shall afford support to the vessels, thereby equalizing the circulation. This elastic support has a tendency to turn the flow of venous blood from the superficial veins into the deep veins, which do not, as a rule, become varicose. The silk stocking should be made to order from accurate measurement of the limb, and should extend from below at the toes, where the trouble begins, to or above the knee, where it should be loose.

The *radical treatment* has for its object the complete obliteration of the vein. Many surgical procedures have been devised for this purpose.

Of these methods, the multiple ligatures, as advocated by Dr. Charles Phelps, who ties the vein in thirty or forty places, and excision of the vein in six, eight, or more places, are the best. All such operations on veins must be done with the most stringent antisepsis, or an acute septic phlebitis and pyemia may readily follow.

III. NÆVUS.—This is an affection of the capillaries and the veins. When the nævus affects the *capillaries* there is a slightly elevated area of skin of a scarlet or purple color. Nævi are situated sometimes upon the trunk, but generally upon the face. They vary in size from that of a pin's head to that of a silver dollar, or even may involve an area nearly as large as the hand. They produce an unsightly appearance, but seldom give rise to any physical discomfort unless they undergo ulceration, in which event a troublesome and in some cases even alarming hemorrhage ensues. The vessels consist of capillaries held together by areolar tissue. The term *telangiectasis* is often applied to this form of nævus, and it is popularly called *mother's mark* (Fig. 29).

FIG. 29.

Nævus (original).

The nævi formed of *veins* are found beneath the skin as well as in the skin. They are also seen in the orbit, the liver, and other viscera. They pulsate, and are much larger than the capillary nævi. They can be made partially to disappear by pressure, but reappear when the pressure is discontinued. The anatomical structure is similar to that of carcinoma, but instead of the spaces

being filled with epithelial cells they contain blood. They are painless. If punctured they give rise to alarming hemorrhage. This form of nævus is termed *cavernous angioma.*

Treatment.—The operations for the removal of nævi are many. The best recognized surgical treatment includes ligation, excision, electro-puncture, the cautery, and coagulating injections.

Ligation is done by passing a pin under the mass and throwing a ligature around the base of the nævus below the pin. If large, a double ligature can be passed under and at right angles to the pin, and then the nævus is tied in two halves. This and excision are the best of the above-mentioned methods. Setons lead to what may be a dangerous suppuration, and coagulating injections may produce extensive thrombosis or distant embolism, and thus cause death. Nævi about the face and scalp should never be injected, on account of the danger of thrombi and emboli. In large cavernous angiomata electrolysis and excision have been employed with good results.

PART II.—DISEASES OF THE ARTERIES.

ARTERITIS.

I. The word *arteritis* signifies inflammation of an artery. Each coat of an artery may be primarily separately inflamed. Thus we distinguish inflammation of the internal coat, of the middle coat, and of the external coat. These inflammations are called, respectively, *Endarteritis*, *Mesarteritis*, and *Periarteritis*. All these different varieties may be either *acute* or *chronic*.

1. Acute Arteritis.—This is a rare surgical disease, and is due to an inflammation excited by an infectious or poisonous embolus lodged in the artery. The internal coats become swollen and infiltrated with pus-cells. The suppurative inflammation is transmitted to the other coats of the artery and to the surrounding parts, and may result in abscess.

Acute Periarteritis is also usually secondary in origin, and is due to an extension of inflammation from the surrounding parts. The exudation is apt to be purulent. In these destructive inflammations of the arterial coats the lumen of the artery generally becomes occluded by a thrombus before perforative ulceration occurs. Should this thrombosis not occur, severe and sometimes fatal hemorrhage may arise if the artery be of sufficient size.

It is still an open question whether acute arteritis occurs as a primary affection. A few doubtful cases have been recorded in which severe pain and tenderness existed along the course of an artery, in some instances accompanied by a certain amount of redness and swelling. The diagnosis of acute arteritis has been made, but, as the termination has been favorable, the pathological proof of its existence is wanting.

2. Chronic Arteritis.—This is the *atheroma* of most authors, and its relation to the production of aneurysm is a subject of great surgical interest. By atheroma is meant a chronic inflammation of the internal coat characterized by a fatty degeneration, with a tendency to cheesy collections and calcareous deposits. The middle coat is not usually involved until late. The external coat becomes affected secondarily, and is hypertrophied and inelastic. As a result of the fatty degeneration the inner coat of the artery swells, the circulation is disturbed in that part, and an ulcer is formed by the rupture of a caseous mass into the lumen of the artery.

Traumatism affecting the artery, alcoholic excesses, syphilis, Bright's disease of the kidney, gout, and rheumatism are among the diseases which are

recognized as the causes of atheroma. This condition ordinarily involves the larger arteries, and in this respect differs from syphilitic arteritis, which, as has been pointed out, affects chiefly the vessels of smaller size. Occasionally the lime-salts are deposited in the ulcer and a calcareous plate is formed. Atheroma is usually seen in persons of advanced age.

Calcification of the artery consists in a low grade of inflammation in the middle coat, and is characterized by the deposit of earthy matter, chiefly carbonate of calcium and the phosphates. This deposit may be in plates, and it is then termed laminar calcification, or it may be arranged in a concentric manner around the muscular fibers, when it is termed annular calcification, and when the latter form is spread over a considerable area it is termed tubular calcification. This disease affects arteries in the extremities, and as a result the parts beyond are inadequately supplied with blood, owing to the narrowed lumen of the vessel and to its loss of elasticity. When the disease is extensive enough completely to occlude the artery, gangrene of the limb may result. When it affects the vessels in the extremities, the calcification can be readily recognized by the finger placed upon the vessel. This is often observed in the radial artery, the vessel becoming roughened and rigid and hard like a pipe-stem.

The **treatment** of arteritis depends upon the variety. If due to syphilis, the iodides and mercury are useful; if to rheumatism or gout, the remedies that are indicated in these affections should be employed. Little can be done to cure the disease, and the treatment should be directed toward the prevention of any extension of the inflammation. Great importance must be attached to the avoidance of all kinds of violent exercise, which might lead to rupture of the vessel with its attendant consequences.

ANEURYSM.

The word *aneurysm* is derived from the two Greek words *ἀνά*, "through," and *εὐρύνω*, "I widen."

An aneurysm is a tumor containing blood and communicating with the interior of an artery. There are some forms of blood-tumor which do not strictly come within the limits of this definition. These will be discussed before taking up aneurysm proper.

The first variety is ARTERIAL VARIX. This consists in an elongation and dilatation of a single artery of medium or small size. The vessel is pouched, sacculated, and tortuous. This condition is similar to that of a varicose vein. The superficial temporal, occipital, and posterior auricular arteries are often the seat of this disease. The skin over the dilated vessel is exceedingly thin, or even ulcerated, and this condition may give rise to alarming hemorrhages.

CIRSOID ANEURYSM is the next variety, and consists in a dilatation and elongation of a number of arteries of medium and small size.

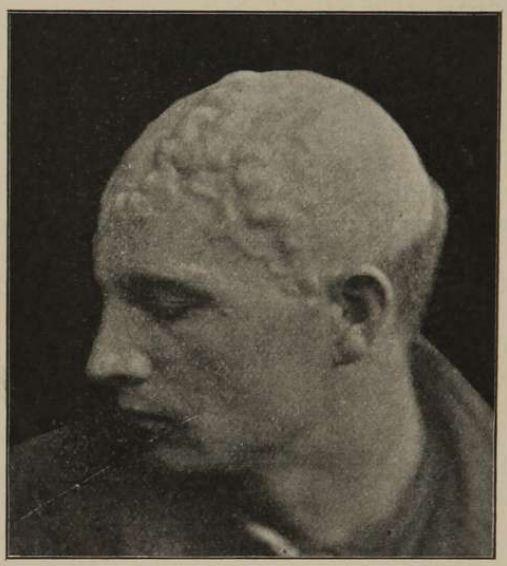
If a *single* artery is involved, and it is pouched and tortuous and dilated after the same manner as a varicose vein, the term *arterial varix* is applied.

If a *number* of arteries held together by connective tissue are affected by these pathological changes, the tumor is called a *cirsoid aneurysm* (Fig. 30). Such an aneurysm usually involves also the capillaries in its immediate vicinity. The cause of this disease is supposed to be an injury in which the vasomotor nerves have been paralyzed. The tumor thus formed is irregular in shape, compressible, bluish in appearance, and pulsating in character. The temperature within the circumscribed area of the outgrowth may be elevated on account of the increased vascular supply. Cirsoid aneurysm is distin-

guished from a true aneurysm by the situation of the growth, the number of vessels involved, the superficial bruit and pulsation, the peculiar spongy, doughy feel, and the difference in the pressure-effects.

The treatment of cirsoid aneurysm is usually unsatisfactory, and often attended with great danger from hemorrhage. The lack of success in treatment is in part due to a lack of comprehension of the nature of the disease.

FIG. 30.



Cirsoid Aneurysm (original).

Extirpation, the lines of incision being carried wide of the tumor, multiple ligation of the individual afferent arteries, the application of the galvano-cautery, the injection of coagulating fluids, the introduction of the electro-puncture needle alone or associated with circular compression of the afferent vessels, acupressure of the main feeding artery, and ligation of the main trunk, are among the recognized methods of treatment; often two or more of these may be combined with advantage.

Preliminary ligature of afferent vessels followed by cutting the tissue around the tumor has proved curative. Removal by excision is the only method which offers a reasonable certainty of cure, and this operation should be immediately preceded by the ligation of every tributary. Bad cases of cirsoid aneurysm of the hand require amputation.

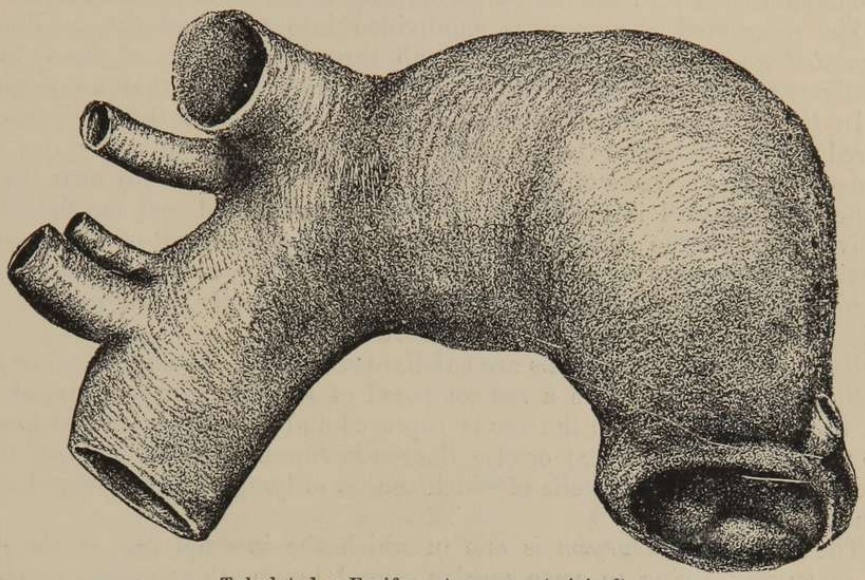
All aneurysms may be divided into two groups—the *idiopathic* and the *traumatic*. In the idiopathic variety there is a sac formed of one or more of the arterial coats, and the blood within the sac is in direct communication with the lumen of the artery. In the traumatic variety there is also a sac, but its walls are composed of inflammatory lymph and a proliferation of the connective-tissue cells.

Idiopathic aneurysms are divided into—

1. Tubulated.
2. Sacculated, { *a*, true, { 1, circumscribed. / 2, diffused. / *b*, false, }
3. Dissecting.

The *tubulated aneurysm* (Fig. 31) is the *fusiform aneurysm* of some authors. In this variety the three coats of the artery are simultaneously dilated, in the

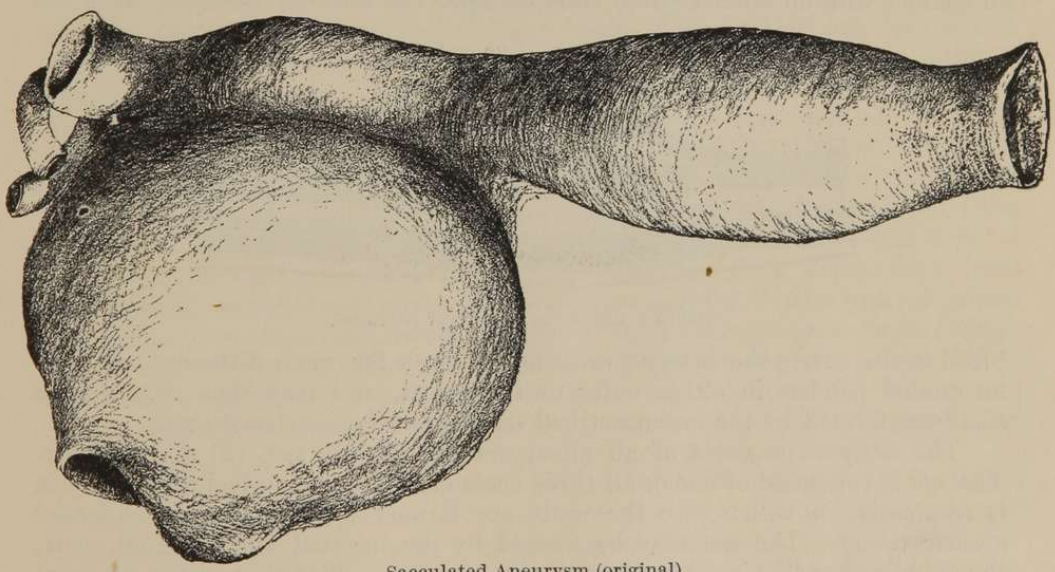
FIG. 31.



Tubulated or Fusiform Aneurysm (original).

circumference as well as in the length of the vessel. The middle coat is not preserved as a continuous layer, but its elements are separated. This aneurysm

FIG. 32.



Sacculated Aneurysm (original).

is found in the cranial, thoracic, and abdominal cavities. The tubulated aneurysm rarely grows to be of any size, and scarcely ever ruptures unless a sacculated aneurysm is engrafted upon it. The sac in this form of aneurysm seldom

contains any laminated fibrin. It, however, gives rise to great discomfort, and often causes severe pain by pressure upon important organs.

The *sacculated aneurysm* (Fig. 32) is one which projects from a tubulated aneurysm or which springs from the side of an artery, the interior of which is in communication with the sac by an opening which is called the mouth.

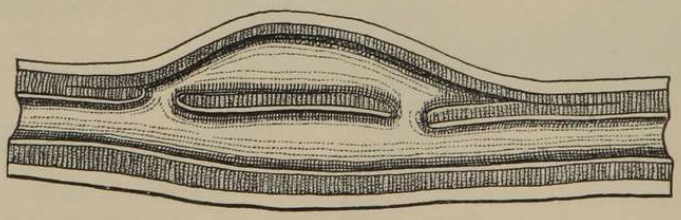
The sacculated aneurysm is subdivided into *true* and *false*. The *true sacculated aneurysm* is one in which all three of the coats of the artery are equally expanded to form the sac. It seldom grows larger than an orange.

In the *false sacculated aneurysm* the inner layer is the thickened and altered intima enlarged by successive additions so as to cover the vastly increased surface; traces of the middle coat are to be found only near the neck of the sac; the wall is mainly formed by the condensed and multiplied connective tissue of the surrounding parts. In short, the wall of the aneurysm contains little or nothing of the original wall of the artery, except that its internal layer is continuous with and similar in character to the intima. This variety of aneurysm may grow to an enormous size.

False sacculated aneurysms are subdivided into the *circumscribed*, in which the blood is confined within a sac composed of some part of the arterial coats, and the *diffuse*, in which the sac is ruptured and the blood has extravasated into the neighboring tissue; or else the sac is ruptured, and the blood is confined within a cavity the walls of which consist of lymph and condensed areolar tissue.

The *dissecting aneurysm* is one in which the internal coat of the artery has given way, owing to some erosion caused by an atheromatous patch, and the blood dissects or makes its way through the middle coat (Fig. 33). The blood may burrow for some distance through the middle coat until it comes in contact with an eroded patch situated upon the outer coat, through which it bursts, and finally extravasates into the surrounding areolar tissue; or it may burrow for some time through the substance of the middle coat until it comes in contact with an eroded patch situated upon the internal coat, and then the

FIG. 33.



Plan of a Dissecting Aneurysm (Holmes).

blood again enters the artery; or it may burrow for some distance and meet no eroded patches in either outer or inner coat, and may thus remain in a small sac formed by the circumscribed separation of the arterial coats.

The *component parts* of an aneurysm are (1) the sac, (2) the contents. The *sac* is composed of one or all three coats of the artery, unless the aneurysm is traumatic, in which case the walls are formed by lymph and condensed areolar tissue. The sac may be formed by the internal and external coats, the middle coat having been ruptured; or by the dilatation of the external coat, the internal and middle coats having been ruptured; or by the dilatation of the internal coat, the middle and external coats having given way. If the latter condition is ever present, which has been denied, the aneurysm would be called an *aneurysmal hernia*. The *mouth* of the sac is the narrow opening

which establishes a communication between the interior of the sac and the lumen of the artery from which the aneurysm develops.

In the fusiform aneurysm there is no mouth, as the aneurysm results from a uniform dilatation of the coats of the artery. In the sacculated variety a mouth is present, and its situation relative to the lumen of the vessel influences the amount of fibrin deposited, as well as the growth of the aneurysm.

The *contents* of the sac vary according to the stage of the disease. In the first stage the sac is very thin, and contains only fluid blood. In the second stage the wall of the sac is very thick, and contains fluid blood in the center and laminæ of fibrin (Fig. 34) around the periphery.

FIG. 34.

Laminated Coagulum (Key and Bryant).

The blood is in greater proportion than the fibrin at first, but later the coagulum or laminated fibrin is in excess of the fluid blood. These laminæ of fibrin vary in firmness and consistency in the different parts of the sac. Thus upon the extreme periphery the layers of fibrin are dry, friable, and opaque, while the layers approaching the center of the tumor are soft and of a reddish color.

In the sacculated variety the fibrin is rapidly deposited, and the rapidity with which it is formed depends upon the relation of the mouth of the sac to the sac itself. The greater the obstruction to the free flow of blood into the sac, the greater the tendency to the deposition of fibrin.

In the fusiform aneurysm, where there is no retardation in the current of blood owing to the absence of a mouth in the sac, there is no deposition of fibrin, or at least it is deposited in exceptional cases only.

The *natural terminations of aneurysm* are—(1) *spontaneous cure*, (2) *death*.

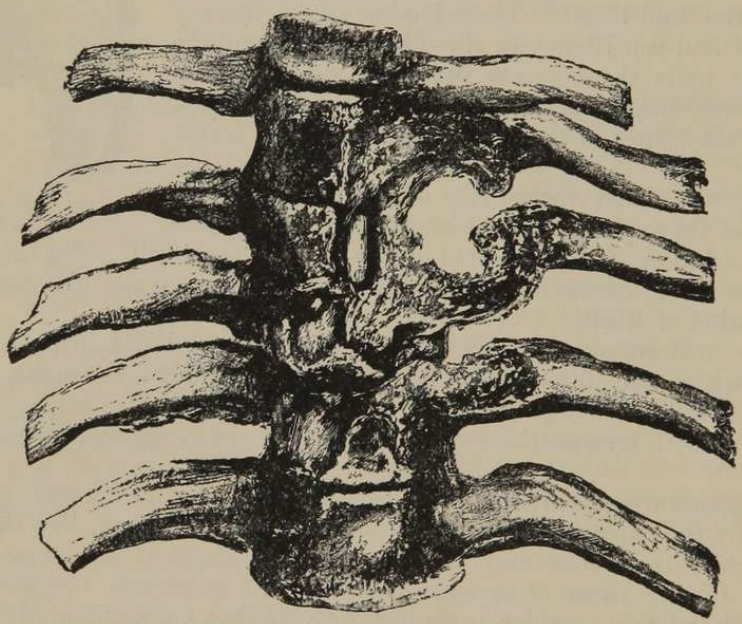
The *spontaneous cure of aneurysm* is occasionally effected by nature unaided by the surgeon. Such a case occurs very seldom, but that a cure under certain conditions may thus be brought about is no longer open to dispute. In the cases of spontaneous cure the aneurysm has always been found solid and firm,—which leads to the belief that a deposition of fibrin had already taken place. A deposition of fibrin takes place in consequence of the slower current in the sac, and finally fills it. The clot thus formed within the sac may extend into the vessel, and thus add to the permanence of the cure. Occasionally the aneurysm is spontaneously cured by an embolus, when a clot is washed out of the sac into the efferent artery and occludes it, so that the current is completely arrested within the sac; the latter then fills with a firm coagulum. Sometimes a spontaneous cure is effected when the sac becomes large enough by its own weight to cause mechanical pressure upon the artery sufficient to retard, or even to arrest, the circulation in the vessel. Finally, a spontaneous cure is accomplished in some cases when the sac becomes acutely inflamed and the coagulation of the blood within it is thereby promoted.

Death is the other natural termination. There are various ways by which an aneurysm destroys life: 1st. By *rupture* of the *sac*. The aneurysm extends to the surface of the body or to a mucous canal or a serous cavity. When the aneurysm has reached the surface of the body the thin skin over the sac sloughs, and when the slough comes away there is a slight hemorrhage through a small opening. This hemorrhage is arrested by a coagulum, but after a while is renewed, until finally the patient dies from repeated hemorrhages. In case an aneurysm bursts into a mucous canal the process is the same. The rupture

may open into the trachea, œsophagus, intestine, or bladder. Here, again, the sac is first rendered thin by absorption, and when the slough separates the hemorrhage occurs. An aneurysm may destroy life by bursting into one of the pleural cavities, generally the left, or into the peritoneal or the pericardial sac. In this situation the serous membrane gives way in a rent, and death follows instantly.

2d. Aneurysm also destroys life by *pressure upon important organs.* If the aneurysm presses upon the trachea or the bronchi or the lungs, it produces asphyxia; if upon the œsophagus or the thoracic duct, it causes inanition; if upon the vertebræ and the ribs, absorption of these bones results (Fig. 35), followed by spinal irritation and meningitis, with severe neuralgia from pressure on the intercostal nerves.

FIG. 35.



Absorption of the Vertebræ and Ribs from Pressure by an Aneurysm (original).

3d. Aneurysm, again, destroys life by *septicemia* and *pyemia*, due to acute inflammation and suppuration of the sac; also, 4th, by *embolism*, in which case the small migratory clot is carried by the cerebral arteries to the brain if the situation of the aneurysm is in the arch of the aorta; finally, 5th, by *gangrene* of the extremity caused by obstruction. In this case the gangrene causes blood-poison and death results from septic infection.

Etiology of Aneurysm.—In general terms, any disturbance of the proper relations between the force of the heart on the one hand and the elastic resistance of the artery on the other, especially if an increase of the former is combined with a diminution of the latter, will give rise to aneurysm.

The causes of aneurysm may be divided into I. *Predisposing*, and II. *Exciting.*

I. *Predisposing Causes.*—(*a*) *Degeneration of the Arterial Coats.*—This is the principal predisposing cause, since in some form it is always present except in traumatic aneurysm. The degeneration most commonly associated with the development of aneurysm is the atheromatous and fatty, frequently accompanied by a calcareous deposit that renders the vessels less elastic. As a result of this atheromatous and fatty condition the artery fails to contract after the

systolic action of the heart, gradually yields and dilates, until finally an aneurysm is formed. It is held by Von Recklinghausen and others that the influence of atheroma upon the development of aneurysm has been exaggerated. It is believed that changes in the middle coat, either inflammatory or degenerative, are among the most frequent predisposing causes.

(*b*) *Syphilis* is a frequent predisposing cause of aneurysm, in consequence of the changes in the arterial walls.

(*c*) *Over-action of the Heart.*—Hypertrophy of the heart, by increasing the strength of the impulse, drives the blood with greater force into the arteries. These are likely to distend under the impulse of an hypertrophied heart if they have undergone the slightest degenerative changes. Hypertrophy of the heart associated with chronic nephritis, in which the arterial tension is increased and the vessels are weakened by atheroma, affords another illustration of the combined action of these two causes.

(*d*) *Certain violent occupations*, as riding and hunting, it has been asserted, predispose a patient to aneurysm. Thus coachmen and postilions, owing to the nature of their occupations, are especially liable to the disease. This clinical fact is explained by the obstruction of the popliteal arteries on account of the constant bending of the knee in horseback riding and sitting on the box, as well as by the contractions of the gastrocnemii and solei muscles when the feet are placed firmly against the footboard or the stirrups. The arteries, too, are bent or stretched in these positions, and the jar and motions of the rider or driver must increase the force of the circulation.

(*e*) *Age.*—This has a marked influence. Aneurysms are most frequently found between the ages of thirty and forty years, because the arteries begin to lose their elasticity at this period, while the heart has not yet lost any of its force or the muscles any of their strength. Aneurysms in very young people are merely surgical curiosities.

(*f*) *Sex.*—Seven to one of the entire number of aneurysms are found in males, presumably because of their more active occupations.

II. *Exciting Causes.*—(*a*) A partial *rupture* of one or more of the arterial coats, produced by external violence, is without doubt a prominent cause of aneurysm.

(*b*) A direct *wound* of an artery also produces aneurysm, since it leads to extravasation of the blood from the artery into the surrounding tissues. In this case the aneurysm is termed *traumatic*, because the sac is not formed by the coats of the artery.

(*c*) *Fractures* and *dislocations* are exciting causes of aneurysm, since the artery is torn or stretched so as to weaken the coats, thus permitting subsequent dilatation.

(*d*) *Strains* have been considered exciting causes of aneurysm, since they produce irregular and forced action of the heart. Strains may also act directly upon the vessel by forcing blood through it while it is under unusual tension, thus causing pressure at right angles to the axis of the vessel, or by stretching the artery in its long axis.

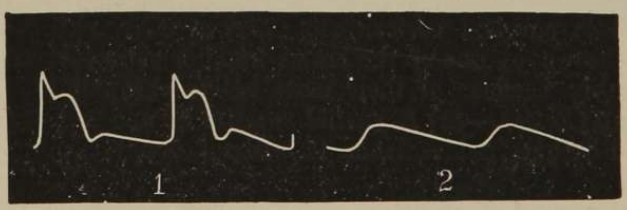
The **signs and symptoms of aneurysm** may be described as belonging to two stages: *First Stage.*—This includes the period from the beginning of the formation of the aneurysm until the tumor is firm from the deposit of fibrin. *Second Stage.*—This includes the period after the aneurysm has become firm and resisting by reason of the presence of the deposit of laminated fibrin. This stage may be absent, as in some aneurysms no such deposit takes place.

First Stage.—(*a*) *Pulsation which is distinct, expansile, and synchronous with the action of the heart.*

The pulsation is distinct in the first stage, because the aneurysm contains only fluid blood and the sac is thin. The pulsation is excentric and expansile in character. If both hands are placed upon the sides of the tumor, they will be separated from each other with every pulsation. The pulsation in this stage is simultaneous with the contraction of the heart. The pulsation of an abscess lying on an artery would be up and down in mass, and not expansile.

(*b*) *Pressure on the artery above the tumor diminishes the size of the latter; when applied below the tumor increases its size; and in both cases causes the pulsation to diminish or cease.* If the artery above the sac is compressed, the flow of blood into the sac is arrested, the blood can be squeezed out of the sac, and the tumor disappears. This can be beautifully illustrated in the first stage while the contents of the sac are composed of fluid blood and the walls of the sac are thin. If, after having compressed the artery above the sac and emptied the latter of blood, the hands are placed firmly over the sac and the pressure is removed from above, the blood will rush into the sac, and as soon as the sac has filled pulsation will return and will separate the hands. In abscess, on the other hand, the instant the pressure from the artery above is relieved, the transmitted pulsation, or upheaval, is felt. If the artery below the sac is compressed, the sac will rapidly enlarge and the pulsation will diminish or cease. If the pulsation in the efferent artery at some distance from the sac on its distal side be felt, it will not be simultaneous with the pulsation of the corresponding artery of the opposite side of the body. Besides the appreciable delay in pulsation as compared with the opposite artery, the force of the pulsation will be markedly diminished. The sphygmographic tracing of the pulse upon both sides of the body will also reveal a wide difference (Fig. 36).

FIG. 36.



Sphygmographic Tracings of the Radial Pulse of a Patient with Aneurysm of the Right Brachial Artery: 1, Left Radial Pulse; 2, Right Radial Pulse (Mahomed).

(*c*) A *bruit* is heard over the aneurysm, and also along the artery for some distance from the sac. The bruit is a noise caused by the rush of blood into, through, and out of the sac, the internal lining membrane of which is roughened. The bruit is blowing or loud and rasping like the noise made by a saw. This blowing murmur is not always present, but its absence will not exclude the possible existence of an aneurysm. In malignant vascular tumors the bruit is sometimes present, but is heard only over the area of the tumor, and is never transmitted along the artery leading from the sac, as it is in aneurysm.

Second Stage.—This stage includes the period after the aneurysm has become firm and resisting by the deposit of laminated fibrin.

(*a*) *Indistinct Pulsation.*—When the aneurysm becomes firm and its sac is lined with fibrin, the pulsation is indistinct and may even be altogether lost. There are certain points over the sac where the pulsation is felt more distinctly than at others. This is because the fibrin is not equally distributed over the interior of the sac.

(*b*) *Pressure.*—Owing to the deposition of fibrin, the tumor cannot be effaced by pressure on the artery above the sac, as in the first stage.

(*c*) The *bruit* is generally present, although it is heard with varying degrees of distinctness over the tumor, and also can be heard at a distance from the sac.

It will be observed that these symptoms, which were so marked and almost pathognomonic in the first stage, are of rather negative character in the second stage. There are, however, additional signs :

(*d*) *Pain.*—The pain is sharp and lancinating, like that of carcinoma, or aching or boring, like that of ulceration. It arises after the aneurysm has attained some size and makes pressure upon the nerves. Thus in popliteal aneurysm the pain is intense along the course of the popliteal nerve. The nerve is sometimes flattened out upon the sac. Pain may be at times an early symptom of aneurysm, but it is generally more pronounced later on in the course of the disease.

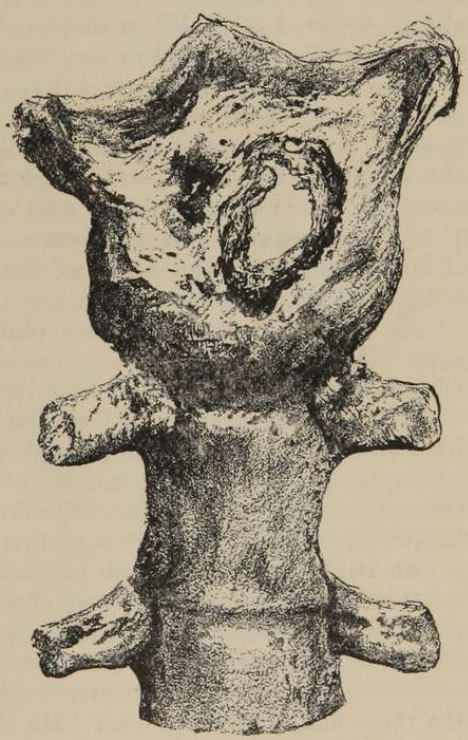
(*e*) *Œdema.*—This is produced by the pressure of the sac upon the veins. Œdema of the limb is constant after the tumor has attained a certain size. The œdema, if excessive, produces a great deal of discomfort to the patient, and may terminate in extensive ulceration and sloughing.

(*f*) *Gangrene* sometimes occurs late in the course of the disease, and generally follows the œdema, but may come suddenly as the result of an embolus.

(*g*) *Pressure-effects* vary according to the parts pressed upon and the amount of pressure exercised by the tumor.

If the aneurysm presses upon bone, it produces a severe aching, boring, gnawing pain, and finally causes the absorption of the osseous tissue (Figs. 35 and 37); if upon glands, it destroys their function; if upon the trachea, respiration is rendered difficult, and there is an obstinate distressing metallic cough and altered voice produced by pressure upon the recurrent laryngeal nerve. This is termed the brassy cough of aneurysm. If the aneurysm presses upon the œsophagus or the thoracic duct, deglutition or nutrition is interfered with and the patient dies from inanition. If the pressure be on the phrenic nerve, hiccough often is produced; and if on the sympathetic nerve, marked capillary congestion.

FIG. 37.



Absorption and Perforation of the Sternum from Pressure by an Aneurysm (original).

Diagnosis of Aneurysm.—If the aneurysm has not consolidated, the symptoms which have been enumerated will enable the surgeon to establish a diagnosis. But it often happens that after consolidation of the aneurysm by fibrin many of the signs and symptoms become obscure and a diagnosis is rendered somewhat difficult. Again, certain other tumors under exceptional circumstances may present signs almost identical with those of an aneurysm.

In a case of consolidation the history of the disease, and occasionally the use of the hypodermatic syringe, are the only safe guides for the surgeon. In pulsating tumors which resemble aneurysm the diagnosis must be made with great care.

The different tumors with which a surgeon may confound an aneurysm are the pulsating encephaloid, the vascular soft sarcoma, erectile tumors of all kinds, pulsating tumors of bone, an abscess over an artery, and hematocele of the neck.

There are also tumors which are not, strictly speaking, pulsating which have led to error in diagnosis and treatment, such as lymphatic enlargement and cystic disease of the thyroid gland, and certain other diseases, as neuralgia and rheumatism, the pain in both of which has been mistaken for that of beginning aneurysm in the thoracic cavity.

Duration of Aneurysm.—An aneurysm may grow very rapidly, but this is rare. The growth, as a rule, is slow, and may extend over several years. The aneurysm is likely to grow as long as the cause is present. Its duration is influenced by the force of the circulation, its situation, the size of the mouth of the sac, the coagulating tendency of the blood, the nature of the surrounding parts, the condition of the sac, and the patient's habits and manner of living.

Treatment.—The surgeon must aim in his treatment to effect a cure by precisely those means which nature adopts. The essential conditions for success in any plan of treatment are obliteration of the cavity of the sac and occlusion of the afferent and efferent vessels.

There are several ways in which obliteration of the sac and the vessels can be accomplished, but often the best results will be obtained by a combination of various methods of treatment. In order to occlude the sac it is necessary to diminish the force of the circulation, thus causing coagulation of the blood in the aneurysmal sac. When this has been effected a cure may be expected.

The methods resorted to may be either *medical* or *surgical.*

The medical methods which have met with the greatest success in curing aneurysm are those suggested by Langenbeck and by Tufnell. *Langenbeck's method* consists in the hypodermatic injection of ergotin. This drug slows the action of the heart, and hence favors deposit of fibrin; it contracts the muscular fibers of the middle coat of the arteries leading into the sac, and produces increase of blood-pressure. All these are favorable to the deposition of fibrin and the consolidation of the aneurysm. Iodide of potassium has also been used in the medical treatment, largely upon the supposition that aneurysms are due to the effects of syphilis, but it probably acts as a heart depressant. Acetate of lead has been employed to equalize the circulation. Bromide of potassium has been used to relieve the cough and pain.

Tufnell's method is a modification of a plan of treatment originally suggested by Valsalva. It is especially applicable to internal aneurysms; but a brief description of it is proper here, as external aneurysm has been thus successfully treated, and as a list of the different methods of curing aneurysms would be incomplete without reference to this peculiar plan of treatment.

In 1875, Tufnell, an Irish physician, published his experience in what may be termed the *rest treatment* of aneurysm. Tufnell required his aneurysmal patients to assume the recumbent position in bed for several months. The object of the treatment was to reduce the watery elements of the blood and to increase its solid constituents. Rest, regimen, and remedial agents were the three means he employed. He showed that in the recumbent position the circulation was tranquillized and the action of the heart became regular and slow. He maintained that recumbency placed the same check upon the circulation in internal aneurysm that mechanical compression does in the treatment of external aneurysm. He demonstrated this proposition in the following way: A patient before assuming the recumbent position had a pulse of 96 a minute;

after a few days' lying supine in bed it fell to 66 a minute. Thus there was a difference of 30 beats a minute caused by position. Multiplying 30 beats by 60, the number of minutes in an hour, the result is 1800 beats an hour, and this multiplied by 24—the number of hours in a day—gives 43,200 beats per diem; that is to say, a patient suffering from aneurysm and occupying the recumbent position has his aneurysmal sac distended 43,200 times less frequently in a day than it would be if he remained in the standing position. Tufnell held that there was no remedial agent in the Pharmacopeia that would produce such an action upon the heart without injury or danger. Recumbency is the secret of cure, but it must be continued for three months. The diet was restricted to 10 ounces of solid and 6 ounces of fluid in the twenty-four hours. This reduction of nourishment diminished the action of the heart and increased the plasticity of the blood, and hence favored the consolidation of the aneurysm. Tufnell also directed certain remedial agents to be combined with rest, such as lactucarium to quiet the patient and induce sleep, and opium to soothe pain. Compound powder of jalap was used at intervals, to reduce the quantity of circulating fluid by withdrawing the serum from the blood. He gives an analysis of 10 cases treated by his method: 7 were cured, and 3 died during treatment. One of the successful cases was an aneurysm of the popliteal artery, cured in twelve days.

The surgical treatment of aneurysm may be subdivided into—1st, those methods which embrace some form of compression; 2d, those which embrace some form of surgical operation; 3d, those which may be classed as miscellaneous.

1. *Compression.*—The treatment of aneurysm by compression was employed over two hundred years ago, but only in cases of traumatic aneurysm. The manner of employing compression in the seventeenth century for the cure of aneurysm was essentially different from that employed at the present time, both in its principle and in its application.

The principle upon which surgeons based the treatment of traumatic aneurysm by compression in the seventeenth century was this: the compression was supposed to prevent the further dilatation of the aneurysm and to squeeze the blood out of the sac into the arteries, as water would be squeezed out of a sponge; the edges of the cut artery were thought to be thus brought into apposition and to become adherent, and the blood to pass through the restored artery as if nothing had happened. From this description it is evident that little was known of the nature or pathology of aneurysm. That the principle upon which the treatment was based was erroneous will be seen when we study the subject in the light which modern pathology has thrown upon it.

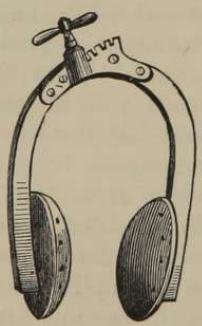
In the eighteenth century Heister was the first to propose to extend the plan of treatment of traumatic aneurysm by compression from the brachial artery, to which compression had been limited, to the popliteal artery, but he did not carry his plan into execution. It was reserved for Guattani, an Italian surgeon, in the year 1772 to treat the first case of popliteal aneurysm by compression. He applied compression directly upon the sac and also bandaged the entire limb, believing that the aneurysm was cured upon the same principle that has been mentioned. The cases treated by this means usually resulted fatally. By direct compression a circumscribed aneurysm was often transformed into a diffuse one; the sac became inflamed and suppurated; the limb became gangrenous, and half of the patients died. This was the state of affairs when, in 1785, John Hunter tied the femoral artery in Hunter's canal for the cure of a popliteal aneurysm, and announced a new principle, which changed all the opinions then held as to the way in which compression cured an aneurysm, and was followed by a complete revolution in practice.

Desault ligated the popliteal at some distance above the sac earlier in the same year, and a claim of priority has been based upon this fact. The Hunterian method is mentioned in this connection only to show the change produced by it in the treatment by compression. In another place it will be considered at length. The new principle involved was this: that it was necessary to arrest only partially, and not completely, the current of blood through the aneurysmal sac, which, from its own inherent elasticity, tends to diminish in size so soon as the full force of the heart's action is taken off: this contractility of the sac is an important element in the cure of circumscribed aneurysms by any method, and its absence in diffused as in traumatic aneurysms explains the failure of ligation and compression in the majority of such cases. Upon this principle and after Hunter's time compression was employed above the aneurysm, instead of, as always before, directly over it, and with greatly improved results. When this method is employed, the cessation of pulsation in the sac after the compression is relaxed, the absence of the thrill and bruit, together with the fact that the collateral circulation is fully established, indicate that the aneurysm is cured.

The enlargement and pulsation in the collateral vessels do not take place until the aneurysmal sac is obliterated by the deposition of fibrin; therefore the establishment of the collateral circulation is in itself a reason for supposing that the aneurysm is cured. It is through this collateral circulation that the extremity is supplied with blood. This prevents gangrene from attacking the parts below the sac. The collateral vessels soon develop into vessels of important size. The pain which has been recorded in the cases in which spontaneous cure was effected, as well as in those cases in which compression accomplished a cure, has been said to have been due to the sudden enlargement of the anastomosing vessels consequent upon the complete solidification of the sac, and may thus occasionally be considered a favorable symptom.

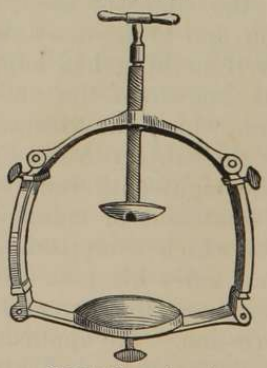
Instrumental compression is carried out by the employment of one of the many different varieties of tourniquets or compressors. Whatever instrument is employed for the purpose (Figs. 38, 39), only the artery must be compressed,

FIG. 38.



Signorini's Tourniquet.

FIG. 39.



Skey's Tourniquet.

and at no time during the period in which the instrument is applied must the pressure be greatly relaxed. A piece of chamois-skin should be placed over the artery, so that the pressure of the instrument shall not excoriate the skin.

The time required to cure an aneurysm by compression varies from one to several days. The instrument must be kept on the artery until the pulsation in the sac has ceased, and then the amount of pressure during the following twenty-four hours can be lessened gradually. This gradual diminu-

tion of the amount of compression after pulsation has ceased is necessary, because otherwise the current of blood might disintegrate the clot in the sac before it is firm and solid.

Digital pressure was first employed by Jonathan Knight of New Haven, Conn., in 1848. In the same year Dr. Willard Parker and Dr. James R. Wood of New York City each cured an aneurysm by digital pressure. The pressure is maintained by relays of students or assistants for from one to two days, and this method is preferred by many surgeons to all other methods of compression. The same principle of treatment has been carried out by the use of instrumental pressure instead of digital, with fairly satisfactory success. A bag of shot, suspended over the bed by means of elastic tubing, has been used to secure uniform pressure upon the artery above the sac.

Flexion of the joint was brought to the attention of the profession in 1858 by Mr. Hart of England. The principles involved in this method are similar to those involved in compression. The plan is usually applicable only to aneurysm at the bend of the elbow and in the ham, although it has been successfully employed also in aneurysm of the external iliac. The leg is flexed upon the thigh and the thigh upon the pelvis; or the forearm is flexed upon the arm. The entire extremity is bandaged before flexion. Flexion causes compression directly upon the tumor itself, and also impedes the circulation through the sac, and probably dislodges a small clot which closes the mouth of the sac. This method is not suitable where the aneurysm is large, because of the liability of the sac to rupture, and is contraindicated if there is much œdema of the leg or inflammation of the sac. In ordinary cases it may be tried, since no harm follows if the treatment is unsuccessful. It is especially applicable to cases in which the tumor is small, the sac not inflamed, and the joint not involved.

Rapid Cure by Esmarch's Elastic Bandage.—In 1864, Murray, an English surgeon, anesthetized a patient suffering from an aneurysm of the abdominal aorta, and applied an instrument which completely checked the flow of blood through the arteries leading into the sac. The treatment resulted in cure. In this the so-called "rapid method" the object was to produce complete stagnation of a mass of blood in the sac until it coagulated. In 1875, Reid of the British navy treated aneurysms successfully by the rapid method by employing Esmarch's elastic bandage. The formation of a blood-clot in the sac is essential in order to effect the cure of an aneurysm by this method. That variety of blood-clot which is formed while blood is at rest is required (the red blood-clot), and not the one that is formed while blood is in motion (the fibrinous or white blood-clot). In order to accomplish the formation of a blood-clot in contradistinction to the formation of fibrin there must be a stasis of blood in the sac, followed by coagulation of the blood. This clot does not finally undergo organization, but contracts. Its chief object is to aid in the formation of a thrombus in the afferent and efferent vessels leading into and out of the aneurysm. Not all aneurysms are amenable to this treatment. There should be no vascular degeneration except in the aneurysm, likewise no renal disease, and the sac itself should be free from inflammation. The administration of the iodides and restricted albuminous diet are useful adjuvants.

The patient should have a hypodermatic injection of morphine before taking ether, and just enough of the anesthetic should be administered to keep him quiet and free from pain during the treatment. The elastic bandage should be firmly applied from below upward till the aneurysmal sac is reached, then carried very lightly over the sac itself, and reapplied firmly above it, so as to confine a quantity of fluid blood in the sac. The patient must be kept under ether for an hour or an hour and a half. A tourniquet should be adjusted above the aneurysm,

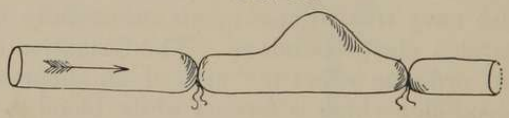
to moderate the blood-current and prevent its disturbing and washing out the clot in the sac and the thrombi in the afferent and efferent arteries. The tourniquet can be kept on the limb for from sixteen to twenty-four hours after the removal of the bandage, and must be unscrewed gradually, so as to restore the blood-supply in proper quantity. The two dangers to be guarded against are, on the one hand, washing out the clot before it is solid, and on the other the production of gangrene of the limb by too long-continued pressure. The effect of the arrest of the blood-supply must be carefully watched from hour to hour as the tourniquet is gradually unscrewed. The collateral circulation will soon be established. The risks of the sudden rise and fall of arterial tension, the compression of nerves, the rupture of the sac, the development of kidney disease, and the possibility of gangrene, are all to be considered. These dangers also accompany other methods, but perhaps are as little likely to occur after this plan as after any other operative interference or after compression applied in any one of the many ways already described.

The treatment of aneurysm by any of the different methods of compression is not without difficulties. If the instrument is not adapted to the exigencies of the case, if the patient is irritable and cannot bear pain well, or if the aneurysm is unfavorably situated for the application of an instrument or of digital compression, there will arise difficulties which will discourage the patient as well as the surgeon. If, however, after even weeks of perseverance no good has been accomplished, both patient and surgeon should remember that no great risks have been incurred involving the life of the patient, and no conditions absolutely contraindicating a trial of operative measures have been produced. Few cases in which the treatment by compression in some form has been faithfully persevered in for a long time have been unattended with improvement.

2. *Those methods which embrace some form of surgical operation.*

The Old Operation of Antyllus (Fig. 40).—The earliest recorded treatment of aneurysm is that devised by Antyllus, who lived in the fourth century. At that time it was employed only in cases of small traumatic aneurysms situated at the bend of the elbow. The method was simple, and was described by him as follows: an incision was made along the inner aspect of the arm over the brachial artery. The vessel, having been exposed, was tied on each side of the aneurysm. The aneurysm was then laid open and the contents of the sac were turned out.

FIG. 40.



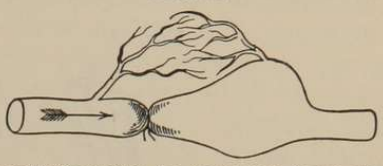
Old Operation of Antyllus for Aneurysm (original).

This operation was performed for several hundred years, and it was not until the eighteenth century that any other was practised even in idiopathic aneurysm. The great mortality in this form of aneurysm was due to the fact that the artery was tied immediately above and below the sac, *where the vessel was unsound*, and hence secondary hemorrhage and exhaustive suppuration, with ankylosis of the joint, followed. The principle involved in the old operation, with certain omissions and modifications, is still applicable in axillary and gluteal aneurysms and in traumatic aneurysm at the bend of the elbow.

Anel's Operation (Fig. 41).—Anel in the year 1710 devised and performed a new operation for the cure of aneurysm. He did not open the sac as in the old operation, or tie the artery above and below the sac, or

stuff the wound with myrrh. He thought that the tumor would collapse if the main artery leading into it were tied near the aneurysm. He was successful, and thenceforward the treatment of aneurysm rested upon a scientific basis.

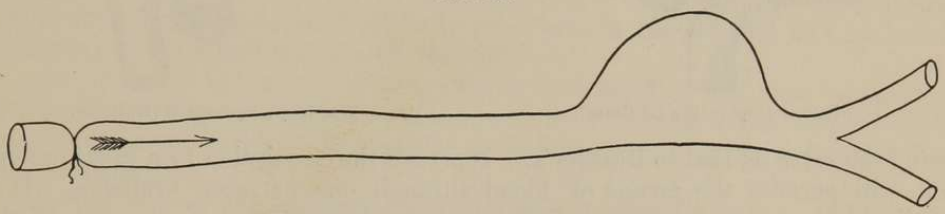
Fig. 41.



Anel's Operation for Aneurysm (original)

Anel, however, did not apprehend correctly the principle which his operation involved. He thought the tumor simply collapsed, and it was not until some years afterward that the true principle underlying this operation of ligaturing the artery upon the cardiac side of the aneurysm was brought to light—not indeed until John Hunter, in 1785, on account of the many failures in the treatment of aneurysm by compression, was led to

Fig. 42.



Hunter's Operation for Aneurysm (original).

investigate the subject from a pathological point of view, and devised the operation for its cure which has made his name immortal.

Hunterian Operation (Fig. 42).—Hunter demonstrated by experiments upon dogs that weakness alone was not the cause of dilatation of an artery, but that there must be some previous disease of the coats of the artery itself before the force of the circulation would develop an aneurysm. He proved that the disease was not confined to the artery at the seat of enlargement only, but extended some distance from the sac; and this fact, he thought, explained the cause of failure of treatment by Anel's method, in which the artery was tied at a point where it was diseased, permitting the ligature to come away too soon and secondary hemorrhage to occur.

Hunter proposed, therefore, to tie the artery at a distance from the sac, at a point where the vessel was healthy, and thus diminish the risk of secondary hemorrhage. He thought, moreover, that if the force of the circulation were taken off from the aneurysmal sac the disease would be arrested, and the sac and its contents would be absorbed. The conclusion which he drew from his observations was that simply taking off the force of the circulation from the aneurysmal artery is sufficient to effect a cure of the disease, or at least to put a stop to its progress, and enable the processes of nature to restore the parts to a normal state.

The *conditions* under which the Hunterian operation is indicated are as follows: the aneurysm must be of moderate size; it must be of slow growth; and the sac must not be inflamed. Slight œdema would not contraindicate the operation. Gangrene would preclude all operations except amputation.

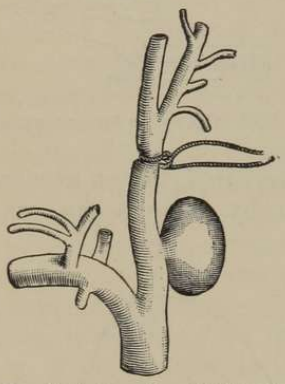
The *accidents* following the Hunterian operation are—secondary hemorrhage, return of pulsation in the sac, inflammation and suppuration of the sac, gangrene of the extremity, pyemia, and septicemia.

Brasdor's Operation (Fig. 43) consists in ligating the artery upon the distal side of the sac, so that the circulation upon that side is completely

arrested. The cases in which this method can be adopted are aneurysms of the carotid artery, of the external iliac, etc.

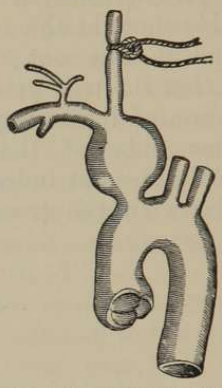
Wardrop's Operation (Fig. 44) consists in tying the artery or one of its branches upon the distal side of the sac, the principle on which it is founded

FIG. 43.



Brasdor's Operation (Holmes).

FIG. 44.



Wardrop's Operation (Holmes).

being the same as that in Brasdor's. It arrests the circulation to a great extent, but still permits the escape of blood through one or more branches. It is applicable only to aneurysm of the innominate artery or of the arch of the aorta. The carotid or the subclavian alone, or both of these vessels, may be tied, and the two operations may be either simultaneous or consecutive. The branches of the subclavian between the ligature and the aneurysm keep up a diminished circulation.

Before dismissing the subject of ligation, the *advantages of compression over ligation* will be considered. These advantages are that—

1st. Compression effects a cure in accordance with nature's laws. The sac after compression consolidates just as in spontaneous cure; only the sac itself is consolidated, and not all the arteries up to the point where pressure is made, as is the case after ligation.

2d. Compression is less dangerous than ligation. If any danger arises during compression, the treatment can be discontinued and then resumed. Not so with ligation, for then the patient may be in great danger for many days after operation.

3d. Compression is more likely to be attended with success than ligation. There are not so apt to be complications, such as secondary hemorrhage, sloughing of the sac, phlebitis, gangrene, or pyemia, occurring during compression and preventing a cure.

4th. Compression is more likely to be permanent than ligation. A second aneurysm has been known to form after ligation, and also suppuration to be set up in the sac; neither of these is likely to occur after compression, though both are possible.

3. *Those methods which may be classed as miscellaneous.*

Introduction of Foreign Bodies into the Sac.—This method consists in puncturing the sac with a canula and introducing through it several yards of fine wire. Moore, in 1864, passed twenty-six yards of fine wire into an aneurysmal sac. The patient died of pericarditis and inflammation of the sac. Recently, Loreta introduced some silvered copper wire into the sac of an abdominal aneurysm. A firm clot was formed, but the patient died two months after the operation. Besides wire, other materials have been employed, such

as catgut, silk, and horse-hair. Whatever material is used, the operation is attended with great danger.

Manipulation.—This method was introduced by Fergusson in 1852. The object is to displace some of the fibrin in the sac by manipulating the aneurysm, and thus to block up the artery upon the distal side of the sac. The aneurysm is first emptied by making pressure on the afferent artery, and then the sac is kneaded and rubbed in order to detach a small embolus which shall be swept into the efferent artery and thus obstruct it mechanically. The operation has fallen into disuse, owing to the fact that emboli were carried to the brain, causing aphasia, hemiplegia, and even death.

Galvano-puncture is a method suggested by Phillips in 1829. The object is to produce coagulation of blood in the sac without the intervention of any foreign body. A galvanic current is passed through an insulated needle which is brought in contact with the point of another insulated needle introduced into the sac about an inch from the point of entrance of the first needle. Suppuration of the sac, hemorrhage through the punctures in the sac-wall, and embolism are among the dangers that attend this method.

Acupuncture by means of very fine gilded needles has been employed. The needles are introduced into the sac so as to cross each other, and the blood coagulates around them. The needles are left in the sac several days, and then are withdrawn.

Extirpation of the aneurysm was first practised by Philagrius of Macedon in the fourth century. A most formidable operation in those days, it has been revived of late with marked success by the aid of anesthetics and with the certainty of aseptic healing.

The technique of the operation consists of a free incision over the site of the aneurysm, so as fully to expose the continuity of the vessel. Two ligatures are now applied to the artery upon the proximal side of the sac, a short distance from it, and the vessel divided between the ligatures. The same procedure is to be followed upon the distal side of the aneurysm after carefully dissecting out the entire sac with its contents and severing them from their connections.

The special advantages of extirpation of the aneurysmal sac over proximal ligature, compression, or any other method are the removal of the dangers of emboli which might cause gangrene, the absolute permanency of the cure, the absence of secondary hemorrhage, the freedom from sepsis, and, finally, the lessened mortality—advantages not secured by the other methods.

The mortality of proximal ligature has been placed by Delbel at 18 per cent., that of total extirpation of the sac at 11 per cent.; the occurrence of gangrene after proximal ligature about 8 per cent., after extirpation only 3 per cent. Ransohoff collected twenty-eight extirpations of major aneurysms of the extremities without a single death.

Extirpation of the aneurysm is especially indicated in the traumatic variety, notably those situated upon the extremities. This operation is also indicated when the sac has ruptured or when other methods have failed to cure the disease.

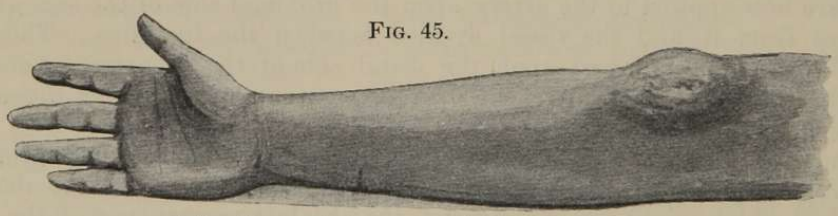
Amputation is required in certain aneurysms. This is necessary if an aneurysm has burst, if hemorrhages are frequent, if a joint is involved, if caries of bone has ensued, or if gangrene of the extremity has occurred.

Coagulating Injections.—In this method injections of certain drugs are made into the sac with a view of causing coagulation of the blood. Such injections should not be employed in aneurysms situated in the neck, because emboli may be transmitted to the brain and cause instant death. In aneurysms

involving the extremities, injections of Monsel's solution of iron, tannin, acetate of lead, and other drugs have been employed. Whatever injection is used, pressure should be made for some little time upon both the afferent and the efferent arteries, to prevent emboli from being swept into the circulation.

Macewen's Method, which consists in inducing the formation of white thrombi within the sac, is a recent plan of treatment which will sometimes be useful. The formation of these thrombi is accomplished by irritating the lining membrane of the aneurysmal sac in such a way as "to induce infiltration of the parietes with leucocytes, and a segregation of them from the blood-stream at the point of irritation." The amount of irritation should be sufficient to cause merely a reparative exudation, as any irritation beyond this stage would result in softening of the sac-wall, which in turn might lead to rupture. The irritation should be evenly applied within the whole surface of the sac, or at least from many foci distributed uniformly throughout its interior. The technique of the operation is as follows. The skin over the sac having been made aseptic, a long, strong cylindrical needle, also rendered aseptic, is introduced into the interior of the sac. The point of the needle should be allowed to impinge upon the opposite wall of the sac, so as to irritate the lining membrane, or else the needle should be held lightly in this position for a few moments, so as to allow the impulse of the blood-current to play on it. It should be shifted to other parts of the sac at intervals of ten minutes, until the whole sac has been uniformly irritated. The simultaneous use of a second or even a third needle at distant points may be necessary. The time required to irritate the whole sac varies from a few hours to forty-eight hours. While the needle is left *in situ* in the sac, an antiseptic gauze dressing should be applied to the surrounding region. It may be necessary to repeat the operation from time to time for weeks or even for months. This method should not be employed

FIG. 45.

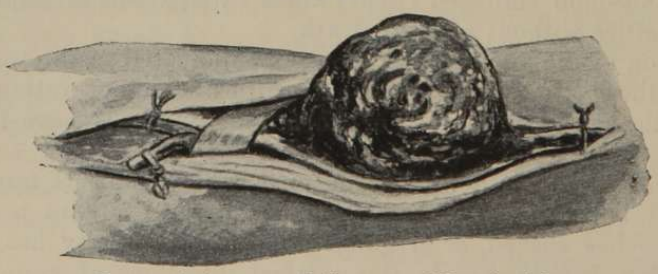


Diffuse Traumatic Aneurysm of the Brachial Artery.

if there is any inflammation in the walls of the sac, any superficial ulceration, or any erysipelatous induration.

TRAUMATIC ANEURYSM (Figs. 45, 46).—This variety of aneurysm differs

FIG. 46.



Traumatic Aneurysm laid open and Vessels tied.

from all the others in the manner of its causation, as well as in the condition of the parts involved. In all varieties of aneurysm except the traumatic, the

disease is situated in the coats of the arteries. In the traumatic variety the lesion, as its name implies, is the result of a direct injury to the vessel, and an arterial hematoma results.

This form of aneurysm is caused by a stab or gunshot wound, or by the giving way of cicatricial tissue which has imperfectly healed a wound of an artery. The blood escapes from the injured artery, and extravasates throughout the tissues until by mechanical pressure the hemorrhage is arrested. The pressure of so much extravasated blood in the tissues with superadded infection by pyogenic microbes causes an inflammation of the parts, and if not treated an abscess may possibly form, the opening of which may result in an alarming hemorrhage.

The **symptoms** of traumatic aneurysm depend upon its situation and the size of the vessel wounded. The presence of a tumor suddenly developed after an injury to a vessel, accompanied by severe pain and tension, with pulsation and bruit, and absence of pulsation beyond the aneurysm, is indicative of this form of aneurysm. In addition to these signs, a certain redness of the skin from inflammatory tension soon appears, and unless this tension is relieved sloughing is apt to occur, and in some cases even gangrene of an extremity.

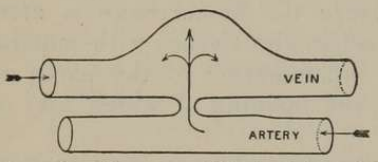
Traumatic aneurysm must not be mistaken for an abscess, which it often resembles. The diagnosis between the two conditions can be made by the history, by the symptoms, and, if necessary, by introducing a hypodermatic needle. Fluid blood indicates an aneurysm, while pus suggests an abscess. The fact that an abscess may be the direct result of a traumatic aneurysm must not be overlooked.

The **treatment** of traumatic aneurysm is based upon the same principles that would guide the surgeon in the management of a primary wound of an artery. If in an extremity, an Esmarch elastic bandage should be applied and the tumor cut down upon until the injured artery is found. The vessel should be completely divided and the two ends securely ligatured. The wound should then be thoroughly disinfected and dressed antiseptically, in order to secure healing by primary intention. In cases in which an elastic bandage cannot be employed—*e. g.* in the neck—a serious difficulty arises. When this is the case the surgeon should carefully dissect down to the aneurysm, and make an opening sufficiently large to admit his finger into the tumor, by which he should seek for the opening into the artery on the proximal side of the aneurysm, in order to arrest the hemorrhage by pressure. The finger may be guided to the opening in the vessel by feeling the current of warm arterial blood impinge upon it. When the opening has been occluded, the surgeon can enlarge the wound so that he may be enabled quickly to turn out the fluid blood and the coagula in the false sac. The vessel is then tied between the finger and the heart by means of a curved aneurysm needle armed with a catgut or silk ligature. The artery on the distal side of the aneurysm must then be secured by a similar ligature, otherwise, if the collateral circulation has been established before the operation is done, very troublesome hemorrhage would arise from this point. If the vessel is in an extremity, is very large, and the traumatic aneurysm is situated near the trunk, an amputation may be necessary, especially if the injury to the vessel has been caused by a gunshot wound.

An Aneurysmal Varix is a communication between an artery and a vein without the intervention of a sac. It may result from unskilful venesection, from the thrust of a sharp instrument, from a pistol-shot wound, etc. If an artery and a vein have been wounded by venesection, for example, so that

a communication is established between them, an aneurysmal varix is formed. When this accident happens, a pad or compress is laid firmly over the wounded part, so as to arrest the hemorrhage. The walls of the artery and vein in consequence of the slight inflammatory action become adherent to each other at

Fig. 47.



Plan of an Aneurysmal Varix (original).

Fig. 48.

Varicose Aneurysm (Spence).

the margins of the wound, but the wound itself does not heal, since at each pulsation of the heart a stream of arterial blood is thrown through the opening into the vein. The blood thus projected from the artery into the vein finally dilates the latter (Fig. 47). The blood as it enters the vein comes in contact with the opposing venous stream, and so produces a whizzing sound which is pathognomonic of an aneurysmal varix. Once heard, the sound will never be mistaken. It has been compared to many noises. One of the best comparisons (which is as ludicrous as it is forcible) was suggested by the late Mr. Spence—viz., the noise which a bluebottle fly imprisoned in a thin paper bag makes in its efforts to regain its freedom. Valentine Mott compared the noise to the purring of a kitten.

Aneurysmal varix may exist for years and give rise to no serious disturbance. There is some alteration in the coats of the vein and of the artery, but none that would offer resistance to the flow of blood, as is the case in an aneurysm. There is dilatation of the vein, but not enough to cause ulceration or rupture. The veins beyond the varix are always more or less dilated and enlarged.

Treatment.—In some cases of aneurysmal varix no operative interference is called for. All that is then necessary is to apply an elastic bandage, which prevents further enlargement. The disease, however, sometimes extends and occasions pain and disturbance in the circulation. In these cases pressure by means of a firm compress should be made upon the artery above and upon the vein below, and also directly over the aneurysmal varix. If this does not cure the disease after a fair trial, the tumor should be treated by operation. The aneurysm should be exposed by dissection, a ligature placed above and below the opening in both the artery and the vein, and the aneurysm extirpated. In aneurysmal varix of the carotid and the internal jugular and of the common femoral vessels operative interference should be undertaken only when the reasons are very urgent.

Varicose Aneurysm.—A varicose aneurysm is similar to an aneurysmal varix, since in both there is a communication between an artery and a vein; but in the varicose aneurysm there is a sac between the artery and the vein. The arterial blood is projected into this sac, and from the sac into the accompanying vein (Fig. 48).

Both aneurysmal varix and varicose aneurysm are often called **arteriovenous aneurysm.**

Varicose aneurysm, like aneurysmal varix, is the result of a wound both of the artery and of the vein; but in the case of varicose aneurysm if not treated, or if the compress which was placed over the wound at the time of the accident was not firm enough, blood will have extravasated between the walls of

the artery and the vein and separated the two vessels. Inflammatory lymph has then been deposited around this space, and thus a false aneurysm has been formed, communicating with both vessels; its sac consists of condensed effused lymph. This intervening sac which comes from the false aneurysm must not be confounded with an ordinary false aneurysm the result of a wounded artery alone. In the ordinary false aneurysm there is no communication with a vein.

On account of the slight arterial pressure exerted by the force of the circulation upon the walls of the sac of a varicose aneurysm, the sac is not subject to great enlargement. In an ordinary aneurysm the force of the blood-current impinges directly upon the aneurysmal sac; in a varicose aneurysm the blood-current finds its way through the aperture into the vein, and thus its force is distributed into the vein instead of impinging directly upon the sac. While, then, enlargement of the sac is not common, yet in view of the liability of the sac to slough, and the danger of gangrene of the limb or of the false aneurysm's becoming diffuse, the indication for surgical interference is plain.

The **symptoms** are nearly the same as in aneurysmal varix, with the exception of the presence of a sac, which sometimes can be made out by palpation, and over which can be heard a soft bruit.

Treatment.—Varicose aneurysm must not be left to itself, for it will finally ulcerate and become diffuse. Compression is not suitable, as the already dilated and varicosed veins would become greatly enlarged, and finally cause much œdema and expose the patient to the risk of gangrene. In most cases of varicose aneurysm, especially if the aneurysm is small, ligature of both vessels above and below the disease, followed by extirpation, is a well-recognized operation. In cases of varicose aneurysm situated in the neck or in the anterior femoral region, this procedure would be attended with great danger. The Hunterian operation of tying the femoral artery above the sac in healthy tissue has been tried in two cases, and death followed in both instances. The reason for the failure of ligation of the artery by Hunter's method is that the conditions in an ordinary aneurysm and in the varicose aneurysm are different. In the ordinary aneurysm the ligation of the artery causes deposition of fibrin in the sac on account of the lessened amount of blood slowly entering the sac; in the varicose aneurysm the communication through the sac with the vein offers an unimpeded passage of the blood into the venous circulation, and the return venous circulation through the sac prevents coagulation, for blood in motion will not coagulate.

The late Mr. Spence of Edinburgh devised and carried into successful execution an operation for varicose aneurysm which meets the theoretical as well as the practical indications. To use his own words, he cuts down upon the artery above the sac, and then below the sac, but does not open the sac or disturb the vein. The application of two ligatures to the artery at the places mentioned removes the disturbing influence in the retrograde current of arterial blood, and thus permits the blood in the sac to remain unagitated by the meeting of two currents and to coagulate, causing the consolidation of the tumor.

ANEURYSMS OF SPECIAL ARTERIES.

Carotid aneurysm is usually situated at the point where the artery bifurcates upon either side of the neck. Upon the right side the aneurysm may develop at the origin of the vessel. It begins with the appearance of a small tumor, which may grow slowly or very rapidly. The symptoms of carotid aneurysm are those common to any other aneurysm, with, in addition, dyspnea, difficult deglutition, vertigo, hoarseness, brassy cough, and ringing in the ears.

The **diagnosis** of carotid aneurysm is often attended with great difficulty. The affections for which this disease may be mistaken have already been considered under the differential diagnosis of Aneurysm.

The **treatment** of carotid aneurysm is best carried out by means of a ligature upon the proximal side of the sac if there is sufficient room, otherwise upon the distal side. Among the accidents that may follow ligature of the carotid may be mentioned embolism, cerebral softening, hemiplegia, syncope, secondary hemorrhage, and suppuration of the sac.

If it becomes necessary to ligate both carotid arteries, they should not be tied simultaneously, as this double operation has been attended by fatal coma.

SUBCLAVIAN ANEURYSM is found most frequently in the third portion of the vessel. The tumor appears under the clavicular origin of the sterno-cleido-mastoid muscle, the direction of its long axis corresponding with the direction of the artery. Besides all the symptoms common to aneurysm in general, subclavian aneurysm has some special signs. Among these may be mentioned pain along the nerves belonging to the brachial plexus, if on the right side a brassy cough from irritation of the recurrent laryngeal nerve, a varicose condition of the jugular veins, delayed radial pulsation, and finally œdema of the arm and hand. These symptoms increase in severity as the tumor enlarges.

The **diagnosis** of a subclavian aneurysm in the third portion of the artery from one involving the lower portion of the carotid or the subclavian in its first portion, or even the innominate, must be made. The chief diagnostic points of subclavian aneurysm in its third portion are the simultaneous pulsation of the carotid arteries and the delayed radial pulsation upon the affected side. The simultaneous delay of the carotid and radial pulsations of the right side indicates an aneurysm of the innominate artery instead of the third portion of the subclavian.

Treatment.—If the aneurysm is small and limited to the third portion, digital pressure upon the proximal side of the subclavian, although difficult for anatomical reasons, may be attempted in conjunction with constitutional treatment. Pressure directly upon the sac has been successful in a few cases. If compression fails, the artery should be ligated upon the distal side, since proximal ligation has rarely proved effectual. It may be necessary, where other means have failed, to ligate the artery on the proximal side as a preparatory step, and then immediately to amputate at the shoulder-joint.

AXILLARY ANEURYSM may be idiopathic or traumatic. The idiopathic variety may be developed by the stretching of the vessel in reducing an old dislocation or by a too free movement of the shoulder-joint, or by atheroma of the vessel. This variety of aneurysm grows very rapidly, owing to the laxity of the surrounding tissues, which permits it to dilate without early mechanical obstruction. It quickly attains a large size, and the situation of the sac renders it especially prone to inflammation. The pressure of the aneurysm soon causes venous obstruction, and œdema of the forearm ensues. The pain is often very severe, on account of the irritation of the brachial plexus. The pulse at the wrist corresponding to the side of the aneurysm is delayed when compared with that of the opposite side. If the sac continues to grow, the shoulder-joint is invaded, the ribs are eroded, and the corresponding lung is compressed. The movement of the arm is soon interfered with, and ankylosis of the shoulder follows. This variety of aneurysm may cause a dry pleurisy or a hyperplastic pneumonia.

The **treatment** consists in applying digital or instrumental compression to the third portion of the subclavian artery, and, in the event of failure, in tying

this portion of the vessel. The application of an elastic bandage to the arm, combined with pressure upon the proximal side of the sac, can also be tried. Other methods of treatment in this form of aneurysm are fraught with danger, and must not be undertaken without deliberate consideration.

In the traumatic variety of axillary aneurysm the injury may be produced by a stab or gunshot wound, or even, as has been said above, by external violence in attempting to reduce an old dislocation. In the treatment of traumatic aneurysm Mr. Syme has suggested a modification of the old operation of Antyllus. The subclavian is compressed firmly in its third portion, and the axillary sac is then opened, the coagula turned out, the wound found, the artery completely divided, and both ends ligated.

BRACHIAL ANEURYSM may be situated either along the course of the artery or at the bend of the elbow. The most frequent variety of aneurysm is the traumatic; but aneurysmal varix, and also varicose aneurysm, are found at the bend of the elbow as a result of unskilful venesection. For the treatment of these varieties of aneurysm see pp. 225–245.

In idiopathic aneurysm of the brachial artery compression or the modified operation of Antyllus or the Hunterian operation may be employed. In rare cases gangrene of the forearm may result from an aneurysm in this situation. This condition calls for amputation.

ILIAC ANEURYSM may involve the common trunk of the vessel, the internal or the external iliac artery, or their branches. In aneurysm of the *common iliac* artery the treatment consists in compression upon the cardiac side of the aneurysm. The pressure should be made as much as possible over the artery, and not over the sac. The results of ligation of the common iliac for aneurysm show a mortality of nearly 75 per cent.

The *internal* iliac artery is seldom the seat of idiopathic aneurysm. The *sciatic* and *gluteal* branches have, however, been the seats of aneurysm both of the traumatic and the idiopathic variety. If the aneurysm is idiopathic, the treatment should consist in proximal compression, and, if this fails, in the injection of remedies with a view to coagulating the blood. Recently, ligation of the vessel by a median laparotomy has been employed.

If the gluteal or sciatic aneurysm is traumatic, compression must be made above upon the main artery, the sac be laid open, the clots turned out, and the vessel tied above and below the wound.

The *external* iliac artery is often the seat of idiopathic as well as of traumatic aneurysm. In the idiopathic variety the method by compression should be first employed, and if this fails the ligature of the vessel above the sac is indicated. The vessel can be reached by a median laparotomy. If the aneurysm is of the traumatic variety, the modified operation of Antyllus is indicated.

FEMORAL ANEURYSM may be traumatic or idiopathic. From the exposed situation of the femoral artery, false aneurysms are of frequent occurrence. The treatment should consist in the application of a tourniquet to the artery as it passes over the brim of the pelvis, incision of the sac, and ligation of both ends of the divided artery. If the aneurysm is idiopathic, compression above the sac should be first tried, and in the event of failure the Hunterian operation should be employed.

POPLITEAL ANEURYSMS are usually idiopathic, but occasionally the traumatic variety is seen. The latter should be treated according to the rules given for the management of this form of aneurysm situated in any other part of the body. The idiopathic variety can be treated by the flexion method, by the Hunterian method, by proximal compression, or by the elastic bandage.

SECTION IV.—INJURIES OF THE BLOOD-VESSELS.

HEMORRHAGE is invariably present when a vessel is wounded. The blood may escape through the broken skin, or may extravasate beneath the skin and form a hematoma. The occurrence of severe hemorrhage is always attended with great danger to life, and the larger the caliber of the wounded vessel the greater the immediate danger. There is no other emergency which the surgeon is called upon to meet that requires so much judgment and presence of mind as the proper management of alarming hemorrhage.

There are four varieties of hemorrhage:

1. ARTERIAL HEMORRHAGE, characterized by bright-red blood spurting out in jets synchronously with the action of the heart. The bright-red color is due to the presence of oxygen in the blood. Arterial blood may be deprived of its characteristic color when the oxygen is greatly diminished and carbonic acid gas is present in excess, as in profound narcosis or when an operation is undertaken to avert death from apnea. During an operation, therefore, the surgeon should always look to the anesthetic if the blood from the wound becomes dark-colored.

2. VENOUS HEMORRHAGE, characterized by the blood flowing in an uninterrupted stream and by its dark color. The steady flow of the blood from the veins is due to the fact that the intermittent cardiac impulse is lost. For the same reason blood from the distal end of a wounded artery also flows in a steady stream. The dark color is caused by the non-oxygenation of the blood and by the presence of carbonic acid gas. The walls of the veins collapse, with the exception of the veins of the liver; the portal system, however, is seldom taken into account by the surgeon.

3. CAPILLARY HEMORRHAGE, characterized by its constant oozing on the one hand, and by its spontaneous arrest on the other. This variety of hemorrhage is alarming in exceptional cases only, but its persistence often makes it a troublesome variety to treat. The capillaries in the mucous membranes bleed more profusely than those situated in the integument. This is due to the fact that in the former the capillaries are larger and more abundant. Hemorrhage from capillaries situated in the skin usually ceases owing to the contraction of the wound.

4. PARENCHYMATOUS HEMORRHAGE, characterized by absence of the features which distinguish the other three varieties, and also by the fact that it is found where there is a peculiar anatomical arrangement of the blood-vessels, or among diseased tissues, as when the main vein is thrombosed. This variety of hemorrhage is seen in those organs or parts of the body where the small arteries empty into small veins without the intervention of a capillary system. Such an arrangement is found in the corpora cavernosa and in the erectile tissue of the female genitalia, as well as in the spleen.

Hemorrhage may be divided upon another basis than an anatomical one—viz. a clinical one. It may be termed—I. Primary; II. Intermediary; III. Secondary.

I. *Primary hemorrhage* occurs immediately after the wound in the vessel. The characteristics of a primary hemorrhage vary according as it is arterial, venous, or capillary, as above described.

II. *Intermediary* or *reactionary* or *consecutive hemorrhage* occurs shortly after an injury to a vessel or after a surgical operation, during what is termed the period of reaction. This variety of hemorrhage usually takes place within twenty-four hours, and is caused by a ligature's coming away, or by the action

of the heart in driving out coagula from the divided end of a vessel, or by some movement of the wounded part.

III. *Secondary hemorrhage* occurs after twenty-four hours and before organization of the thrombus and cicatrization of the wound, and most frequently between the fifth and tenth days. It usually occurs during suppuration, and is caused by disease of the walls of the vessel, by sloughing of the wound, by ulceration of the vessel, by sepsis, or by the too rapid absorption of a catgut ligature. Secondary hemorrhage is often seen in gunshot injuries and in wounds where there have been extensive contusion and sloughing.

The **constitutional symptoms of hemorrhage** are rapid, feeble pulse; subnormal temperature; frequent and irregular respiration; convulsive movements; lividity of the lips and blueness of the finger-nails; dilatation of the alæ nasi; nausea and vomiting; pale face and pallid mucous surfaces; great dyspnea; profuse perspiration; muttering delirium; tinnitus aurium; syncope; collapse; disturbances of sight and hearing; unconsciousness.

The symptoms just enumerated are present to a greater or lesser degree according to the amount of blood lost, the size of the vessel injured, and the general condition and the age of the patient. Infants and children do not tolerate the loss of blood well, but they recuperate rapidly. Aged people likewise are seriously affected by the loss of blood, and, unlike children, do not rally quickly. Adults in health endure well the loss of blood, and women during parturition tolerate hemorrhages which under other circumstances would prove rapidly fatal.

After hemorrhage has been arrested and the patient has rallied, the symptoms denoting the existence of hemorrhage change and a slight febrile disturbance follows. To this condition the term "hemorrhagic fever" has been applied. The elevation of temperature is due to the nervous irritation consequent upon the hemorrhage and to the absorption of the "fibrin ferment," as after operation. (See p. 35.) The pulse is accelerated and often irregular, and its wave is apparently more distinct than normal, owing to the relaxation of the coats of the vessel due to the absence of the natural stimulus of the blood.

The patient is in an asthenic condition from exhaustion consequent upon the loss of blood, and septic processes are likely to develop under these circumstances. The lowered vitality in hemorrhagic fever predisposes the patient to unhealthy inflammations, and great care must be exercised to guard against the onset of these pathological changes. The mental condition in hemorrhagic fever is characteristic. The patient is affected with a low form of muttering delirium, never becoming maniacal or violent. The intellect is restored in proportion to the general improvement in the symptoms. The distinguishing feature of hemorrhagic fever is that it is not due to absorption of any septic material, but is due chiefly to an altered nervous condition consequent upon the loss of blood, which fails to supply the proper nutriment to the great nerve-centers.

Spontaneous arrest of hemorrhage may be effected by a combination of several agencies. Contraction and retraction of the divided vessel and coagulation of the blood are among the means which nature adopts. Cardiac syncope is also sometimes a most important factor in bringing about an arrest of hemorrhage, because this condition of the heart reduces the force of the blood-current, and thus permits coagulation in the wounded vessel. Contraction of the middle and internal coats and retraction of the entire vessel within its sheath help to form a barrier to the exit of blood at the divided end of the artery. Coagulation of the blood is brought about by the diminished flow of blood and also by its exposure to atmospheric influences. The hemorrhage after laceration of the vessel is controlled by nature, owing to the fact

that the internal and middle coats curl up and the external coat and sheath are twisted over the open mouth of the vessel. This phenomenon explains the small amount of blood lost in cases where the extremities are torn from the body.

The **diagnosis of hemorrhage** is attended with no difficulty when blood makes its appearance externally. When the hemorrhage occurs within the great cavities of the body, and is therefore concealed, the diagnosis is fraught with uncertainty. Hemorrhage into the pleural, peritoneal, pelvic, or cranial cavity must be diagnosticated upon the special evidences manifest in each case. The general symptoms of hemorrhage are present, but in many respects they are so similar to those found in shock that a discrimination must be made with great care. (See p. 89.) The aseptic hypodermatic needle can sometimes be utilized with great advantage. If the hemorrhage is within the cranial cavity, the study of the nervous phenomena will aid in the diagnosis. (See Intracranial Hemorrhage.) If it is within the pleural, peritoneal, or pelvic cavity, physical signs will establish the diagnosis when taken in connection with the history of the case.

The **treatment of hemorrhage** is divided into constitutional and local. The *constitutional* treatment consists in the judicious administration of cardiac stimulants, such as strychnine, tincture of digitalis, carbonate of ammonium, nitro-glycerin, and hypodermatic injections of ether, brandy, or whiskey. As a rule, the remedies to excite the action of the heart should be given hypodermatically in order to secure an immediate effect, and great care should be taken lest the patient be suddenly over-stimulated. Ergot of rye has been used to cause contraction of the involuntary muscular fibers of the vessels. In view of the subnormal temperature, artificial heat should be applied to the surface of the body. This can be accomplished by warm blankets, bottles of hot water, and hot-air baths. In the use of bottles of hot water or hot-water bags care must be exercised lest the patient be burned, an accident as unfortunate as it is frequent. An enema of brandy, or of turpentine and hot water, can be employed as a valuable adjuvant.

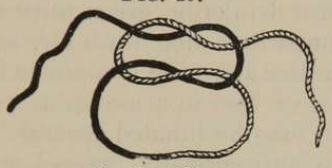
The head should be placed low, to prevent cerebral anemia, and the patient kept as quiet as possible. An abundance of fresh air should be supplied to a patient suffering from profuse hemorrhage. The application of Esmarch's elastic bandage to the extremities, elevation of the arms and legs, and raising the foot of the bed should be employed, in order to increase the amount of blood in the brain and internal organs. Galvanism or sinapisms may be applied over the precordial region. Towels wrung out of hot water and applied to the head will help to bring about reaction. Warm fluids can be given as soon as the patient is able to swallow, and a good nutritious diet as soon as possible. Opium should be administered during reaction, especially if nervous excitement is present.

Transfusion after hemorrhage has been resorted to with marked success in cases in which a sudden loss of a large amount of blood has occurred. The operation of transfusion as formerly employed consisted in the injection of blood from a healthy person into the blood-vessels of a patient suffering from hemorrhage. It was attended with a high death-rate, and investigation into the causes of death demonstrated the fact that the mortality was due to the presence of emboli. Entrance of air was another source of danger. At present transfusion is employed, but instead of injecting blood a saline solution is generally used. (See Minor Surgery.)

The *local* treatment of hemorrhage consists in the arrest of the bleeding either by compression, ligation, torsion, or acupressure. If the hemorrhage proceeds from an injured vein, compresses should be placed over the wound

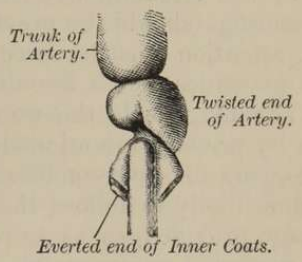
with uniform equable compression of the limb. This will suffice to control the bleeding in venous hemorrhage. If the hemorrhage is from a wounded artery, the bleeding vessel must be sought for and tied at both ends. The divided end of the artery, without any surrounding tissue, should be seized with a pair of artery forceps or hemostatic forceps, and the ligature should then be tied by means of the reef knot (Fig. 49). Catgut and sterilized silk are the materials employed for tying wounded arteries. Torsion of the vessel is applicable especially after amputation, as the vessel in this case is completely divided. In a wound in the continuity of the artery the vessel must be divided before torsion is applied. If the wound is a lacerated one, it can be converted into an incised one and the divided vessel caught and ligated or twisted. In applying torsion the vessel should be seized with the torsion forceps as if to ligate it (Fig. 50). A second pair of forceps may be placed upon the artery at right angles with and a short distance above the first pair. The open end of the artery is now to be twisted by the forceps on the long axis of the artery, which is held securely by the second pair of forceps. Only a few turns

FIG. 49.



The Reef Knot.

FIG. 50.



Effects of Torsion on Femoral Artery. (Bryant).

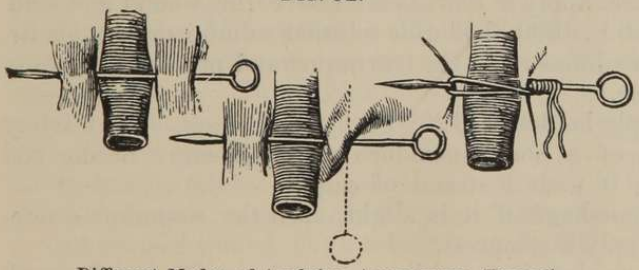
FIG. 51.

Artery laid open to show Turning Up of Inner and Middle Coats from Torsion (Erichsen).

should be made or the end of the artery may be twisted off. The effects of torsion on the inner and middle coats of an artery are shown in Fig. 51.

Acupressure (Fig. 52) is occasionally useful; one method consists in passing a needle under the vessel and compressing it precisely in the same manner as the stem of a rose is fastened in the lapel of a coat by a pin.

FIG. 52.



Different Modes of Applying Acupressure (Bryant).

If the hemorrhage is capillary, gentle pressure can be employed. Hot water at 120° F. will act as an astringent, and is one of our most convenient and reliable means of arresting hemorrhage. Ice is sometimes employed. Heat and cold both act by stimulating the muscular fibers of the vessels to contract. The actual cautery is a powerful hemostatic, but it has the great disadvantage of causing a slough. Styptic cotton, though generally objectionable, may be useful in hemorrhage from places where the ligature is inadmissible. The position of the part, according to the laws of hydraulics, should be such as

to diminish the force of the circulation and to favor venous return. Elevation of the limb will accomplish this result if the wound is in an extremity.

Comparative Merits of Various Methods of Treatment.—In all cases of hemorrhage the constitutional treatment is the same. The local treatment, however, is subject to certain variations. The ligature or torsion is the preferable method. If catgut or sterilized silk is used for ligatures, both ends may be cut short, the wound closed, and primary union obtained. Acupressure possesses no special advantage over ligature or torsion since the principles of antiseptic surgery have been applied to wound treatment.

Transfusion should be employed in any case of hemorrhage in which the symptoms become alarming. A patient may have lost a great quantity of blood, and may even be apparently moribund, but if the heart's action is perceptible, transfusion is indicated. It has often saved life even under these extreme circumstances.

In the *after-treatment* of hemorrhage the patient should be kept perfectly quiet both physically and mentally, and all visitors should be excluded. Any tendency to syncope must be combated by lowering the head, and cardiac stimulants should be judiciously employed. The surface of the body should be kept warm by artificial means, and warm drinks be given until the equilibrium of the circulation is restored. A nutritious diet, fresh air, and hygienic surroundings should be provided. After the alarming symptoms have passed away, attention must be directed to the use of iron in some form, wine in moderate quantities, and a free diet. Oxygen may be inhaled several times a day with advantage. If the wound has been antiseptically dressed and drained, union by primary intention should follow. If it has been improperly dressed, or if, owing to some condition for which the surgeon is not responsible, suppuration is likely to follow, the wound should be thoroughly disinfected and free drainage provided, so as to repair the damage with as little constitutional and local disturbance as possible. From what has already been said in regard to the treatment of hemorrhage the following rules may be formulated:

1. (*a*) If *primary* hemorrhage is serious and bleeding is actually going on, apply an Esmarch bandage or a tourniquet above the injury to the vessel, open the wound, turn out the blood-clot, find the wounded artery, divide the vessel at this point, unless it has been already divided, and tie the proximal and distal ends with aseptic catgut.

(*b*) If primary hemorrhage is serious, but bleeding is not actually going on and the patient is in collapse, apply a tourniquet above the wound and stuff into it sponges soaked in hot 1 : 4000 bichloride solution, administer stimulants, and when everything is in readiness relax the tourniquet and proceed as already described under the first rule.

(*c*) In general oozing apply hot water (120° F.) by compresses. If an artery spurts from the sawn end of a bone, introduce an acupressure needle and lacerate the vessel or plug it with a strand of catgut.

2. (*a*) In *secondary* hemorrhage, if it is slight, open the wound or stump, turn out the coagula, and apply a compress.

(*b*) If the hemorrhage is alarming, apply a tourniquet or an Esmarch bandage, open the wound, and tie the ends of the vessel if possible. If this is not practicable on account of diseased or sloughing tissue, ligate the vessel above in its continuity according to the Hunterian method.

(*c*) If secondary hemorrhage occurs after ligation of a vessel in its continuity, apply a tourniquet, open the wound, turn out the clots, and tie the artery above and below the bleeding point if the tissues are not too much lacerated.

(*d*) If this fails, tie the artery higher up in its continuity, or amputate.

WOUNDS OF ARTERIES.

These may be punctured, contused, lacerated, gunshot, or incised. Besides the varieties just mentioned there may also be rupture.

A *punctured* wound is caused by the penetration of the artery by a sharp or a thin blunt instrument. If the opening is very small hemorrhage may not result, but if the puncture is of any size bleeding occurs. A punctured wound of an artery usually gives rise to a traumatic aneurysm, and must be treated as such.

A *contused* wound of an artery may be insignificant, or it may be of sufficient magnitude to cause gangrene by obliteration of the vessel or death by secondary hemorrhage. A slight contusion of the arterial wall may be followed by an inflammation which leads to a thickening of the walls of the vessel and complete occlusion. This condition may give rise to gangrene. If a thrombus forms in a contused artery which supplies some internal organ with blood, the viscus, having been deprived of its nutriment, will undergo degeneration. The contusion may be extensive enough to destroy the coats of the vessel, so that a fatal secondary hemorrhage follows the separation of the slough.

A *lacerated* wound of an artery deserves special attention, because the results are likely to become serious. If an artery is stretched or torn sufficiently, the middle and internal coats snap. In the middle coat the circular fibers separate from each other so as to leave a space, and the separated circular fibers contract upon the internal coat, which is torn completely across and curls up within the lumen of the vessel in the same manner as it does after the application of a ligature. In a lacerated wound of an artery the external coat is drawn out so as completely to lose its normal elasticity, in the same manner as a piece of rubber tubing will lose its elasticity when it is overstretched. Such an injury to an artery of large or small size may occur without any bleeding. The vessel is, however, permanently injured.

A *gunshot* wound of an artery derives its special importance from the fact that secondary hemorrhage is likely to occur. The vessel may be only contused by a bullet, and no bleeding occur until some days after the injury, when serious hemorrhage supervenes as a result of sloughing. A gunshot wound of an artery is often associated with injury to the accompanying vein, and an aneurysmal varix is formed. In case an extremity is blown off by shot or shell, the hemorrhage is often slight, on account of the fact that the vessels are lacerated, the middle and internal coats contract, curl up, and a plug is formed at the open end of the vessel. If, however, a rifle bullet enters the body when it is travelling at great speed, it may cut an artery like a knife, causing immediate and alarming hemorrhage. In addition to the primary or secondary hemorrhage which may be produced by a gunshot wound of an artery, the contusion of the vessel may lead to the formation of a thrombus, which may cause occlusion of the artery and be followed by gangrene. Pyemia is also a serious complication in gunshot wounds; and often a secondary hemorrhage ushers in a fatal septicemia.

An *incised* wound of an artery is an injury inflicted by some sharp cutting instrument. The hemorrhage is always profuse in such a wound, because there is no mechanical obstacle to the outflow of blood through the opening, such as is often found at the open mouth of a torn artery, and also because the contraction of the two ends of the vessel causes the wound in the artery to gape. The direction of the incised wound may be transverse, oblique, or longitudinal. The hemorrhage is very profuse in a transverse cut of an artery, while it is not so abundant in an oblique incision. If the artery is upon the stretch and is wounded longitudinally, the bleeding is very slight, but may become very

alarming when the artery is relaxed. In case of a partially divided artery the proper rule to follow is to divide the vessel completely and tie both ends.

Rupture of one or all of the coats of an artery is an injury that occurs under certain circumstances. The rupture may be partial, for example, when the internal and middle coats are torn and the external coat is stretched. This accident is not followed by hemorrhage, but it is a condition favorable to the production of secondary hemorrhage by sloughing, or to the development of an aneurysm. The same condition may also cause thrombosis or embolism of the vessel, and gangrene of the extremity or part may result. The rupture may be complete, in which case the artery is in the condition of a lacerated vessel. If it is subcutaneous, a traumatic aneurysm develops. If the rupture is partial and a clot has formed sufficient to occlude the vessel, then the pulsation below is lost and gangrene may supervene.

The **treatment** of wounds of arteries must necessarily vary according to the character of the injury. If the opening is of any size, the vessel should be completely divided and both ends tied. In case a traumatic aneurysm has developed as a result of a punctured wound of an artery, the rules prescribed for the management of this condition must be followed—*i. e.* it is a wounded artery, and should be treated as such.

If the *wound is a contused one*, the treatment consists in securing as much physical rest for the artery as possible by tranquillizing the circulation. This is effected by absolute rest and the administration of cardiac depressants. The possibility of the occurrence of secondary hemorrhage must not be forgotten, and measures to arrest it must be instituted immediately if it appears. The area or extremity which may be deprived of blood as a result of a contusion of an artery must be kept artificially warm in order to encourage the determination of blood to the part and to stimulate the collateral circulation.

If the *wound is a lacerated one*, the primary hemorrhage is usually slight on account of the curling up of the internal coat and the contraction of the middle coat, and the coagulation of the blood at the torn end of the vessel; but on account of the danger of secondary hemorrhage both ends of the vessel should be diligently sought, by a careful dissection if necessary, and securely tied.

If the *wound is a gunshot one*, the primary hemorrhage must be treated according to the same principles that would guide the surgeon in the management of an ordinary wounded artery. If the vessel is one of large size, digital pressure directly upon the artery and in the wound is indicated for the instantaneous arrest of the bleeding; in no case should styptics be employed. An Esmarch elastic bandage should now be applied, and the surgeon should cut down immediately upon the bleeding vessel, completely divide it at the seat of injury, and tie both ends of the artery with aseptic catgut. If the hemorrhage comes from an artery situated in the neck, or in any other place where the application of an elastic bandage is impracticable, the surgeon must be guided by the rules for the management of traumatic aneurysm. The dressing of such a wound should be conducted with the most rigid adherence to the principles of aseptic surgery in order to prevent secondary hemorrhage, a danger which is peculiarly frequent after gunshot wounds. The occurrence of gangrene is also a complication of an exceedingly fatal character in gunshot wounds, since septicemia rapidly develops. If the main artery of the limb is injured, and also its accompanying vein and nerve, even without a fracture of the bone, as a rule amputation is necessary to avert gangrene, which would almost surely follow.

If secondary hemorrhage occurs, it will be during the second or third week—that is, at the time when the sloughs separate. The bleeding should be arrested, if possible, at the site of the hemorrhage; but when this is impossible, a ligature

should be applied according to the Hunterian principle—*i. e.* in healthy tissue upon the proximal side of the wound. If the hemorrhage is alarming and it comes from several points, and the suppuration is extensive, with sepsis, amputation of the limb is indicated. The best way to prevent secondary hemorrhage is to keep the wound aseptic and to provide sufficient drainage. Good nutritious diet is required in order to maintain a high standard of vitality, which conduces to repair of the wound and averts the dangers of exhaustion, suppuration, and septicemia.

If the wound is an *incised* one and involves the neck or axilla, digital pressure must be promptly employed, and at once preparations should be made to search for the wounded vessel. This should be completely severed at the point of injury and a proximal and distal ligature of aseptic catgut or silk should be applied. If the incised artery is in an extremity an Esmarch bandage can be applied in the same manner as already described in the management of primary hemorrhage in gunshot wounds. The application of the bandage permits the surgeon to make a bloodless dissection and secure with certainty and ease the wounded vessel.

In case of a *ruptured* artery the treatment is practically the same as would govern the surgeon in the management of a contused or lacerated vessel.

WOUNDS OF SPECIAL ARTERIES.

The **carotid artery** may be wounded as a result of gunshot injury, a stab, or other wound, or during the performance of an operation upon the neck. The wound of so large a vessel is necessarily a most serious event. If the vessel is entirely cut across, the patient usually (but not always) expires in a few minutes; but if the carotid is partially wounded, the hemorrhage may be arrested by compression until the vessel is secured and ligatured. This artery is seldom divided in an attempt at suicide, especially when the head is thrown back, because of its anatomical situation deep in the neck; but the superior thyroids lying in front and more superficially are often wounded; the incision rarely extends deeper than these vessels. In all cases of wounds of these larger vessels of the neck the treatment is based upon the general principles which govern the surgeon in his management of hemorrhage. A primary hemorrhage should be treated by dividing the vessel at the point of injury, if not already divided, and instantly tying both ends of the vessel. A secondary hemorrhage must be controlled by methods already mentioned. In wounds of the carotid and its branches the possibility of the occurrence of œdema glottidis must not be overlooked, and a prophylactic tracheotomy should be performed if this occur.

The **vertebral artery** may be injured in any of the ways mentioned in reference to wounds of other vessels. Compression has effected an arrest of the hemorrhage; but, as a rule, a search for the wounded vessel may be made, and if possible the artery be divided and tied at both ends. There is danger of escape of blood into the spinal canal and compression of the cord when a wound of the vertebral artery occurs.

The **subclavian artery** has been wounded in the various ways that have been described, and possibly by a puncture from a fragment in fracture of the clavicle or of the first rib. A wound of this vessel is most serious on account of its size and its situation. A large traumatic aneurysm is developed, and must be treated after the manner described in the management of such an aneurysm.

The **axillary artery** is subject to the same injuries as other vessels, and

is additionally exposed to the danger of rupture in reducing old dislocations of the shoulder-joint. Fortunately, in the wounds of the axillary artery due to complete laceration of the vessel the artery retracts and contracts and the hemorrhage may be spontaneously arrested. In injuries of this artery, as a rule, the vessel should be exposed, completely divided, and both ends secured by a ligature. In rupture from attempts at reducing an old dislocation this procedure has been uniformly fatal, and should be replaced by compression, ligature of the subclavian, or amputation at the shoulder-joint.

The **femoral artery** is often exposed to injury, and on account of its superficial situation the hemorrhage is easily controlled. The same rules govern the surgeon in the management of wounds of this vessel as in those of other arteries. After ligation of the artery the limb should be elevated and artificial warmth should be applied to prevent gangrene.

The **popliteal artery** is seldom wounded, owing to its deep situation and to the protection which is afforded to it by the joint in front. In case of an injury to the vessel an Esmarch bandage should be applied, the vessel found, and both ends of the divided artery ligated.

In case of a wound of any of the other arteries in the body—in the forearm, arm, leg, or foot, or upon the trunk—the principle of searching for the bleeding vessel and ligating it at both ends must always be kept in mind. The hemorrhage from an intercostal or from the internal mammary is serious, because generally some of the thoracic viscera are also implicated. It has been suggested to introduce a finger-shaped tampon made of a piece of antiseptic gauze, which is pushed between the ribs with a probe, and then to fill the tampon with strips of iodoform gauze and draw the entire mass outward, so as to make firm pressure against the inner wall of the thorax and the two corresponding ribs. It is, however, best to secure the two ends of the divided vessel by ligatures in the manner already described. A rib may be resected if necessary.

WOUNDS OF VEINS.

A wound of a vein is in some respects less dangerous than a wound of an artery of the corresponding size; but serious complications may readily follow a wound of a vein, unless kept aseptic. The hemorrhage from *a small vein* is less than that from an artery of the same size, because the vein collapses and the force of the circulation is not so great as in the corresponding artery. A considerable quantity of blood is extravasated in the surrounding tissues, so that external pressure will also contribute to the arrest of the hemorrhage. The loss of blood from *a large vein*, however, is so rapid and excessive as to endanger life in a few minutes.

The **symptoms** of venous hemorrhage upon which the **diagnosis** is based, are—1st, the escape of dark-colored blood in a continuous stream; 2d, the special effects of pressure: if applied upon the distal side of the wound, it causes the hemorrhage to cease; but it causes it to increase if the pressure is applied upon the cardiac side of the wound.

The *complications* that follow an injury to a vein depend chiefly upon the size of the vessel and upon the septic or aseptic conditions attending the injury. Among the complications are phlebitis, œdema, thrombosis, embolism, ulceration, metastatic abscesses in organs directly connected with the wounded vein, gangrene, and secondary hemorrhage.

The *treatment* of a wounded vein depends upon the size and situation of the vessel. If the vessel is small and situated superficially, elevation of the limb, a compress applied upon the distal side, and rest will be all that is neces-

sary. If the vein is large and deeply situated, the injured vessel should be found and both ends of the divided vein secured by an aseptic ligature. Of course thorough asepsis of the wound must be secured. If the wounded vein is within one of the three great cavities of the body, an operation of great magnitude may be indicated in order to reach the bleeding vessel. If a vein is wounded laterally, the slit can be picked up with a pair of forceps and a ligature applied to it, so that the lumen of the vessel will not be obliterated. In the case of a large vein where the tissues are abundant this method of treating a wounded vein has many advantages. Hemostatic forceps may be applied and left *in sitû* for forty-eight hours. They should of course be entirely covered by the dressing.

Wounds of Special Veins.—A wound of the **internal jugular vein** is generally quickly fatal from the loss of blood or occasionally from the entrance of air into the vein. The direction of the wound influences the prognosis, because a longitudinal slit will not gape, while a transverse one is held wide open by the action of the deep cervical fascia. If the internal jugular is wounded near its entrance into the skull, besides the dangers arising from the loss of blood and also the entrance of air, there is the additional danger of cerebral septic infection and venous and sinus thrombosis.

Injuries of the **subclavian** and **axillary** veins are also very serious, for the same reasons that have been mentioned in reference to the jugular vein.

A wound of the **femoral vein,** besides the loss of blood, has an additional danger—gangrene of the leg—which may follow the ligation required to arrest the hemorrhage. Ligation of the popliteal vein may also be attended with the same complication. After either of these ligations the limb should be elevated to help the venous return, and be enveloped in cotton and hot-water bottles to keep up the temperature of the leg. If gangrene intervenes, amputation must be done.

For Wounds of the Cerebral Sinuses see Injuries of the Head.

CHAPTER II.

SURGERY OF THE OSSEOUS SYSTEM.

As the ossous tissue differs in no material respect from the soft parts except in the added lime-salts that give it firmness, its injuries and diseases are in the main of like character and course, wounds, inflammations, and tumors terminating in more or less complete return to the normal state or in constructive or destructive changes. The soft structures in the cancellous and medullary spaces, in the Haversian canals, and upon the exterior of the bone, though for convenience' sake and with a seeming anatomical and pathological basis they may be separately considered, are but parts of a common whole, a lesion of which may be general or limited according to its nature and intensity.

The most numerous and important affections are the inflammations consequent upon injury; upon the existence of special diathetic states, as the tubercular or syphilitic; upon a general infective disease, as typhoid fever; or upon the presence and action of pyogenic organisms. They may be *acute* or *chronic*, and end in resolution, in organization of an exudate, or in destruction, limited or extensive, molecular or in mass, of the part involved. According to the presence or absence of the pyogenic microbes suppuration will or will not occur.

Liquefaction to a greater or less extent is an ordinary effect of the syphilitic invasion, still more of the tubercular. The intensity of the symptoms is always greater in the suppurative than in the non-suppurative affections. The pyogenic organisms (generally the staphylococcus aureus or, but much less frequently, the streptococcus pyogenes) gain admission to the diseased area either through an open wound or by the blood-stream, having been taken up at some distant and often small pus-dépôt, or by the lungs, or the intestinal canal, to which they have been brought from without the body.

These inflammations may be considered under the general heads of *osteo-periostitis* and *osteo-myelitis*, since pure periostitis is of very infrequent occurrence, perhaps is only met with as a syphilitic manifestation, and pure myelitis is equally infrequent.

OSTEO-PERIOSTITIS.

This condition usually exists in cases commonly thought to be examples of periostitis, in which not only the periosteum, but the superficial layers of the bone also are diseased. It may be acute or chronic, plastic or suppurative, limited or diffused. It is the result of cold, of wounds or contusions, of strains from undue traction on inserted tendons, of contiguous inflammations, as from old ulcers, or of special infections, syphilitic, tubercular, or pyogenic. The more superficial the bone, the more likely is osteo-periostitis to occur, because of the greater exposure to injuries and the action of cold. The periosteum both in its outer and inner layers is thickened and reddened and its cells increased in number. More or less of the surface of the underlying bone is similarly affected, and its blood-supply may be so diminished in consequence of the separation and occlusion of the vessels by the swollen periosteum as superficially to destroy its vitality. When neither suppurative nor tubercular, the disease terminates either in resolution or in permanent thickening with new formation of bone, or, but much more rarely (and chiefly on the head in cases of syphilis), in thinning and absorption.

When suppurative and limited, after evacuation of the pus repair takes place with either little or no thickening, with decided hypertrophy, or with some loss of substance. When diffused, unless very promptly arrested, extensive destruction of membrane and bone commonly follows. These purulent varieties are rarely, if ever, primary, though the antecedent deeper inflammation may be but slight.

The **symptoms** vary somewhat according to location and cause, being least marked in the traumatic non-suppurative cases, but pain and swelling are always present, the former, as a rule, severe and worse at night. If it is a deeply-situated bone that is affected, it is often impossible to recognize the swelling, but if a subcutaneous one, for example the tibia, as is so frequently the case, the spindle-shaped thickening can be readily felt; there is much tenderness on pressure and the overlying soft parts are œdematous and reddened. In the suppurative varieties constitutional symptoms are present, and are of a high grade in the diffused phlegmonous form. In the chronic syphilitic inflammations the pain is, as a rule, not acute.

The **treatment** in the beginning is by rest and the application of either cold or heat as is more comfortable to the patient.

If speedy resolution does not take place and the pain is great, subcutaneous punctures of the swelling should be made, or, if pus is present, the parts should be freely laid open. When the disease is due to syphilis, the knife should not be used, but reliance should be placed upon the administration of the ordinary antisyphilitic remedies.

OSTEO-MYELITIS.

Osteo-myelitis (which includes both osteitis and medullitis—*i. e.* myelitis of bone) is the more common form of bone inflammation, the cause of which may be either local, general, or septic.

As in inflammation of the soft tissues, the parts are congested, the blood-vessels dilated, effusion and exudation take place, and there is increased cell-growth. If the disease is slight and due to traumatism, and if resolution quickly follows, no organic change is produced in the bone-layers; but ordinarily there occurs more or less destruction, either in mass (**necrosis**) or molecular (**caries**), limited or extensive according to the degree of the inflammation and its exciting cause. In necrosis the dead part is called a *sequestrum* (p. 264). When perforation of the overlying tissues has taken place, upon probing necrosed bone is to be recognized by its hardness and its sharp, clear percussion note when struck, carious bone giving out a dull sound, if any, and being generally readily penetrated by the instrument.

These two forms of bone-death are to the osseous system what gangrene and ulceration are to the soft parts—necrosis, like gangrene, being due to a cause which directly or indirectly cuts off the blood-supply to or interrupts the outflow from an area large enough to be recognizable by the unaided eye; while in caries, as in ulceration, the cells of an abnormally succulent part melt down and are discharged.

As met with in practice, necrosis is commonly due to a non-traumatic infective inflammation. At times it is consequent upon injuries (*e. g.* fractures permitting of the entrance of pyogenic organisms or severe contusions), or, less often, exposure to severe cold or high heat. In the bones of the head and face it not rarely is of syphilitic origin.

Caries—the ulceration of bone—is almost always due to tubercular infection.

Osteo-myelitis is either acute or, more frequently, chronic. If the inflammation is acute and severe, the resistance of the rigid walls of the central cavity and of the Haversian canals generally causes such compression of the vessels (which often become strangulated by the newly-formed cell-masses) that the vitality of the part cannot be preserved; necrosis then necessarily results (Fig. 53). Such death in mass in greater or less measure is always to be looked for in the acute infective or suppurative inflammations.

When the process is a slower one, there may still be an arrest of circulation with resulting necrosis, but generally the death of the bone-layers is a molecular one, due in part to the disintegrating action of the excess of fluid, but chiefly to the pressure made by the enlarged vessels and the newly-formed cells and to the destructive action of the latter. These are especially abundant in the Haversian canals over the flexures of the vessels, and as a consequence the walls of such canals break down unevenly and are pitted, the depressions being commonly spoken of as the *Howship lacunæ*. As the result of the softening and disappearance of the bone the cancellous spaces enlarge, the central cavity widens, and the Haversian canals increase in diameter, granulation-tissue becoming more and more abundant and progressively occupying the places from which the bone has been removed. In other words, a condition of *osteo-porosis* has been developed, and the affection is a *rarefying osteitis*, which may be, on the one hand, of very limited extent, or, on the other, involve a large part of the bone, even from center to cortex. Outside the area of rarefaction there will often be found a space of greater or less width in which formative changes have occurred, the bone being thicker and denser than normal, *osteo-*

sclerosis instead of osteo-porosis being present. Such secondary changes may affect parts of limited extent previously in a state of rarefaction, which when the inflammation has entirely disappeared will remain unduly hard, with their Haversian canals abnormally narrow.

During the rarefying action small pieces of bone may be destroyed and separated (necrotic caries). The great majority of the cases of caries, nine-tenths if not more, are of tubercular origin, the deposit taking place readily, as the result of slight traumatisms, in the cancellous tissue, the vessels of which are numerous and thin-walled and the capillaries very large in proportion to the size of their associated arteries and veins. It is during the years of growth in the parts of the bone in which such growth chiefly occurs, as about the epiphyseal lines and in those portions of the skeleton particularly subject to blows, shocks, and the action of cold, that this form of disease is ordinarily observed.

FIG. 53.

Necrosis of the Diaphysis, following Acute Osteo-myelitis of the Humerus (Duplay and Reclus).

Here as everywhere else the bacilli cause softening of the parts immediately about them. If few in number and limited in action, they may be rapidly destroyed or shut in, so that either by cicatrization or encapsulation recovery takes place. This often occurs; in the great majority of cases, however, the disease is not so arrested, but infected granulation-tissue continues to be developed in the cancellous spaces, in the Haversian canals, and in the central medulla, more and more bone is softened down or pieces of appreciable size are deprived of their blood-supply, and consequently die. Thus the tubercular area grows larger with accompanying liquefaction and caseation, and the rarefaction extends farther and farther.

When it is the presence and action of the pyogenic microbes that excite the inflammation the osteo-myelitis may be either acute or chronic, limited or widespread, with accompanying destruction of bone and corresponding intensity of local and general symptoms. Though there are a number of the pyogenic organisms that may cause these septic diseases of bone, the staphylococcus aureus is the one most commonly met with, and next to it the streptococcus pyogenes.

Associated with certain of the acute infectious diseases, especially typhoid fever, there occurs an inflammation, generally superficial, which causes a necrosis commonly of limited extent and with a strong tendency to become symmetrical—*e. g.* to simultaneous or consecutive development in like parts on both sides of the body. Whether because the disease-germ is itself pyogenic or because of a double infection, these typhoid inflammations are as a rule suppurative. Osteo-sclerosis is a very frequent effect of syphilitic infection, but both necrosis and caries often occur, and in different portions of the same skeleton the three forms of osteitis, condensing, rarefying, and hypertrophic, may be observed.

In phosphorus-workers severe and extensive necrosis of the jaws is at times,

though now very rarely, produced by the action of the poison that has gained access to the bone through decayed teeth.

Acute osteitis is either *simple* or *septic*.

Simple acute osteitis is consequent upon traumatism, and occurs in parts protected against the action of the pyogenic micro-organisms either by an unbroken soft covering or by antiseptic treatment. It is of comparatively little importance, and usually terminates by resolution in a short time. Its symptoms are few. Pain is the most prominent symptom, and is often not severe; it is apt to be deep-seated, boring or gnawing, worse at night, aggravated by the dependent position, and increased by pressure. If it is superficially located—when, indeed, it is an osteo-periostitis rather than a simple osteitis—it may be associated with some œdema of the soft parts and discoloration of the skin. Rest, elevation of the limb, fomentations, and moderate compression are the local remedial measures to be adopted, pain being controlled by opiates. If the suffering is very severe and does not quickly subside, the overlying soft parts should be incised, and if this does not relieve, the bone should be aseptically drilled at one or more points, thus lessening the tension.

Of the **septic inflammations** of bone there are *two varieties:* (1) the one associated with an open wound, originating ordinarily in the shaft of a long bone and generally met with in adults; (2) the other, without such associated wound, beginning in the parts near the epiphyseal line. The latter is peculiarly a disease of childhood. It may, however, occur later in life, and is then in the great majority of instances a recurrence of a similar inflammation of early life, some of the causative germs of which had been encapsulated. Boys are attacked three times as often as girls, and nearly half of the patients are adolescents between the ages of thirteen and seventeen.

The *first variety*, since the introduction of antiseptic surgery, is comparatively rare. Typical examples in former years were often seen in cases of compound fracture, especially gunshot fractures, and after amputations, infection of the wound having taken place at the time of injury, during the operation, or later. The severity of the inflammation varies, from that in which there are but little suppuration and limited destruction of bone to that in which the parts quickly become putrid; the whole bone is destroyed, and the patient dies early of septicemia or pyemia, even within twenty-four or forty-eight hours, in the most malignant of the latter cases.

When associated with a *compound fracture*, in addition to the ordinary conditions, such as congestion, extravasations, and cell-development, following an injury of this character, pus is present, with the general symptoms commonly attendant upon suppuration. Since the great danger lies in the development of septic infection, the local treatment should consist in securing free drainage and in rendering the diseased area aseptic.

When the disease arises after *amputation*, the medulla appears discolored by extravasated blood, and in the severer cases bleeds upon slight pressure and protrudes beyond the level of the sawn surface, at times to a large extent, covering the end of the bone with a fungous mass. The discharge is abundant and sero-purulent, often having a very offensive odor. As the result of the inflammation, when the constitutional infection is not such as to cause early death, the bone about the medullary cavity necroses, and after a time is separated in the form of a tubular sequestrum (Fig. 56), much worm-eaten on its exterior, of greater or lesser length, thick at the base, irregularly thinning out higher up, and ending in sharp points. The constitutional symptoms, increase of temperature, acceleration of pulse, mental hebetude, etc., are of varying intensity.

The local **treatment** should consist in the free removal of the infected medulla and in curetting the walls of the cavity, followed by its thorough disinfection and drainage and by antiseptic dressing of the stump, thus limiting, as far as possible, the extension of the septic inflammation. When the dead bone has been loosened from the living, chiefly by a process of rarefying osteitis in the latter, it should be promptly removed, since, its extrusion unaided by surgery would be effected slowly, and while in progress there would be liability to extension of the suppurative inflammation, with further destruction of bone.

The *second variety*, **acute epiphysitis**, arises when the pyogenic organisms have not found entrance through an open wound, but have been brought to the affected area in the blood-stream. The effect then produced is very variable. In a comparatively small proportion of cases intense and rapidly-destructive inflammation of the bone follows. It is this variety of osteomyelitis that is most frequently met with at the present time, wounds involving bone, however produced, being protected in the great majority of cases against the action of the pyogenic cocci by aseptic and antiseptic treatment, provided they come under the care of the surgeon before infection has taken place.

FIG. 54.

Arrest of Development of the Ulna following Osteitis near Epiphysis; continued Growth and Deformity of the Radius (Poncet).

As has been stated, it is a disease of childhood and adolescence, and has its starting-point in the tissues near an epiphyseal line, due to the frequency of juxta-epiphyseal strains, the femur and the tibia being the bones most commonly affected. Fig. 54 shows arrest of development of the ulna followed by deformity of both ulna and radius consequent upon such an inflammation near the epiphyseal line of the ulna.

The **symptoms** are, in the beginning, high fever (with often an initial chill), delirium, and great pain, gnawing or boring in character and located ordinarily near the end of a long bone, with a peculiar helplessness of or inability to move the limb by its own muscles. The attack comes on suddenly, generally at night, after exposure to cold and dampness, combined sometimes with unusual exertion. Sitting on a stone doorstep and unduly prolonged swimming are common causes, even in summer. If the inflammation is at first deeply seated in the cancellous tissue, no change in the overlying soft parts, either in thickness or in color, will be observed for a number of days, even in the graver cases, though there is from the first sensitiveness to pressure over the affected area, and frequently the superficial veins are abnormally distinct. Before long, however, the external layers of the bone and periosteum become involved, and swelling of the soft parts and redness of the skin occur, with quickly-following fluctuation, indicating the presence of pus. When the disease originates near the surface, these latter symptoms will be noticed early, the rapidly-forming and widely-spreading pus lifting the periosteum off the shaft for a variable distance, in the graver cases from end to end and around the

whole circumference of the bone. The temperature continues high, with daily fluctuations of two, three, or more degrees, and the pain is excessive until tension is relieved by the spontaneous opening of the abscess or by operation. As soon as there is such an opening, probing will almost certainly reveal the presence of dead bone. The neighboring joint generally soon becomes inflamed, with resulting effusion into its capsule, the fluid often becoming purulent after a time, either from direct communication with the suppurating area in the bone or from transmission of the pyogenic cocci through the blood-vessels or the lymphatics.

In young children the acute epiphysitis that at times occurs is very apt to cause separation of the epiphysis, followed by suddenly produced displacement, resulting in shortening and deformity (Fig. 54). This variety of bone-inflammation is usually located at the hip, knee, or shoulder.

At times, though not often, the pyogenic organisms are carried from one end of the bone to the other without involvement of the intervening shaft, two entirely distinct areas of inflammation being produced in the same bone.

The intensity of all the symptoms will vary according to the character and number of the infecting organisms. In the most severe cases, fortunately very rare, only pain and the temperature and typhoid state of an acute septicemia are observed, death occurring quickly. Generally, swelling and abscess-formation are added. These abscesses are extensive and developed early in the graver cases, but are limited and appear more slowly in the milder ones, the latter being those more commonly met with. In certain cases the attack may be so mild that pus is not formed, but a synovia-like fluid, chiefly subperiosteal, the nature of which is not discovered until after its evacuation; or perhaps pus is formed and undergoes a later mucoid degeneration. This *periostitis albuminosa* has been observed only a very few times.

The **diagnosis** in the earlier hours or days may be uncertain, the affection being often regarded as a typhoid fever or an acute rheumatism, or, in the periosteal variety, because of the redness of the skin, as an erysipelas. But if due regard be had to the age of the patient, the location of the pain close to but not in the joint (commonly the knee, the ankle, or the hip), its peculiar gnawing, boring character so indicative of bone-inflammation, and the suddenness of appearance and severity from the start of the constitutional symptoms, with the absence of the progressive daily rise of temperature that belongs to typhoid fever in its first week, there will seldom be any doubt as to the nature of the disease.

The **prognosis** as respects both part and life is grave. Death from septicemia in a few intensely infective cases takes place so soon (within one, two, or three days) that its osteo-myelitic origin is not recognized. When it originates superficially, the disease is less dangerous than when of central origin, as the pus more readily and rapidly reaches the surface and is more quickly evacuated.

Though the prognosis is much affected by the intensity of the inflammation, it is more influenced by **treatment.** This to be effective must be operative, and the sooner the diseased area is cut down upon and the bone drilled or trephined, the greater the likelihood of arresting the inflammation and lessening the local destruction. The application of heat, pressure, tincture of iodine, etc. will not stop the disease; tension must be relieved, pus evacuated, the bone trephined and the bone cavity scraped, and the parts irrigated with a sublimate solution in order to kill the staphylococci.

When the medulla is extensively involved, much benefit will follow trephining at two different levels or at many points, scraping out the intervening

infected tissue, even to the removal of the whole medulla of a long bone, such as the tibia, and thoroughly irrigating with antiseptic solutions. In the superficial variety (even in the so-called acute phlegmonous periostitis), when the periosteum has been extensively separated, it may regain attachment to the bone to a large extent after early free incision and irrigation and the vitality of the shaft in the main be preserved.

If, as is generally the case, from neglect of treatment or in spite of it, necrosis has resulted, the dead bone should be removed as soon as it has become detached; but often in the more severe cases, in order that the profuse discharge and progressive exhaustion may be stopped, an early operation will be required at the end of four, five, or six weeks, even at the risk of taking away too much or too little of the shaft and having little or no regeneration of bone follow.

Fig. 56.

Fig. 55.

Superficial Sequestrum (original).

Tubular Sequestrum (original).

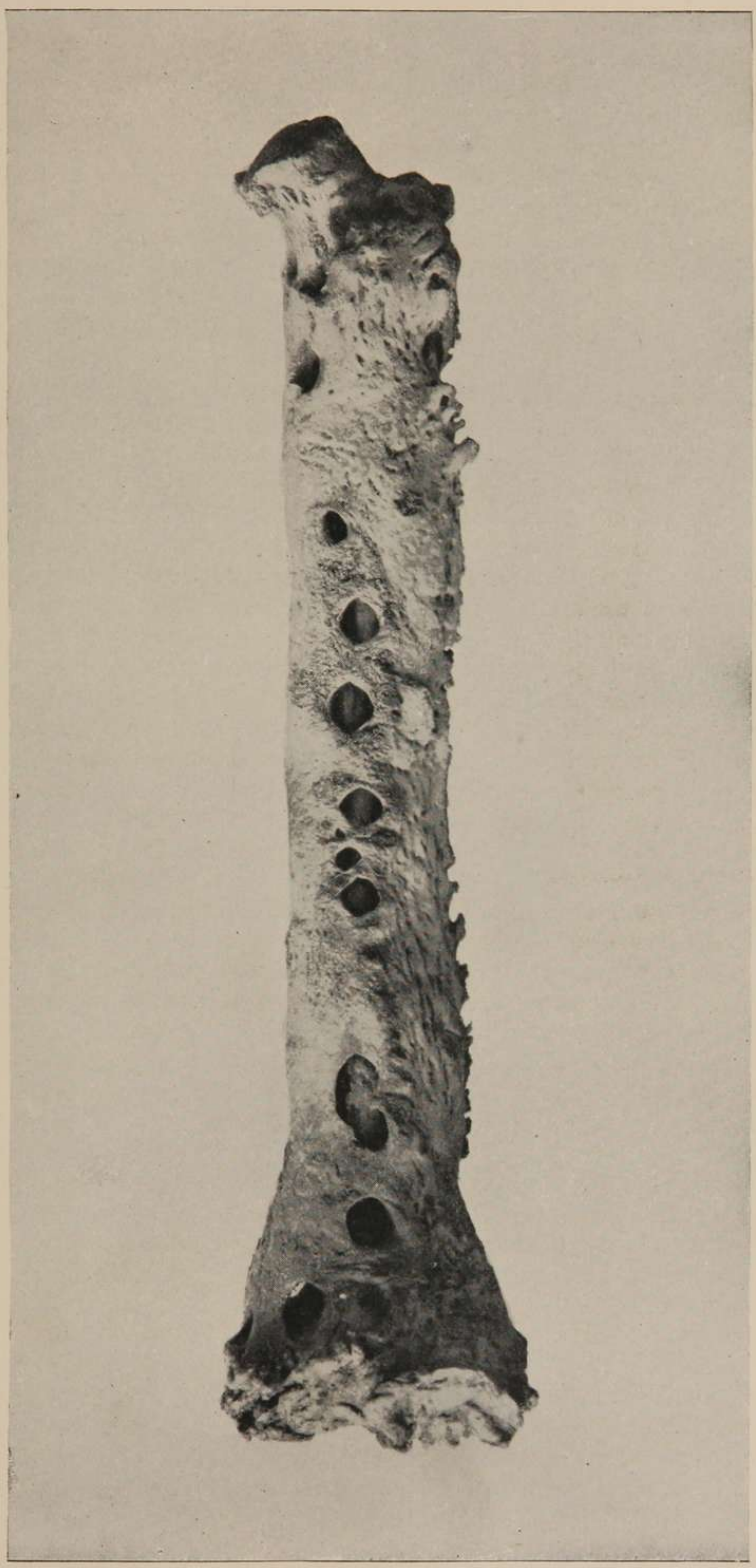
Sequestra—The dead piece of bone, whether large or small, is called a **sequestrum**; when upon the exterior it is *superficial* (Fig. 55); in the interior it is *central;* when of limited thickness, but involving the entire circumference, as after amputation, it is *tubular* (Fig. 56) or *ring-shaped* according as it extends for a considerable distance up the bone or is confined to the sawn end; when it embraces the whole shaft, with or without the epiphysis, it is *complete*. For a long time the fragments in a compound fracture have been spoken of as sequestra—primary when completely separated at the time of the injury, secondary when for a time held by periosteal or muscular attachments, and tertiary when later destroyed by inflammation; but the term should be restricted to the latter, since the others are not at first dead nor in a large proportion of cases will they die if suppuration be prevented.

When not exposed to the air, sequestra are almost always of a dull-white color; when so exposed, they are generally black. When struck by a probe, the note is clear and high-pitched, altogether different from that given out by healthy or by carious bone. The orifice of a sinus communicating with the sequestrum is more or less open, the granulations are pouting, and the bony rim is firm to the touch.

When the periosteum with its deeper layer is not destroyed, and especially when the external layers of the bone are living, if sufficient time is afforded for the production of new bone an osseous envelope is formed, called the **involucrum.** This more or less completely shuts in the sequestrum, whose outer surface is either smooth if the new formation is of periosteal origin, or rough and worm-eaten if the separation has been produced by a rarefying osteitis.

Where there has been ulceration through the periosteum and bone-layers outside the sequestrum, no such re-formation occurs at these points, and the involucrum is pierced by openings of a size corresponding to the parts destroyed; these openings are called **cloacæ.** Plate X shows on the exterior the involucrum pierced by numerous cloacæ and on the interior the sequestrum of the entire shaft of the femur, the result of an acute osteo-myelitis.

When the necrosed piece is central, the living bone about it often becomes so sclerosed that it can be cut through only with difficulty. Occasionally,



Sequestrum of entire shaft of femur, involucrum riddled with cloacæ; the result of acute osteo-myelitis.

though rarely, this condensed bone is not perforated by even a single sinus and the sequestrum is completely enclosed. (Pl. XI, Fig. 1.)

The separation of the dead bone from the living is a comparatively slow process, occupying two, three, or more months, but it should nearly always be waited for when removal by operation is to be effected, so that only the dead bone may be taken away and time be afforded for the formation of a firm involucrum: the only exception to this rule is found in those more severe cases of acute osteo-myelitis in which an early removal is demanded in order that fatal exhaustion from profuse suppuration may be prevented. That such separation has taken place may generally be recognized by the mobility of the sequestrum when pressed upon through one or more of the cloacæ, though occasionally movement is prevented by the firm hold of the granulations upon the dead piece. Detachment from the living bone must then be inferred from the length of time that has elapsed. Though a non-infected sequestrum may in very rare instances be absorbed or remain shut in and innocuous for a long time, dead bone, as commonly met with, is an irritating foreign body, which must be got rid of either by spontaneous extrusion, by chemical solvents, or by operative removal before a healthy condition of the affected region can be secured. Small sequestra, especially superficial ones, may make their way to the surface and be thrown off, but the process is a very slow one.

Treatment by the application of a dissolving fluid, such as dilute nitric or hydrochloric acid, is uncertain, tedious, and to be advised only in those rare cases in which the sequestrum is so placed that it cannot readily and safely be got at by operation. In the great majority of cases the removal of the sequestrum will be by operation—sequestrotomy.

Sequestrotomy.—When practicable, the parts should be rendered bloodless by the Esmarch bandage, or, better, when the disease involves an extremity, by elevation for four or five minutes, followed by the application of the rubber band. If there is a cloaca large enough to permit of the introduction of a forceps, the dead bone is seized through it, and if of small size is dragged away. When necessary the opening should be enlarged and the sequestrum divided before removal. When the necrosed piece is a large one it will generally be necessary to cut away with chisel or gouge a portion of the involucrum, it may be for nearly the entire length of the bone. The dead bone having been lifted out, the granulations in which it has rested are to be thoroughly scraped away, the parts well irrigated, the cavity stuffed with iodoform or other antiseptic gauze, an antiseptic dressing applied, and the limb immobilized. When the involucrum is quite thin or imperfectly developed, it may be broken in the removal of the sequestrum, but repair, as a rule, readily and rapidly takes place after immobilization. Usually the progress of the case is very satisfactory: the cavity more or less completely fills up by the formation of new bone, and after a few weeks the patient can begin to use the part if, as is generally the case, the operation has been done on one of the extremities. Only rarely, and when there has been great general weakness or when the wound becomes infected, is the result a fatal one. If the gap in the bone is long and deep, much of the involucrum having been cut away, an effort should be made to fill it up, either by an organizable blood-clot, by bone-chips, by breaking down and bending in the edges of the involucrum, or by skin-flaps turned in and attached at the bottom; preferably the first or second. The decalcified bone-chips, originally employed by Senn, generally serve the purpose of a framework or scaffolding on which new bone is built up, the chips themselves undergoing absorption. In Lücke's "Osteoplastic Necrotomy," in the shafts of the long bones a longitudinal incision is made through

the skin and periosteum, as nearly as possible in the line of the cloacæ, and a section of involucrum chiseled out corresponding with this incision. At either end where the sequestrum-cavity terminates the soft parts are divided transversely and the bone correspondingly chiseled through. With a small chisel the base of the skin-periosteum-bone-flap, thus obtained, is divided from within the sequestrum-cavity so that the entire flap may be turned back out of the way. Such a flap may be made on one or both sides of the cavity. After cleaning out the bone the flaps are bent inward so as to fill the cavity as far as possible. In order that success may follow the adoption of any of these methods the wound must be made aseptic and kept so.

THE CHRONIC INFLAMMATIONS OF BONE.

The **chronic inflammations** of bone are generally such from the beginning. They are of much more frequent occurrence than the acute, and, like them, are of pyogenic, syphilitic, malignant, or tubercular origin. They are very rarely traumatic and unassociated with pyogenic infection, though, as is seen in the vertebræ pressed upon by an aneurysm, ulceration from prolonged, frequently-repeated injuries may take place.

The prevailing type is the rarefying. Molecular death occurs to some degree in all cases; death in mass results chiefly in those due to syphilitic or pyogenic infection; often extensive new formation, both in length and thickness, takes place in the syphilitic, and, to a certain extent, in the pyogenic.

The diseases induced by the different causes are located by preference in different parts of the skeleton: thus, syphilis infects chiefly the long bones and those of the head and face; sarcoma and carcinoma, the long bones, the pelvis, and the jaws; pus infection, the long bones; tuberculosis, the bones of the hands and feet and the spongy tissue in close relation with the hip-, knee-, and elbow-joints.

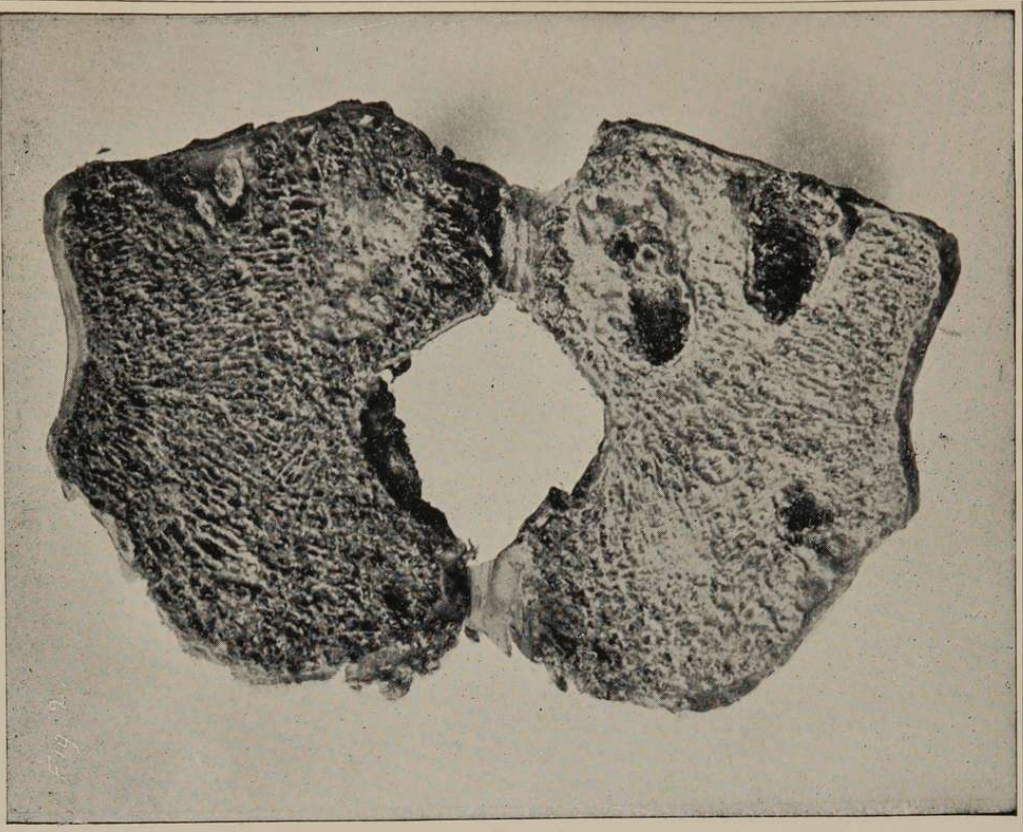
Children and adolescents are the ordinary subjects of osteo-myelitis, tuberculosis, and inherited syphilis; young adults, of sarcoma, acquired syphilis, and the relapses of the inflammations of youth; persons of middle and advanced life, of syphilis and cancer.

Symptoms.—Pain is the most common symptom, its intensity, however, being very variable even in cases having a like origin. As a rule, it is worse at night, the increased fulness of the veins and capillaries due to the more sluggish circulation making greater the tension-pressure upon the nerve-fibers. It is aching, gnawing, boring, or, in tubercular cases in which there is inflammation of the subarticular layer of osseous tissue, starting.

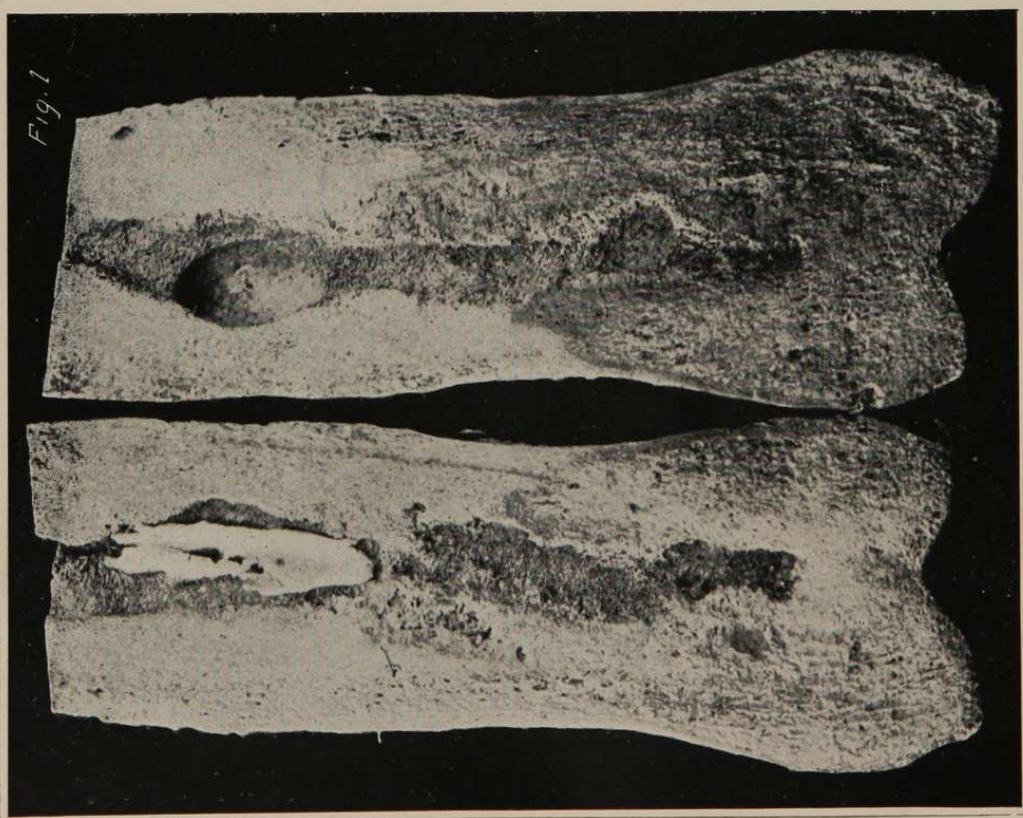
With or without the development of an abscess a sinus may form, through which more or less discharge may take place, the discharge being often gritty or having in it small yet readily detected spicules of bone, showing, as does the bone itself, that the affection is truly a caries or decay of the osseous tissue.

When the inflammation is located upon the surface, examination by the eye, the finger, or the probe, or of the cleaned and dried specimen, shows that the process is an ulcerative one, producing an ulcer with all the characteristics of an ulcer of the soft parts; and the same is true, certainly as respects the process, when it is centrally developed. The granulations may be numerous and moist, as is commonly the case, or large and abundant with little fluid (fungous caries), or very feebly developed with no discoverable fluid (dry caries), as in a few cases of syphilitic or tubercular origin.

This **caries sicca** is frequently observed upon the skull and in the upper ends of the humerus (Fig. 57) and femur. The bone-destruction is



Tubercular foci of the lower end of the femur.



Central sequestrum and osteo-sclerosis.

often extensive, and in the long bones is due in a measure to the wearing effect of the pressure of contiguous parts. Not seldom its existence is indicated only by impairment of function and by severe pain, very persistent, and irremediable except by removal of the diseased part.

Fig. 57.

Caries Sicca, resulting in Absorption and Deformity of the Head of the Humerus (Duplay and Reclus).

This form of osteitis, if left to itself, (1) may terminate in arrest of formation of the granulations, absorption or elimination of the dead tissue, and sclerosis of the new layers and of the parts around, with or without overgrowth of the affected bone, which when it occurs causes permanent alteration even to the extent, it may be, of marked deformity; or (2) may continue for a long time without material local change or the development of visceral lesions; or (3) may often slowly but steadily advance, destroying more and more widely the bone, involving other portions of the skeleton, causing marked general debility, and inducing grave disease of internal organs, especially the lungs, the kidney, and the intestine.

The **treatment**, in general, is made up of measures calculated to relieve irritation and to hasten the elimination of dead tissue—measures therapeutic and operative, considered in detail under the separate heads of the various classes of bone-inflammations, septic, specific, malignant, and tubercular.

Tubercular Inflammation of Bone.—The most frequent and most typical of these inflammations is the *tubercular*, and is often secondary to some distant primary focus of the disease. Infected granulation-tissue forms more or less rapidly, showing, as a rule, comparatively few bacilli, and these chiefly in the new growths farthest from the point or points of original deposition; such tissue, by its pressure and after-caseation with its associated fluid, produces wasting of the osseous trabeculæ.

Caseation and liquefaction so affect the cells of the growth that, together with the altered layers of bone, they may be scraped away as grayish-yellow masses saturated with fluid. At times little or no fluid is to be seen, though the bone has become so soft as to be easily cut with a knife. Cavities, larger or smaller, few or many, filled with fluid degenerated cells and bone detritus, are of frequent formation (Pl. XI, Fig. 2). In the long bones infiltration of the medulla of the central canal may occur throughout its length or be limited to a few distinct areas. Usually, however, the new growth is in the cancellous spaces of the extremities and in the Haversian canals, pushing toward the exterior of the bone. After the bone itself is involved, there is subperiosteal new formation, which, if caseation has not occurred, may remain for a considerable time as a semi-solid mass, the adjacent bone and periosteum undergoing thickening and hardening. Sooner or later, and quite rapidly as a rule when caseation has taken place, the periosteum is infected and destroyed, the adjacent soft parts become tubercular, and by one or several tortuous channels following the lines of least resistance the disease reaches the skin, the piercing of which completes the formation of the sinus or sinuses. The walls of such sinus, from its mode of formation, are necessarily tubercular, and its outlet is filled with granulations more or less exuberant, more or less dark-colored, readily bleeding when torn, and at times quite sensitive. A probe being introduced, often with much difficulty because of the flexures of the canal, softened, easily-penetrated bone may be felt, but its presence may escape detection because of the heavy granula-

tion-layer covering it. The difference in the appearance of the external granulations, in the resistance to the probe offered by the bony walls, and in the percussion note elicited by the probe (which is here flat), enables one readily to distinguish caries from necrosis.

When a circumscribed area of bone has broken down and liquefaction of the caseated granulation-tissue in it has taken place, such a collection of fluid has long been spoken of as an abscess; and the same is true of the similar collections between the periosteum and bone and in the overlying soft parts. But, though accumulations of a fluid in appearance much like pus, they are not, properly speaking, abscesses, since true pus is not present (unless it be a fact that at times the bacillus is a pyogenic organism) except when a double or mixed infection has taken place. This is not often the case until a communication with the external air has been established by the spontaneous or operative opening of the sinus. When such an opening has been made, the previously pent-up liquid, with its associated characteristic cheesy, curdy material, escapes, and the continuous development of similar fluid, now probably become purulent, keeps up the discharge. This varies in amount from a few drops to many ounces a day, and lasts indefinitely, with occasional temporary stoppages from blocking up of the canal at one point or another. Its complete arrest can be secured only by destruction of the infected area. This prolonged suppuration, by the exhaustion and amyloid visceral changes which it induces, often has much to do with the production of a fatal termination.

In consequence of plugging of the vessels necrosis may take place, the produced sequestrum being often of considerable size. If centrally located in the cancellous tissue, it is surrounded by the infected granulations, and remains until removed by art or until, after a long time, it has broken down, when it may be discharged piecemeal. Often in the extremity of a long bone, because of the arrangement of the vessels which have been plugged by a tubercular embolus or by a thrombus resulting from the mural implantation of tubercle bacilli, it is conical in shape, its base directed toward the articulation; and to its presence may be due rapid involvement of the articulation in the morbid action.

In its earlier stages the progress of tubercular osteitis is ordinarily insidious, often the only symptoms of its existence being impaired function of the part, rigidity of the muscles about the neighboring joint, and pain in the affected area. Muscular rigidity, which is a reflex condition and protective in its action (or intended to be such), is of great diagnostic value. It is often the only symptom present, and when observed is deserving of careful consideration, for if no other cause for its existence is apparent, it may be safely assumed that there is something abnormal in the neighboring joint. The pain may be spontaneous or exist only as tenderness on pressure over the diseased spot, but it can always be developed by such pressure. By the thermometer slight increase in the heat of the region may at times, or possibly always, be detected; but a long-recognized peculiarity of this form of inflammation is the absence of any decided elevation of temperature.

The appearance of the overlying skin is generally unchanged, even after infection of the superficial soft parts; though, because of interference with the circulation by pressure, there may be some general discoloration or certain of the veins may become unduly prominent.

Even up to the time of the establishment of a communication with the exterior the symptoms are far from severe, pain, swelling, and impairment of function being present, but no decided constitutional symptoms, and the patient may go about as if in health. But when septic infection has taken place all the local symptoms are aggravated and the constitutional ones become decided.

The only disease with which the affection is then likely to be confounded is protracted osteo-myelitis of pyogenic origin; and this, though more common than is often supposed, is far less frequently met with than tubercular osteitis, and seldom if ever attacks the parts of the skeleton which are so often the seat of the latter disease—the vertebræ, the tarsus and carpus, the upper end of the femur, and the bones of the elbow. It is largely to the prevention of secondary pyogenic disturbances that the present favorable course and prognosis, as compared with those of but a few years ago, are to be attributed. Under any treatment, and especially under inefficient or no treatment, the course of the affection is ordinarily slow, occupying many weeks, it may be months. At any stage it may be arrested spontaneously (1) by removal of the diseased tissue, which is followed by condensation of the surrounding bone with or without cicatricial obliteration of the cavity; or (2) by encapsulation of the infected tissue, which permanently or temporarily protects the part. Very often it is temporary, since recurrence frequently takes place.

The **treatment** is mechanical, therapeutic, or operative—more frequently the first and second, but often all three methods, are employed either simultaneously or successively.

Mechanical treatment may be held to include all measures adapted to ensure rest of the diseased part, whether by position, immobilization, or the application of fixation apparatus of one sort or another. Rest is of prime importance at any stage of the affection, and is especially valuable in the earliest, when it may be sufficient to bring about arrest of morbid action and more or less complete restoration to health. Simple confinement to bed may be all that is needed, or an immobilizing dressing—*e. g.* the plaster-of-Paris or a properly constructed and applied splint—may be required. Under such treatment, even when there has been much destruction of bone and "cold abscess" has formed, the symptoms may subside. This will be because of absorption and contraction, it may be calcification, of the tubercular masses, condensation taking place in and around the carious area, and functional action being resumed; though, as a rule, there will be more or less impairment, more or less deformity, and an ever-existing danger of a recurrence of the disease.

The therapeutic treatment is general and local. The former consists in the administration of remedies serving to improve nutrition and increase the general strength; and of these cod-liver oil has long been regarded as the most valuable. The local treatment consists in the injection into and around the diseased center of agents calculated to destroy the infecting germs and produce condensation of the surrounding bone and of the uninfected new-formation layers, thus bringing about cicatrization. The remedies of this class that have proved of decided value are the acid phosphate of lime, the chloride of zinc, and iodoform; the latter of which in ethereal solution, or, better, suspended in glycerin (10 per cent.) or in oil (5 to 25 per cent.), has been found of great value as a substitute for the operative removal of the morbid tissue, or employed after it. These solutions are carried down by means of a syringe to and into the diseased area, and injected in small quantity, the injections being repeated every three, seven, or ten days according to circumstances.

Operative treatment consists in the removal of the diseased area by scraping or excision. Amputation is rarely demanded, at least in properly treated cases. Scraping, to be effective, must be thorough, and special care must be taken to clean away the walls of sinuses, to remove infected deposits in the medullary canal of a long bone, and in the foot and hand to leave no part of a softened bone (unless it be perhaps the shell of the os calcis, and this, as a rule, should be taken away). No associated tubercular growth in the tendon

sheaths, the synovial pouches, or the superficial fascia or skin should in any case be allowed to remain.

Ignipuncture by means of the thermo-cautery has been practised by a few surgeons with good effect.

Cases of visceral tuberculosis are generally much benefited, and not seldom cured, by change of climate and altitude, and strumous children often rapidly improve at the seaside. Much good would unquestionably be effected, in the earliest stages especially, by sending patients with chronic bone disease to the coast, the highlands, or the pine woods.

Chronic pyogenic osteitis is almost always the sequel of an acute osteo-myelitis that occurred, it may be, many years before, and is the cause of two very different conditions—abscess and overgrowth. It is usually circumscribed, and may be located in the medullary canal, or, much more often, in the cancellous extremity of a long bone, especially in the head of the tibia or the lower end of the femur. It probably is due ordinarily to the newly-aroused activity of long-latent pyogenic organisms left over from an osteo-myelitis of childhood; but at times it may be consequent upon a new infection attacking parts less resistant than others because of their having previously been the seat of a septic inflammation.

Rarefaction of the bone takes place in a limited area; condensation goes on around it, though rarely to the extent of producing necrosis, except, it may be, of very limited amount; pus may be almost altogether absent or may be present in considerable quantity and form a *chronic abscess in the interior of the bone* (Pl. XII, Fig. 1). This is especially frequent in the cancellated tissue in the lower end of the femur or in either end of the tibia. The most characteristic symptom is pain, severe, often intense, gnawing or boring, decidedly worse at night, limited to a small space, pressure over which is usually painful, sometimes because of associated periostitis, at times disappearing for weeks or months to reappear again, often without any apparent cause. The bone is frequently decidedly enlarged as the result of its early inflammation or of the hypertrophying effect of the long-continued secondary osteitis.

No treatment is of value except drilling or trephining, by which exit is afforded the pent-up pus, thus taking off the tension. Careful exploration with a long pin or fine drill, carried in various directions through different openings or from the sides of the trephine-well, should be made before deciding that pus is not present. Even if no pus can be found, relief is afforded and the so-called neuralgic condition is removed. Not seldom the pierced bone is abnormally dense. When pus is found it is wise not to be content with simple evacuation of the matter, but to scrape away the softened bone, letting the resulting cavity fill up or contract as it may, or, better, endeavoring to secure its rapid and complete closure by means of a blood-clot or bone-chips, for the success of which attempt complete asepsis is required.

The overgrowth from irritation resulting from this form of osteitis may affect a part or the whole of a bone. At times it is very great, producing marked deformity. Although a chronic process, it is very generally the result of the early osteo-myelitis, and the process never having been altogether arrested, it can hardly be considered a part of the phenomena of chronic pyogenic osteitis unless there is joined with it the limited suppuration already considered. Overgrowth in length consequent upon the irritative action of a tubercular osteitis is at times observed, and has occurred after excision, particularly of the lower articulating extremity of the femur, the region of the epiphyseal line not having been removed.

Much more often after both tubercular and septic inflammations, whether

1. Abscess in the great trochanter. 2. Impacted fracture of neck of femur.

an operation has been done or not, there is arrest of development, and as a result shortening, which in children is apt to be progressive up to the time of full maturity.

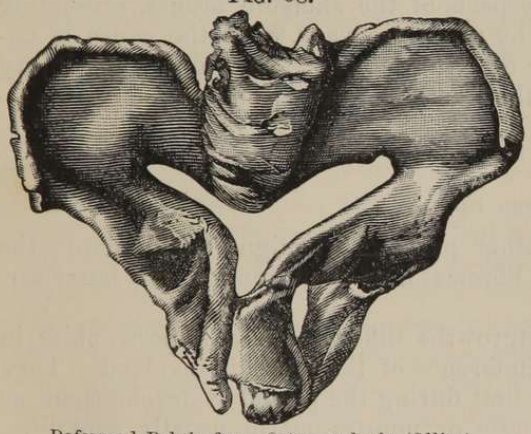
Atrophy, evidenced by lessened solidity, thickness, or length, or by all of these conditions, is the necessary result of long-continued defective nutrition due to feebleness of the general circulation or to disturbed innervation of the part. It is a common phenomenon of chronic osteitis. It may be temporary, as after fracture, or permanent, as in infantile paralysis and in old age. It causes more or less impairment of the functional value of the bone and strongly predisposes to fracture. No special treatment is of value, unless it be the production of hyperemia, as by frequent applications for a limited time of the Esmarch bandage or by drilling the bone.

RHACHITIS. (See Chapter xv., p. 81.)

OSTEO-MALACIA (MOLLITIES OSSIUM, MALACOSTEON).

This is a disease of adult life, and is very rarely met with in children or old persons. In the great majority of cases it affects women, chiefly those who are pregnant or who have borne children. It is characterized by progressive softening of the various parts of the skeleton, with resulting deformities (Fig. 58), usually goes on from bad to worse, and after it may be a number of years causes death, chiefly from exhaustion or disease of the lungs. It has been attributed to the action of many causes, such as defective nutrition, excess of lactic acid, disease of the trophic nerves, ovarian and uterine changes, etc., but the real exciting cause is uncertain.

Fig. 58.



Deformed Pelvis from Osteo-malacia (Ollier).

The bone lesions are great increase of vascularity with resulting hemorrhages, degeneration of the medulla and its ultimate conversion into a pulp resembling splenic tissue, absorption of the lime salts, destruction of the trabeculæ, formation of cavities or more rarely tumor-like enlargements, and absorption of the cortical layers. The periosteum is ordinarily thicker and more vascular than normal, and serves as a protective envelope to the broken-down bone. Fracture from muscular action or from slight movement is of frequent occurrence, and deformity to a greater or lesser extent is sure to be produced in other than the mildest cases, the distortion at times becoming excessive and most peculiar.

Until such deformity has occurred, or until at least the softening has advanced so far as to permit of bending of the bone, the **diagnosis** is difficult and uncertain, since the progress of the disease is for a considerable time an insidious one. The early-developed and persistent pain ordinarily causes the affection to be regarded as rheumatic; but the multiplicity of the painful areas, the sex of the patient, the existence of pregnancy, and the presence of large quantities of the lime salts in the urine, should direct attention to the probable existence of osteo-malacia.

Though commonly for a time not exerting any unfavorable influence upon life, and occasionally ceasing to advance, even being recovered from, though very rarely, its **prognosis** is grave, the disease usually ending fatally. Medical treatment by the use of phosphorus and the phosphates, the lime salts, cod-liver oil, etc. has proved of little or no value. The best possible hygienic surroundings should be secured and the patient kept quiet and free from pain. Proper retentive dressing should be applied to prevent fracture and lessen deformity. Of late in a few cases the ovaries and uterus have been removed with reported decided benefit. When this operation is not done, pregnancy should be prevented, as childbearing exerts a powerful and deleterious influence upon the progress of the disease.

FRAGILITAS OSSIUM.

Abnormal brittleness due to rarefaction and predisposing to the occurrence of fracture upon the infliction of slight violence is sometimes observed in cases of syphilis, of malignant tumors, and of trophic disturbances after injuries of bones and joints necessitating long confinement. It is also seen in the earlier stages of rickets, in general paralysis, and in tabes. But, besides this condition, which is a sequel of disease, there is at times seen a pure and simple fragility, accompanied, so far as can be discovered, by no pathological changes, general or local. This fragilitas ossium is, as a rule, an inherited peculiarity manifesting itself in infants (even in the fetus in utero), in children, and in adolescents, and ceasing to exist when full maturity is reached. Fracture after fracture in one or in several bones or in many parts of the skeleton occurs, presenting the usual symptoms and followed by rapid recovery. As the cause is unknown, nothing can be done further than to protect the individual from injury as much as possible, and to treat the fractures in the usual way.

SYPHILIS OF BONE. (See Syphilis.)

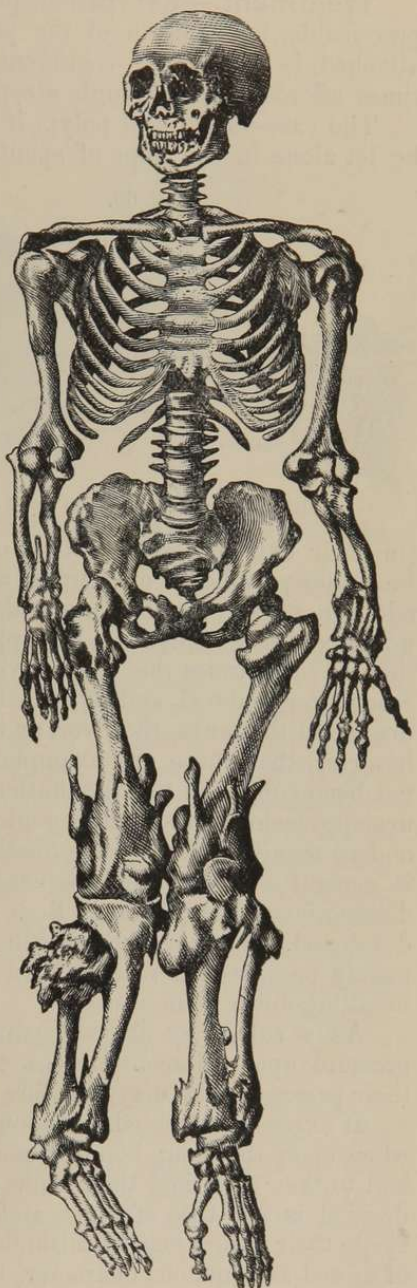
TUMORS OF BONE.

Bone tumors, like tumors of other parts, are benign or malignant; the former being commonly exostoses, fibromata, or chondromata, the latter sarcomata or carcinomata.

Exostoses are homologous outgrowths differing from hypertrophies in that but a limited part of the circumference of the bones is involved. They are either spontaneous, and appear first during the period of development, or are symptomatic of osteitis, traumatic or non-traumatic, usually syphilitic. They are located chiefly upon the long bones, the skull, or the maxillæ, and are generally cancellous in structure, but at times compact, even of ivory hardness; this is particularly true of the syphilitic exostoses of the skull. When developmental, originating in childhood, though the outgrowths may be found upon any part of the skeleton, even upon many and generally symmetrical parts at the same time (Fig. 59), they are commonly in connection with a long bone near its epiphyseal line. If primarily upon the diaphyseal side of the cartilage of conjunction, they may apparently be carried upward as the shaft elongates, so as ultimately to occupy a level much above the articular extremity. They may be either broad-based or pedunculated, and not seldom the free extremity is covered by a bursa resulting from friction or the separation of a part of the synovial sac in the outgrowth of an originally subsynovial spur. Their growth ceases, as a rule having few exceptions, at or before the twenty-fifth year.

The **diagnosis** is commonly easy, the tumor being hard and fixed and readily felt or seen. Pain is seldom present, and whatever local damage results is from pressure causing atrophy or ulceration of the overlying soft parts (and this is not of common occurrence) or from position interfering with the free use, especially with flexion, of the limb, as in sitting or riding. In a large proportion of cases no serious inconvenience is experienced. When the mass is upon the inner side of the skull (of diploic origin, as a rule), a resulting compression of the brain may give rise to serious cerebral disturbances, but often no appreciable effect is produced, and the existence of the tumor is not discovered until after death.

FIG. 59.



Exostoses of Various Dimensions (Pierret).

The only effective **treatment** is operative, removal of the growth, or the breaking of it off, the former being preferable, the latter practicable only when the attachment is by a pedicle. In many cases no treatment is required.

FIBROMATA.—Springing from the periosteum or, much less frequently, central in origin, the fibrous tumors of bone are found generally in connection with the maxillæ and the base of the skull, though they are occasionally located upon the vertebræ, the pelvis, or the long bones. When of long standing they are likely to undergo degeneration, fatty, cystic, or, particularly, calcareous, rarely becoming ossified. Not seldom they are either primarily or secondarily mixed in character—fibro-sarcomata, fibro-chondromata. Their development is slow, and they often cease to enlarge about the time when the skeleton has reached full maturity, after which they may atrophy, or even completely disappear.

If superficially placed, they can generally be readily **diagnosticated** by their more or less irregular contour, their firmness but not bony hardness, their evident close connection with bone, and their gradual enlargement. The most common of these growths are the *naso-pharyngeal polyp* and *epulis*, both of which are often decidedly sarcomatous. The former is a disease of adolescence. It originates from the under surface of the sphenoid, fills up the naso-pharynx, pushes into the nasal fossæ and the antrum on one or both sides, and, it may be, outwardly through the spheno-palatine foramen, causing extensive destruction of the bones of the face by pressure. It is dangerous because of the attending hemorrhages, which, as a rule, are profuse and fre-

quently recurring. The character of the central tumors, which are often cystic, will not be recognized so long as they are surrounded by a bony envelope, and usually is not determined until after their removal.

Treatment.—Extirpation, preferably by enucleation or, when this is not practicable, by excision of the portion of the bone to which the growth is attached, is the proper treatment, though, as has been stated, nature sometimes affords relief through atrophy.

The naso-pharyngeal polyp, if not rapidly growing or often bleeding, may be let alone in the hope of spontaneous disappearance when the patient shall have reached the age of twenty-five years or a little more; but in the majority of cases the risk of death from exhaustion consequent upon repeated hemorrhage will forbid such delay. (See Diseases of the Nose.)

FIG. 60.

Multiple Chondromata of the Hand (Leo).

CHONDROMATA.—As might be expected, the cartilaginous are the most common of the benign osseous tumors, their chief places of election being the long bones (in their extremities) and those of the hands and feet (Fig. 60). They may be either peripheral or central, and are not seldom mixed in character, the addition of sarcomatous elements being particularly frequent. Even when microscopical examination has apparently shown them to be pure chondromata they have at times the characteristics of malignant growths, in so far as they recur after removal and by transference of their cell-elements develop visceral disease in the lungs, the liver, or the spleen, especially the first. It is possible, however, that these are examples of mixed tumors, all portions of which had not been subjected to examination. The more nearly their histological structure approaches that of embryonic cartilage, the greater is the liability to secondary manifestations. Traumatism is often an exciting cause. Their growth is generally slow; they frequently become cystic, and always tend toward destructive changes both in their own tissues and in the part in which they are developed. The overlying skin may be unaffected for a long time, but ultimately becomes ulcerated, and a sinus is established communicating with the breaking-down tumor-mass.

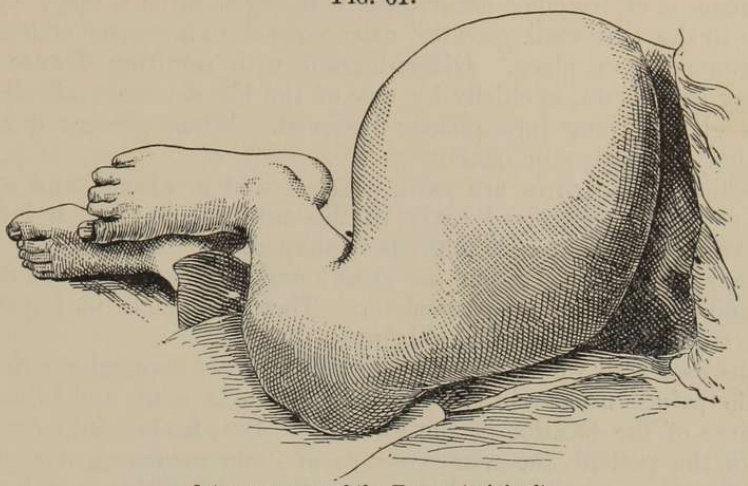
As a rule, they are not painful except when there is involvement of or pressure upon adjacent nerves, either of which is comparatively rare; but by their presence they may interfere with free muscular or articular movements.

If externally located, as upon the hands or feet, their **diagnosis** is easy: when upon the long bones it can be made as a strong probability if regard is had to their position, their slow growth, their elastic firmness, which though decided is not that of bone, and their irregular contour. When softened or cystic their nature may be misunderstood until after incision or puncture. When of mixed sarcomatous character, because of rapid growth and associated constitutional weakness they may be readily mistaken for osteo-sarcomata—a mistake, however, of no practical importance, since the treatment of the two affections is the same. The central growths cannot be recognized until they have reached considerable size, and even then their character will not generally be determined before removal.

The only **treatment** of value is operative, the growth being removed either by itself when it is external and pedunculated, or with a part or the whole of

the bone in which it rests; in other words, by taking it out and scraping away

Fig. 61.



Osteo-sarcoma of the Femur (original).

the tissue immediately about it, by excision of the diseased portion of the bone, or by amputation.

Malignant Tumors.—The malignant bone-tumors are either carcinomatous or sarcomatous. The former are comparatively rare and always secondary; the latter are of frequent occurrence and primary, except when following upon like disease of the adjacent soft parts or upon melanotic sarcoma. Unlike osteo-carcinoma, osteo-sarcoma is a disease of early life, even of infancy and childhood, only a very small proportion of the cases observed occurring in individuals over forty years of age. Histologically, it is of three varieties—round-celled, spindle-celled, and giant-celled; locally, there are two varieties—central and periosteal. Its malignancy structurally is in inverse proportion to the size of the cells, being greatest in those tumors made up of small round and spindle cells, least in those composed chiefly of giant cells. As respects location, when originally external it progresses more rapidly, has earlier and more frequently secondary visceral manifestations, and is more certainly fatal than when internal. It especially affects the maxillæ and the long bones; of the latter, those of the lower extremities much oftener than those of the upper. The adjacent ends of the femur and tibia are the most common sites (Fig. 61). Local injury is a strongly predisposing cause.

Osteo-sarcoma affects a neighboring joint comparatively seldom, even at times passing outside the articulation from one bone to another. Often the bone in which it is situated is so weakened by it that spontaneous fracture occurs, and this is occasionally the first indication of its existence. Its rate of growth is variable, though with rare exceptions it is rapid as compared with that of the benign tumors. The size which it may attain is usually not great, but is occasionally enormous. The central growths, which, speaking generally, are giant-celled at the extremities of the long bones, and round- or spindle-celled in their shafts, have for a time an osseous envelope, so thin in some cases as to yield and crepitate on pressure, and later a complete or partial osteo-periosteal capsule. This is not the case with the external growths, the limiting wall of which is periosteum until that membrane has become involved and the disease has pushed through it into the adjacent soft parts. The vascularity of the internal tumors may be so great as to render them pulsatile, apparently

aneurysmal. Without doubt nearly all the reported cases of *aneurysm of bone* have been sarcomata of this character. Hemorrhage into the substance of the tumor is of frequent occurrence, and degenerations, fatty, cystic, and, especially in the periosteal growths, calcareous or to a greater or lesser extent bony, commonly take place. Dissemination, with resulting disease of remote parts, bony or visceral, is chiefly by way of the blood-vessels, affections of the lymphatic glands being infrequently observed. When present it is in large measure only irritative in character.

The chief **symptoms** are pain, which is seldom absent, and at times is intense; swelling, recognized early in the external, but much later in the internal, variety, in shape globular, pear-shaped, or conical near the end of a long bone, spindle-shaped upon the shaft; and increased heat, as determined by the hand or the surface thermometer. There is little or no impairment of the joint motions for a considerable time.

The diseases with which it is most likely to be confounded are rheumatism, because the pain is usually in the neighborhood of a joint, and tubercular disease, because of the location of the swelling. But, taking into consideration the age of the patient, the non-existence of other evidences of any diathetic affection, the absence of joint disease, the firmness of the growth, especially in its earlier stage, the rapidity of its enlargement, and the local temperature-changes, a strongly probable, if not absolute, diagnosis can usually be readily established. Puncture or exploratory incision may be made if necessary. It may also be mistaken for an abscess.

The **treatment** to be effective must be radical, the affected bone being removed, or in an extremity amputation being done at or above the nearest joint rather than in the continuity of the bone, except in cases of central giant-celled growths in the lower end of the bones of the leg or of the femur. When necessity seems to demand disarticulation at the hip, it is very questionable if any operative interference should be resorted to, in view of the risks of the amputation and the almost absolute certainty of an early recurrence of the disease in the stump or viscerally. After amputation other than at the hip the probability of reappearance is strong: even in the least malignant variety, the central giant-celled, it occurs in about one patient out of five.

ACTINOMYCOSIS. (See p. 133.)

ACROMEGALY.

Enlargement of many of the bones of the skeleton, especially of the face and head, the thorax, the pelvis, and the foot and hand, is a very constant symptom of the peculiar and rare nervous affection first described by Marie in 1886, and by him named *acromegaly*. Such enlargement is a true hypertrophy, new growth taking place under the periosteum and at the cancellous extremities. The bones of the hands and feet and the lower jaw are early and markedly affected.

The more common surgical diseases with which it is likely to be confounded are osteitis deformans and arthritis deformans. From the former it may be differentiated by the earlier age at which it appears, by the almost constant affection of the feet and hands, by the absence of curvature of the long bones, by its being generally symmetrical, and by the ordinarily much greater disease of the face than of the head; from the latter, by the great overgrowth of the hands and feet, and by the absence of the pain, the deformity, and the later ankylosis that are symptomatic of the joint affection.

The disease is of long duration and incurable, and no treatment has any special influence upon the progressive hypertrophy.

CHAPTER III.

FRACTURES.

DEFINITION.—The sudden, forcible destruction of the continuity of a bone, in whole or in part, except when done with a cutting instrument, is called a fracture. A *simple* fracture, in the common use of the term, is one that is not compound (see below); a *spontaneous* fracture is one produced by very slight violence; a *pathological* fracture is one made easy by partial destruction of the bone by disease; an *ununited* fracture is one in which bony union has not yet taken place after the lapse of a period of time that is usually sufficient for repair.

The injury is a common one; it occurs about three times as frequently in males as in females, but the proportion varies at different ages: in infants and between the ages of fifty and seventy years both sexes are about equally affected; in middle life fractures are ten times as frequent in men as in women; and after the age of seventy women are much more frequently affected than men, the commonest fracture then being that of the neck of the femur. The majority of fractures occur in the first and third decades of life, but if the number of people living at the different ages be considered, the greatest relative frequency will be found at about the age of sixty years.

The following table shows the relative **frequency** of fractures of the different bones. The italics mark bones with more than 10 per cent.:

Fractures Treated in the London Hospital, 1842–77.

	Hospital.	Out-patients.	Total.	Per cent.	Number by Regions.	Per cent.
Skull	730	27	757	1.457	Head, 2,002.	3.854
Face	732	513	1245	2.397		
Spine	169	3	172	0.331	Trunk, 9,067.	17.457
Pelvis	139	3	142	0.273		
Coccyx	5	10	15	0.028		
Ribs	4784	3477	8261	15.905		
Sternum	45	7	52	0.100		
Scapula	135	290	425	0.818		
Clavicle	382	7458	7840	15.094	Upper extremity, 27,119.	52.214
Arm	1064	3020	4084	7.863		
Forearm	709	8731	9440	18.175		
Hand	856	4899	5755	11.080		
Thigh	3072	171	3243	6.243	Lower extremity, 13,750.	26.473
Patella	649	15	664	1.278		
Leg	8067	256	8323	16.024		
Foot	965	555	1520	2.926		
	22,503	29,435	51,938			

VARIETIES.—The varieties of fracture are numerous, the differences depending upon the extent, direction, and seat of the fracture, the number of bones involved, the associated injury of the soft parts, and the character or mode of action of the causative violence. They may be grouped as follows:

1. **Incomplete fractures.**
   - (*a*) Fissure.
   - (*b*) True incomplete fracture, "green-stick" fracture.
   - (*c*) Depressions.
   - (*d*) Separation of a splinter or of an apophysis.

2. **Complete fractures**, subdivided, according to—
   (*a*) *Direction* of the line of fracture, into transverse, oblique, longitudinal, toothed, V-shaped, T-shaped;
   (*b*) *Seat* of the fracture, into fracture of the shaft, neck, condyle, etc., separation of the epiphysis;
   (*c*) *Relations to neighboring joints*, into intra-articular, extra-capsular, intra-capsular;
   (*d*) *Mode of production*, into fractures by direct violence, by indirect violence, by muscular action;
   (*e*) *Number* of fractures or of bones fractured, or the extent and character of the crushing, into multiple, comminuted, impacted, and fractures with crushing.
3. **Compound fractures**, including, as a special class, Gunshot fractures.

1. **Incomplete Fractures.**—This class includes fractures of long bones in which the continuity of the bone has not been entirely lost, and fractures of the flat bones in which the line of fracture does not extend completely across the bone or through its entire thickness.

Fissure, or *fissured fracture*, is a split or crack of limited extent; the most frequent examples are in the bones of the cranium and in connection with complete fractures of other bones.

True incomplete, or "green-stick," fracture is one involving part of the thickness of a long bone, and accompanied by some longitudinal splitting and by a permanent bending of the unbroken portion. Possibly in some cases there is only permanent bending without visible fracture. It occurs in the young, and especially in the clavicle and forearm (Fig. 62). In correcting the deformity, which is best done by bending the bone in the opposite direction, the fracture is frequently made complete.

Fig. 62.

Partial or Green-stick Fracture of the Radius (Stimson).

Depression is the crushing of a portion of the thickness of a bone; it perhaps belongs more properly among "wounds of bone" than among fractures. The class also includes certain rare "fractures by depression," in which by the forcible bending of a flat bone a fragment is broken from the side toward which the bone is bent, as in isolated fracture of the inner table of the skull: it does not include "depressed fractures of the skull," in which the entire thickness of the bone is broken.

Separation of a Splinter or of an Apophysis.—Direct violence, as by a bullet or a sword, may break off a piece without completely fracturing the bone, or the violent contraction of a muscle or a strain exerted through a ligament may tear off a scale of bone or an apophysis to which the tendon or ligament is attached.

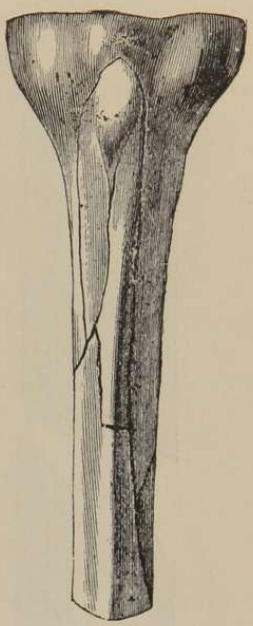
2. **Complete Fractures.**—(*a*) *Subdivided according to the Direction of the Line of Fracture.*—The fracture is termed *transverse* (Fig. 63) if its line is exactly or nearly transverse to the long axis of the bone and regular; *longitudinal* (Fig. 64) if it runs for a considerable distance more or less exactly parallel to the long axis; *oblique* (Fig. 65) if its direction is intermediate between the two preceding. The division is of course somewhat arbitrary. The fracture is termed *toothed* or *dentate* (Fig. 66) if its line is broken by sharp points and depressions, which may constitute a serious obstacle to complete reduction. *V-shaped* fracture of the tibia (Fig. 67) is

characterized by a prominent triangular projection at the lower end of the upper fragment on its inner aspect; its especial importance, other than the occasional difficulty of reduction, is due to a fissure which may extend from the corresponding re-entrant angle on the lower fragment down to the ankle-joint. T-*shaped* fractures are found at the lower end of the humerus and femur, and are sometimes termed *intercondyloid* (Fig. 68): there is a transverse line of fracture above the condyles, and a longitudinal one running from the transverse line downward between the condyles.

FIG. 63

Transverse Fracture of the Femur (Gurlt).

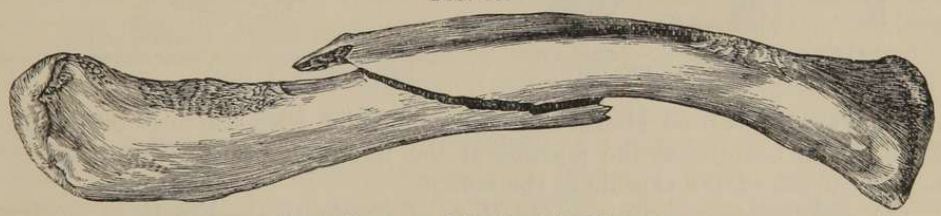
FIG. 64.



Longitudinal Fracture of the Tibia (Stimson).

(*b*) *Subdivided according to the Seat of the Fracture.*—The fracture receives a name indicative of the portion of the bone involved in it: thus, fracture of the shaft, of the neck, of a condyle, or of a specific process, as the malleolus, greater tuberosity of the humerus, olecranon. The term *separation of an epiphysis* also indicates that the fracture lies wholly or mainly at the cartilaginous junction between the epiphysis and the shaft; this variety is found, of course, only in persons whose growth is not yet complete; that is, as a rule, only in those who have not yet reached the age of twenty-four or

FIG. 65.



Oblique Fracture of the Clavicle (Stimson).

twenty-five years; the date of consolidation of the epiphysis with the shaft varying with the sex, the individual, and the different bones. Separation of the epiphysis is more easily effected than a fracture of the same bone by cross-strain: the periosteum is usually stripped up from the shaft for a considerable distance, varying with the displacement, and remains attached to the epiphysis. The injury is of especial importance because of frequent difficulty of reduction, and because the irritation of the traumatism may lead to premature ossification of the cartilage, with consequent local arrest of growth. This consideration is of most importance at the knee, the upper end of the humerus, and the lower end of the radius and of the ulna, where the principal growth in length of the respective bones occurs.

(*c*) *Subdivided according to the Relations to Neighboring Joints.*—The term *intra-articular* indicates that the line of fracture extends into a joint—a complication that is important because of the possible inflammation of the joint

and of possible change in the relations of the fragment, either of which may permanently restrict the mobility of the joint. *Intracapsular* and *extra-*

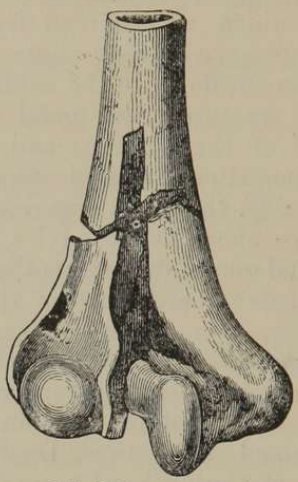
FIG. 66.

Toothed Fracture of the Femur (Stimson).

FIG. 67.

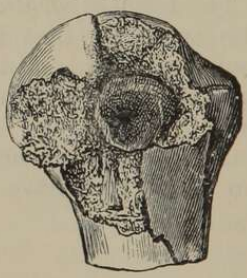
V-shaped Fracture (Stimson).

FIG. 68.



Intercondyloid Fracture of the Humerus (Stimson).

FIG. 69.



Comminuted Gunshot Fracture of the Head of the Humerus, with Impacted Ball (Army Med. Mus.).

capsular are terms used almost solely in connection with fractures of the neck of the femur to indicate the position of the line of fracture within or without the attachment of the capsule to the femur.

(*d*) *Subdivided according to the Mode of Production.*—Fractures by *direct violence* are those in which the fracture takes place at the point where the blow is received; fractures by *indirect violence* are those in which it takes place at a distance from that point; fractures by *muscular action* are those in which the fracture is produced by the action of the patient's muscles.

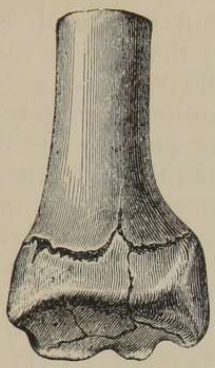
(*e*) *Subdivided according to the Number of Fractures or of Bones Fractured, or to the Extent and Character of the Crushing.*—The term *multiple* indicates two or more separate fractures of a bone, or the fracture of two or more bones other than the tibia and fibula or the radius and ulna of the same limb. A *comminuted* fracture (Figs. 69 to 72) is one accompanied by considerable splintering of the bone, which is broken into several small fragments. An *impacted* fracture is one in which one main fragment is driven into and firmly fixed in the other, which is commonly the expanded spongy end of the bone; the spongy portion into which the other fragment is driven is necessarily more or less crushed thereby, and if the crushing and splintering are such that the enter-

ing piece is not firmly impacted, the fracture is said to be one *with crushing*. Both conditions are more common in advanced life, and, as the crushing amounts to an actual loss of substance, some deformity must persist.

FIG. 70.

Comminuted Perforating Gunshot Fracture of the Head of the Humerus (Army Med. Mus.).

FIG. 71.



Comminuted Fracture of the Lower End of the Radius, palmar aspect (Stimson).

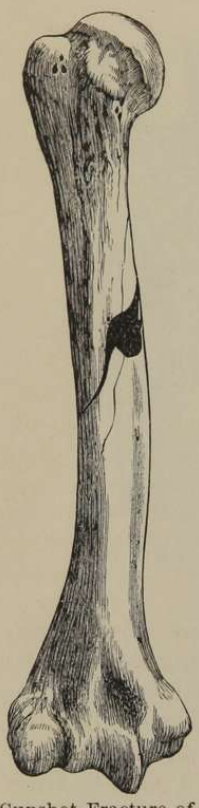
FIG. 72.

Comminuted Fracture of the Neck of the Femur (Stimson).

3. **Compound Fractures.**—A compound fracture is one which communicates with the exterior through a wound of the overlying soft parts. The latter wound may be directly caused by the same violence that produces the fracture, as in the passage of a wheel of a wagon across the leg, or it may be made from within outward by the forcible projection of the end of one of the fragments through the skin; or a simple fracture may become compound through sloughing of the soft parts occasioned either by bruising inflicted at the time of the accident, or by the pressure of a displaced fragment, or through careless handling, or by the movements of the patient while delirious. The injury is much more serious than a simple fracture, because of the possibility of infection of the wound, with its train of consequences—suppuration, necrosis, failure of union, septicemia, and loss of limb or life. Excluding the hand and foot, compound fractures, according to Gurlt, are most frequent in the leg, being 17.96 per cent. of all compound fractures; those of the forearm form 11.68 per cent.; those of the femur, 7.05 per cent.; those of the humerus, 6.66 per cent. The prognosis is serious in compound fractures by direct violence, because the soft parts are usually so bruised and lacerated that primary union cannot be obtained; whereas in fractures by indirect violence in which the wound of the skin is made by the end of a fragment the prognosis is much better, for the wound is generally small and clean, and if properly treated will usually unite promptly, and the fracture will thus be transformed into a simple one. The diagnosis of the compound character of a fracture, when in any doubt, may be made in case of necessity by careful exploration of the wound with the purified finger, but usually, and especially whenever the wound is small and bruising or laceration is absent or slight, it is better to abstain from completing the diagnosis by any measures that may increase the chance of infection, and to direct all efforts to obtaining the prompt disinfection and closure of the wound.

Gunshot fractures (Figs. 69, 70, 73) constitute an especially severe form of compound fractures because of the usually extensive comminution and fissuring of the bone, the bruising of the soft parts along the track of the bullet, and the greater frequency of associated injury of important blood-vessels and nerves. A small bullet may make a clean perforation with but little splintering; a large one literally smashes the bone at the point of contact and produces fissures that may extend to a great distance; the bullet may pass completely through the bone or may lodge in it. In fractures produced by a charge of shot the associated laceration of the soft parts is usually the dominant feature of the case. Amputation and excision have been the rule in the past, and discussion has turned mainly on the respective merits of primary and secondary operations. Antiseptic surgery has not yet been put to a sufficient test in war to determine fully the extent to which it will modify previous rules of treatment, but it will undoubtedly avail to save a much larger proportion of limbs and lives. In civil practice it has been clearly shown that suppuration and infection can be prevented in a large proportion of bullet wounds, and that the removal of the bullet is not a necessary preliminary to successful treatment. The guiding principle is to abstain as far as possible from exploration of the wound with probe or finger, to disinfect it thoroughly by antiseptic washing, and to seek its prompt healing under a single dressing combined with measures to immobilize the fracture: this failing, counter-openings, drainage, and irrigation to meet the needs created by suppuration.

Fig. 73.



Gunshot Fracture of the Humerus (Army Med. Mus.).

Displacements.—The following six classes comprise the common changes in the relations of the principal fragments,—the name indicating, in all but the fifth, the direction in which the change has taken place: 1, transverse displacement; 2, angular; 3, rotary; 4, overriding; 5, impaction or crushing; 6, direct longitudinal separation. Commonly two or more are associated in any given case.

Transverse or lateral displacement may take place in any direction at right angles to the long axis of the bone, and may be complete or partial. In angular displacement one fragment deviates obliquely from the line that represents the normal relation of its long axis to that of the other fragment. In rotary displacement one fragment has been separately turned about its long axis. In overriding, the upper and lower ends of the bone are brought nearer to each other by the passage of the broken surfaces past each other: it is common in oblique fractures, and is necessarily associated with some transverse displacement, and usually with angular displacement. In impaction or crushing the bone is shortened by the forcing of one fragment into the other, or in spongy bones an angular displacement is effected by the crushing of the bone at the angle on the side toward which it is bent. Direct longitudinal separation is most commonly seen after fracture of the patella and olecranon, and is then due to the contraction of the attached muscle; but it may be produced after fracture of the humerus by the unsupported weight of the lower part of the arm and the forearm.

Displacement may be caused at the time of the accident by the force which produces the fracture, or subsequently by the action of gravity or of the attached muscles upon the fragments. The tonicity of the muscles and

their contraction when excited by pain habitually tend to produce angular displacement, and overriding when the character of the displacement permits it. (See Figs. 63 and 65.)

Etiology.—**1. Predisposing Causes.**—These are of two kinds, normal and pathological. Normal predisposing causes are found in the shape, structure, and functions of the different bones, with such modifications as are produced by advancing years. A long bone is exposed by its very length, as well as by the uses which that length subserves, to fracture by indirect violence, by cross-strain, or by torsion; length is to that extent a predisposing cause. A short bone or the spongy end of a long one is fitted by its texture and its breadth to receive and transmit violence with the minimum of damage to the bone with which it is in contact, but the same texture and breadth expose it to easy crushing and splintering when the violence is unusually great or is abnormally directed. To that extent its spongy texture is a predisposing cause. The normal curves found in so many long bones, and the transformation of the segments of a limb into the equivalent of a single sharply-bent bone by the rigidity of the strongly-contracted muscles, tend to diminish the risk of dangerous violence to the trunk and viscera in a fall, but in thus protecting vital organs they become themselves more exposed to fracture.

As age advances the bones become more fragile by rarefaction of their spongy and compact tissue: the change is an actual diminution of the amount of bone-tissue in the bone, not an alteration in the proportions of the different elements that compose that tissue; there appears to be no increase in the amount of the earthy matter, either actually or relatively. As an habitual incident of advanced age this senile atrophy may be deemed a normal predisposing cause, but when it appears prematurely or in an excessive degree it is pathological. Such premature and excessive fragility, dependent upon causes that are not always understood, may be inherited or acquired. Cases have been reported in which successive generations have shown remarkable liability to fracture from infancy; in one instance a child received fourteen fractures before he was thirteen years old. In other cases some or all of the children of a family have shown it, the parents being free from it; thus, a girl suffered thirty-one fractures between the ages of three and fourteen years, and her sister nine between the ages of eight months and six years, while two brothers and a third sister showed no such predisposition. The cases are much more numerous in which a similar liability to fracture has developed later in life, the bones breaking under the slightest violence or muscular effort. Such fractures commonly unite within the usual time. Post-mortem examination has shown great thinning and rarefaction of the bone. Fragility may be developed by disuse, as in limbs that have remained dislocated, and in conjunction with certain diseases of the nerve-centers. Rhachitis is a predisposing cause in childhood, through the incomplete development of the bone-tissue to which it leads, the bone remaining spongy instead of developing a firm, compact, cylindrical formation. Syphilis, cancer and other tumors, and caries may predispose to fracture by destroying a portion of the bone. Rheumatism has been alleged to be a predisposing cause, because some patients have suffered aching pain in certain bones for some time before they have broken under slight violence or, more commonly, by muscular action. The widespread disposition to call such pains "rheumatic" accounts for the supposed connection. Fracture of the patella is not infrequently preceded by such pain, which seems possibly to be evidence of previous slight injury or partial fracture.

2. Immediate or Determining Causes of Fracture.—The immediate cause of a fracture may be violence received at some point upon the surface of the

body, or exerted upon the bone that is broken by the muscles that are attached directly or indirectly to it. The former are termed *fractures by external violence*, the latter *fractures by muscular action*. The latter class does not include cases in which, while the causative force originates in the contraction of the patient's muscles, an additional and essential factor is created by external resistance, as in the breaking of the leg by a sudden turn or forward movement of the body while the foot is held fast, or of the arm by striking it against some object.

Fractures by external violence are divided into two classes which have important clinical differences—those by *direct* and those by *indirect* violence. Fractures by *direct violence* are those in which the bone is broken at a point corresponding to that upon the surface where the blow is received; fractures by *indirect violence* are those in which the bone is broken at a distance from the point where the blow is received. An important clinical difference is that in the former the overlying soft parts are contused, and often to such an extent that the fracture is or soon becomes compound, and primary union of the wound is difficult or impossible; in fractures by indirect violence the injury to the soft parts is habitually less, and if the fracture is compound the edges of the wound in the skin are not so contused that primary union is difficult to obtain.

Fractures by muscular action are most common at the patella, the bone being broken by the powerful contraction of the quadriceps; in other cases the muscles produce the fracture by exaggerating the normal curve of the bone, as the humerus or femur in spasmodic or voluntary contraction, or the ribs in coughing, or the sternum in straining during labor; or by tearing off an apophysis to which the muscle is attached, as the coracoid process or the posterior end of the calcaneum; and in others by creating in portions of the body conditions of momentum which act in the same manner as external violence, as in fracture of the humerus by throwing a stone, of the femur by kicking at, but not striking, an object, of the neck in throwing the head back.

Symptoms and Diagnosis.—Before proceeding to the examination of the injured region inquiry should be made into the circumstances connected with the injury, and the question should always be asked if the part has been previously injured, in order that an old deformity may not be mistaken for a recent one.

1. Objective Symptoms.—**Deformity.**—Under this term are included changes in the appearance of the injured region, in the dimensions of the limb, and in the relations of different bones or parts of bones to one another. Swelling occurs promptly, and is often associated with heat and redness. Ecchymoses appear rather tardily in fractures by indirect violence, and usually at some distance from the seat of fracture. Large blebs, containing a liquid that is at first yellow and later bloody, sometimes appear during the first or second day, especially in fractures of the leg and forearm. Most of the various displacements that have been above described may be readily recognized by the eye or finger when the bone is not thickly covered by soft parts; angular displacement is often shown by a change in the direction of the segments of the limb; and overriding or impaction is demonstrated by measurement of the length of the bone or of the limb. When the two ends of a bone can be readily recognized, as those of the forearm or leg, its length can be directly measured, but in fractures of the femur or the humerus it is necessary to measure from points on other bones, the ilium and the acromion respectively; and then it is essential to accuracy that the injured limb and its fellow with which the comparison is made should be symmetrically placed with reference to the bone on which one of the fixed points is taken. Two other possible sources of error in measuring

should always be borne in mind: one is previous injury or disease that may have affected the length of either limb; the other is the normal inequality in the length of the limbs which exists in many people; this rarely amounts to more than a quarter of an inch, although it may reach an inch or more, and its existence is usually unknown to the individual until revealed by measurement.

By **abnormal mobility** after fracture is meant the independent mobility of the fragments of a fractured bone which is normally one unbroken structure, or the mobility of a joint in an abnormal direction or to an abnormal extent in consequence of the fracture of a portion of the end of one of the bones that constitute it. It is usually present and recognizable with great ease when the fracture occupies the shaft of a long bone, but it may be absent or unrecognizable when the fracture is close to the end of the bone. It is habitually accompanied by a sensation of grating which may be heard or felt, and which is technically known as **crepitus.** This is produced by the rubbing of the broken surfaces upon each other. Abnormal mobility and crepitus are pathognomonic of fracture, but it must be remembered that in not a few fractures either or both are absent or unrecognizable, and that failure to obtain them is not a proof of the non-existence of a fracture. Furthermore, the manipulations necessary to recognize them are, in some cases, actually harmful, and the diagnosis must be made on other symptoms.

2. Subjective Symptoms.—These are chiefly diminution or loss of function, and pain. The history of the case is also of much value. The extent of the interference with function depends upon the importance of the broken bone to that function, the relations of the fragments to each other, and pain or fear of pain. After fracture of the thigh or leg the patient is, as a rule, entirely unable to walk or to lift the limb from the bed when he is recumbent, but, on the one hand, the disability may be much less, and, on the other, equal disability may be caused by a simple contusion. Pain, either spontaneous or aroused by pressure or movement, is a constant accompaniment of fracture, and when limited to a small area and invariably aroused by pressure with the end of the finger or by slight movements communicated to the limb, is a valuable sign of fracture—one upon which a diagnosis of fracture in certain regions can be safely made when the history of the accident indicates that such a fracture may have been produced.

The examination should be made quietly and systematically; movements communicated to the bone in the search for abnormal mobility and crepitus should be slight and gentle, and if the muscles are spasmodically contracted, or the patient timid, or the injury obscure and of doubtful character in the neighborhood of a joint, an anesthetic should be employed.

Repair of Fracture.—In simple fractures there is at first some rise of temperature, the limb swells promptly, blebs sometimes appear on the surface, ecchymoses and yellow discoloration of the skin extend to a considerable distance: then the swelling subsides, and a firm ovoid mass, which is tender on pressure, can be felt about the seat of fracture. This gradually grows smaller and harder and the abnormal mobility diminishes. After a lapse of time, the length of which varies with many conditions, abnormal mobility entirely disappears and the fracture is said to be united. The length of time requisite for such union is greatest, as a rule, when the fracture is of the shaft of the femur in an adult, in which case it is usually from six to eight weeks; it is least at the spongy ends of the bones, less in children than in adults, and greater when there is much permanent displacement. After final healing the limb slowly regains its usefulness, the muscles fill out, and the skin becomes soft, but for

many weeks the limb may show a tendency to venous congestion and œdema and the movements of its joints be restricted. In compound fractures that do not promptly become simple, if left to itself the wound suppurates, the pus burrows, neighboring abscesses form, union of the fracture is delayed, and even after it has taken place the wound may be kept open for weeks or months by suppuration about a loose or attached necrotic fragment.

The lesions of a fracture comprise the breaking of the bone into two or more fragments, the tearing of the periosteum, and the laceration of the soft parts. A portion of the periosteum habitually remains untorn, although stripped up for a greater or less distance from one or both fragments, and constitutes a remaining bond, a "periosteal bridge," between the fragments. This plays an important part in the repair of the fracture. The periosteum thickens, and on its under surface appears a layer, at first soft, then cartilaginous, which extends along the periosteal bridge from one fragment to the other, as well as under the periosteum that remains adherent; the portion belonging to the periosteal bridge thickens and spreads between the fragments, and ultimately becomes bony and continuous with the granulations coming from the bone itself. This is the only portion of the callus which passes through a cartilaginous stage. The bone becomes rarefied by enlargement of its Haversian canals, and at its broken edge and on the adjoining surface of the medullary canal granulations appear which increase until they meet those coming from the periosteal bridge and from the other fragments, and fill the space between them, and also usually the medullary canal at the seat of fracture.

These granulations become fibrous and finally bony, and thus is formed the **callus**, which, when complete, fills the gap between the fragments, occupies the medullary canal for some distance, and forms a layer on the outside of the bone for a greater or less distance above and below the fracture. As time passes this callus becomes smaller, and the portion that forms the medullary plug may entirely disappear, and thus the continuity of this canal may be restored. If there is much permanent displacement, or if the fragments are not effectually immobilized during repair, the callus will be larger than under other circumstances, and tendons and fibrous tissue attached to the bone near the fracture may be included in the area of irritation and become ossified. Such ossification at a distance may be destructive to the functions of the limb, as when a fracture is in the neighborhood of a joint, or in the case of the radius and ulna, which may become united to each other with consequent loss of rotation of the forearm. Sometimes a neighboring joint becomes entirely obliterated by bony union of its opposing articular surfaces.

Fragments that are entirely detached, even from the periosteum, may regain their vital connection with the body, apparently by the growth of new vessels into their Haversian canals, and again form an integral part of the bone. Others may remain imbedded in the callus, but without vascular connection, and be tolerated for years: under the influence of various causes they may ultimately lead to suppuration.

Occasionally the evolution of the callus is arrested at the fibrous stage, and union is then said to have failed or to be fibrous. Fibrous union may be so close and firm or so well supplemented by the interlocking of the different parts of the callus that have ossified that the limb is very useful. The common causes of fibrous union are separation of the fragments and insufficient immobilization.

Complications and Late Consequences.—With the healing of the fracture the limb is not immediately restored to a normal condition; it is

shrunken, the skin is dry and rough, the limb swells on use, and its joints are more or less stiff.

Most of these abnormal conditions gradually disappear, but in the aged the limb may long remain sensitive to free use and to changes in the weather, and the **stiffness of the joints** may persist. The latter is due in great part to the inflammatory conditions that have existed in and about the joint as a direct consequence of the fracture, or to the implication of neighboring tendons; but in the joints of the *fingers* it may be due to the immobilization, and is much more likely to arise when the fingers have been kept extended. It has been clearly shown that prolonged immobilization of the *large* joints, *per se*, is not a cause of permanent stiffness, and that passive motion of the joint is not necessary, or even desirable, during treatment of the fracture, to prevent it. If the joint is inflamed, the best means of reducing the inflammation and restricting its results is to keep the joint at rest. Persistent swelling of the limb, especially of the leg, is apparently the result of interference with the venous flow, and may be the cause of or be associated with much trouble and annoyance, especially if the callus is large and adherent to the skin. The nutrition of the limb is interfered with, persistent ulcers form, and eczema torments the patient.

Persistent paralysis of one or more groups of muscles may appear as a consequence of injury of a nerve-trunk at the time of the accident, or of its later inclusion in the callus; the latter has been observed only in the musculospinal nerve after fracture of the shaft of the humerus.

Exuberant and Painful Callus—Excessive size of the callus may cause trouble by interference with the circulation, or by stretching the skin, or by pressure on a nerve. The second cause is not uncommon in the leg, and may call for relief by chiselling away the bone. Pressure upon a nerve may occur at any point where a nerve lies in close proximity to the bone, as in the case of the ulnar nerve at the back of the elbow. Persistent pain in the callus may be due to an inflammatory process, as suppuration about a sequestrum, or to a non-inflammatory condition of unknown character which has been termed osteo-neuralgia; occasionally it has been traced to inclusion of a nerve-filament in cicatricial tissue.

The other complications to be described are those that arise during the earlier period of the case and put the patient's life in danger. Most of them are extremely rare.

Embolism.—The thrombus of the small veins that have been torn may extend to the large ones, and a portion may be detached and lodge in the heart or in the pulmonary artery. For the symptoms and course the reader is referred to the section on Thrombus and Embolism (p. 57). **Fat embolism** (see p. 92) has been recently recognized as an occasional cause of death in the first few days after the receipt of a fracture. Liquid fat set free by the crushing of the marrow passes into the open veins and lodges in the pulmonary capillaries. The symptoms are not constant or characteristic; there may be sudden dyspnea with subsequent œdema of the lungs, or there may be only prostration without dyspnea, but with cyanosis, quick, feeble pulse, and coarse râles. In some cases the symptoms resemble those of shock, from which the affection is to be distinguished by its antecedent period of comparative well-being.

Rupture of a large artery may be caused by stretching or by perforation; the blood escapes freely until the resistance of the soft parts checks it, and then a traumatic aneurysm forms. The general practice is to postpone active treatment of the injury of the artery, if possible, until repair of the

fracture has taken place. The bruising of an artery may be followed within a few hours by the formation of an obstructing thrombus within it.

Gangrene may be the result of direct bruising of the soft parts or of interference with the circulation in the large vessels arising from their injury or compression by a displaced fragment or from the pressure of a bandage. It may be partial or may involve the limb as far up as the seat of the fracture.

Septicemia and **pyemia** occur, as a rule, only after compound fracture, and, if the fracture is treated antiseptically, are very rare.

Tetanus is a rare complication, and is seen most frequently after compound fracture.

Delirium tremens is a frequent complication of fracture in adults addicted to the use of alcohol. It is, as a rule, milder than the delirium tremens that develops without an injury. Warning of its approach is given by agitation and insomnia, and it can often be aborted or arrested by the vigorous use of sedatives. The outbreak seems generally to be due to the cutting off of the daily ration of alcohol, which is usually the result of the accident and the admission to a hospital; and this indicates the advisability of continuing moderate stimulation for the first week or two in patients who are habitual drinkers.

Treatment.—By the reduction or setting of a fracture is meant the restoration of the displaced fragments to their normal position, or at least to that in which it is desired that reunion shall take place. The manipulations commonly employed are traction upon the lower fragment to correct overriding or angular displacement, and direct pressure to correct lateral displacement or longitudinal separation. Reduction should be made as completely and as promptly as circumstances will permit, having regard to the condition of the patient and of the limb. If there are severe associated injuries and the shock is great, it is well to wait for reaction, and meanwhile to immobilize the parts in partial reduction with simple dressings; if the limb is greatly swollen it may be impossible to restore it to its full length without causing dangerous pressure. An anesthetic may be required to overcome the opposition of the muscles; and in the case of a fracture near to or involving a joint anesthesia is doubly valuable, both to recognize the details of the fracture and to facilitate the complete and accurate readjustment of the parts.

Usually no greater force is required to effect reduction than that which can be exerted by the hands of the surgeon or of an assistant, but in some impacted fractures the fragments are so firmly wedged together or one is so small or inaccessible that reduction cannot be made. Traction is made by grasping the lower segment of the limb and pulling firmly and steadily upon it; coaptation is made by the direct pressure of the fingers and thumbs upon the fragments close to the fracture; angular displacement in "green-stick" fracture, and in others where it is not combined with overriding, is corrected without traction by forcibly bending the bone back into line. If there is so much crushing of the spongy end of a bone that the restoration of the fragments to their normal position would leave an important gap between them, the restoration should not be made, but the fragments should be left in contact.

Permanent dressings have for their main object the prevention of displacement of the fragments by the action of the muscles or by external forces, especially gravity. The means by which this object is to be attained vary greatly in the different fractures, but in most cases they consist of some form of lateral support, often combined with permanent traction upon the lower segment of the limb. Dressings applied circularly about a limb expose it to the danger of constriction, and consequent gangrene, if swelling should occur after the dressing has been applied, and therefore, as a general rule, such should not

be used during the first few days, or if used should be frequently inspected. If applied while the limb is swollen, they are liable to be made too loose by the subsidence of the swelling and to need renewal or readjustment. As a general rule, a roller bandage should not be applied to the limb under the splints; it will rarely do good, and may do great harm. Another rule is to include in the dressings the joints at either end of the broken bone.

The simplest form of lateral support is that furnished by wooden **splints:** they should be longer than the broken bone, of such breadth and thickness that they will not yield under the weight of the limb, and should be thickly padded with cotton to fit the contour of the limb or placed over detached cushions made for the purpose; they are made fast, one on each side, with strips of adhesive plaster, straps, or a roller bandage; they should be so wide that the enveloping bands will not circularly constrict the limb. Projecting bony points should be protected by thick padding *about* them, not *on* them. Carved wooden splints made to fit average limbs rarely have advantages commensurate with their cost. Gooch's flexible wooden splints (Fig. 74) made of thin strips of wood fastened close together on a muslin backing are convenient in some cases. They can be easily made by fastening the strips upon a sheet of adhesive plaster.

FIG. 74.

Gooch's Flexible Wooden Splint (Stimson).

Fracture-boxes are essentially a combination of lateral and posterior splints, and are used only for fractures of the leg. They consist of a long rectangular piece of wood with two hinged sides and a movable foot-piece. The central posterior piece is first well covered with cotton, oakum, or bran; the limb is laid upon it and the foot bound to the foot-piece; then the sides are turned up, with interposed padding, and bound to each other across the front of the leg by cords or bands running through holes made for the purpose. To avoid troublesome pressure upon the heel the foot may be suspended by a long and not too narrow strip of adhesive plaster running from the middle of the calf along the back of the leg to the heel, and up past the sole of the foot to the top of the foot-piece. After application of a fracture-box or any equivalent apparatus suspension from a horizontal bar held up by two vertical side-pieces is often of great advantage.

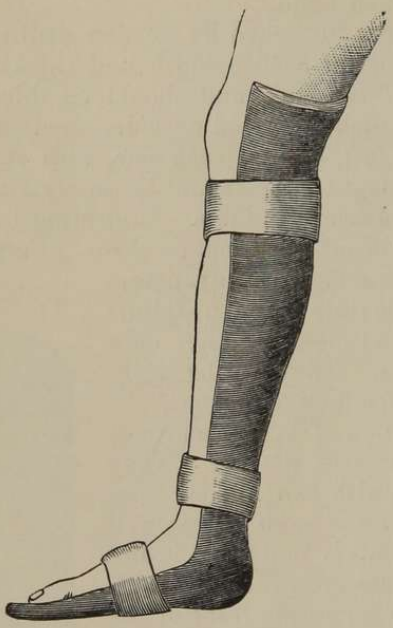
Volkmann's splint is a convenient substitute for a fracture-box, and very useful as a temporary dressing for fractures of the leg. It is a shallow gutter of tin with a foot-piece and a movable support by which the lower end is held at a convenient height above the bed.

Wire gauze is a convenient dressing for fractures, since it is flexible enough to adapt itself to the varying dimensions of the limb under the pressure of a roller bandage, and can be bent to fit the elbow or ankle by cutting it partly through on the sides.

Moulded splints can be made of any material that can be temporarily softened so as to be fitted to the limb and will then harden and retain the shape that has been given to it. For the lighter splints plaster of Paris, pasteboard, leather, felt, and gutta-percha are used; for the heavier ones plaster of Paris is the most convenient. To make a *plaster-of-Paris splint* (Fig. 75) the surgeon cuts strips of gauze, coarse muslin, or thin blanketing of the desired length and width, and soaks them with freshly-prepared plaster of the consistency of thick cream; he then squeezes out the superfluous water, covers the limb thickly with vaseline, applies the splint, and secures and at the same time moulds it to the limb with a roller bandage; after it has hardened he removes the roller and secures the splint by circular turns at two or three points. If sharp angles are

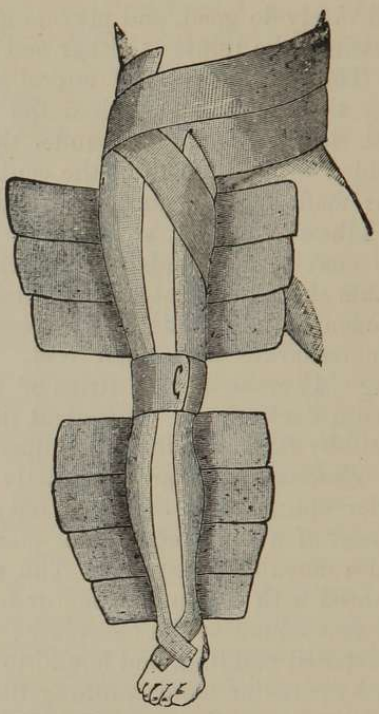
made, as at the elbow or ankle, the fit can be improved by notching the splint while it is still soft and slipping one edge of the cut under the other. Such

FIG. 75.



Posterior Plaster-of-Paris Splint or Gutter (Stimson).

FIG. 76.



Plaster-of-Paris Dressing, made of coarse sackcloth (Esmarch).

splints are very useful in the treatment of fractures of the leg, but are not strong enough for those of the femur; they may be applied while the injury is still recent, and permit inspection without having to be removed.

The *plaster-of-Paris bandage* for complete encasement of the limb is most conveniently made by using gauze rollers that have been prepared by thorough filling with dry plaster. The limb is enveloped in cotton or other soft material, and then the prepared roller bandages, after having been thoroughly wet, are applied in the usual manner. Or strips of some coarse material soaked in plaster cream may be applied, as shown in Fig. 76. They can be fenestrated at any point by cutting out a piece after the plaster has hardened, or may be "interrupted," the two segments being attached to each other by iron bands ——⌒—— set into the dressing. Similar dressings can be made with silicate of soda, dextrin, starch, or glue.

In order that such a dressing shall prevent shortening of the limb within it, it is essential that it should have a bearing against bony prominences or a flexed segment of the limb above and below the fracture: such points of counter-pressure are easily found in the leg and forearm, but with difficulty in fractures of the arm and thigh.

If any splint, or still more any circular encasement, has been applied shortly after the receipt of the injury, it should be inspected at intervals of a few hours for the first day or two, with the view of loosening it at once if it should prove to have been too tightly applied or if it should have become too tight in consequence of the subsequent inflammatory swelling of the limb. The patient and his friends should be warned of the possibility of strangula-

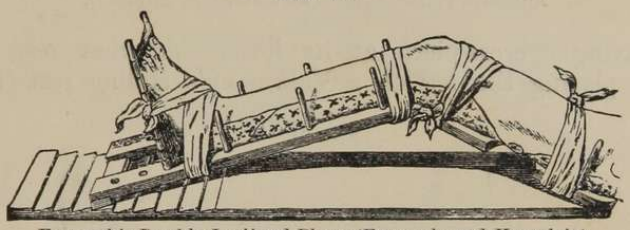
tion of the limb, and instructed to watch the color and temperature of its distal portion, which, for this reason, should always be left uncovered by the dressing. It is almost always advisable to use during the first few days splints that can be easily loosened or which will permit swelling to take place without causing dangerous constriction; and then after the swelling has notably diminished to readjust the splints or apply a permanent immovable dressing.

In fracture of the leg a plaster splint can be so made that the patient can walk about on it after the first week. A layer of cotton two inches thick is bound under the sole by a few turns of the bandage, and then a plaster sole, made of eight or ten layers of gauze, added and firmly included in the dressing. The leg portion of the splint should be applied directly to the skin, or with only a thin layer of cotton interposed, and should be snugly moulded to fit the expanded upper portion of the tibia and fibula. If the fracture is above the lower third, the dressing should be carried up above the knee. Patients with fracture of the thigh can also be enabled to walk about by supplying them with a plaster dressing and adding an apparatus like the splints used in cases of hip disease. The advantages claimed for this "ambulatory method" are the avoidance of the risks of confinement to bed, less atrophy of the muscles and stiffness of joints, and shorter convalescence.

The **methods for applying continuous traction** to the lower segment of the broken limb include the double inclined plane, suspension, Buck's extension, and india-rubber bands in combination with side-splints.

The *double inclined plane* (Fig. 77) is sometimes used in fractures of the

FIG. 77.

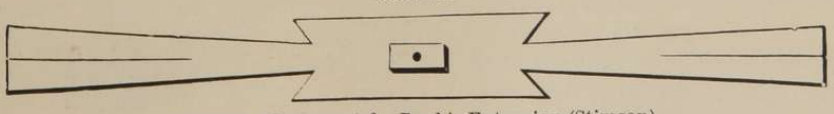


Esmarch's Double Inclined Plane (Esmarch and Kowalzig).

thigh; it is made of a short thigh- and a long leg-piece hinged together at the knee, and hinged at the upper end of the thigh-piece to a long underlying third piece, as shown in the figure. Traction is made by the weight of the pelvis as it sinks in the bed.

In *Buck's extension*, a very popular method of treating fractures of the femur, the traction is effected by a weight attached to the leg by a cord which runs over a pulley at the foot of the bed. This attachment is made by adhesive plaster, the introduction of which constituted an immense improvement in the treatment of these fractures. It is applied as follows: A strip of stout adhesive plaster, four or five inches wide and long enough to reach from well above the knee loosely around the sole of the foot and back to the same height above

FIG. 78.

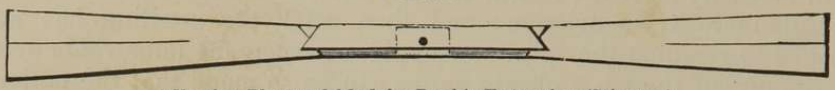


Adhesive Plaster cut for Buck's Extension (Stimson).

the knee, is cut as shown in Fig. 78; a piece of wood five by three inches and perforated at its center is placed at the middle of the strip, the edges of

which are turned down over it and over each other, as shown in Fig. 79; a stout cord is then passed through the hole in the piece of wood and its end

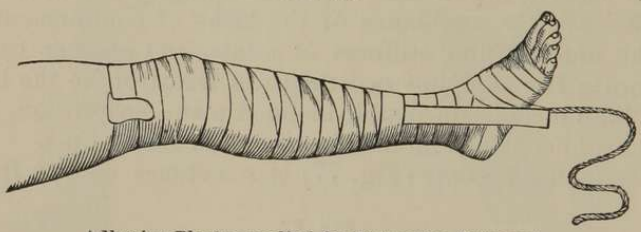
FIG. 79.



Adhesive Plaster folded for Buck's Extension (Stimson).

is tied in a knot. A roller bandage is applied to the foot and the lower third of the leg; the adhesive plaster is then applied to the sides of the leg and thigh above it, and secured by continuing the bandage upward (Fig. 80). The cord is then carried over a pulley at the foot of the bed and attached to the weight, ten to twenty pounds according to circumstances. The foot of the bed must be raised, to obtain the counter-extension by the weight of the body. Outward rotation is prevented by securing the limb to a long

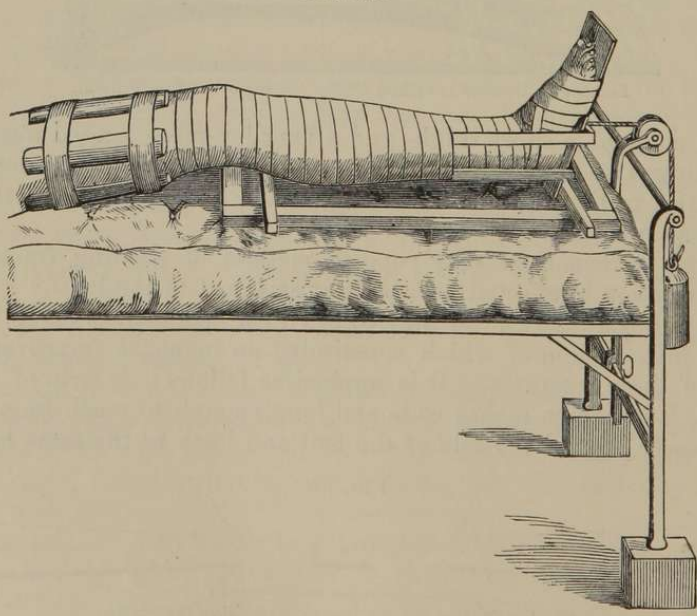
FIG. 80.



Adhesive Plaster applied for Extension (Stimson).

side-splint having a cross-piece at its lower end that rests on the bed, or, better, by placing the leg on a Volkmann's sliding rest (Fig. 81) which

FIG. 81.

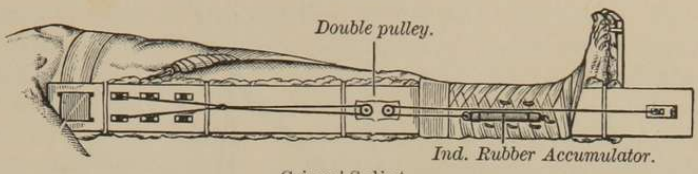


Volkmann's Sliding Rest for Fractures of the Thigh.

is composed of two side-pieces about two feet long and eight inches apart, on which rest by two cross-pieces a posterior splint and foot-piece, to which the

foot and leg are attached in the usual manner. Instead of the weight and pulley an india-rubber cord may be used. The attachment to the limb is made by adhesive plaster. Fig. 82 shows such an apparatus in use for fractures of the

FIG. 82.

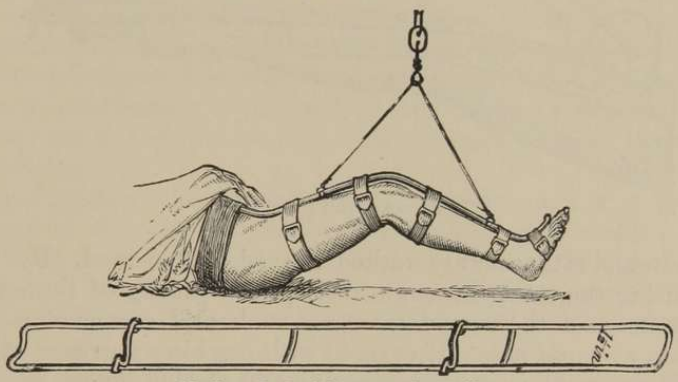


Cripps' Splint.

thigh. Vertical suspension of the limb by a rubber cord attached to the limb by adhesive plaster is sometimes useful in fractures of the humerus close to the elbow, and is common in the treatment of fractures of the thigh in young children.

Nathan R. Smith's anterior splint (Fig. 83) acts like the double inclined

FIG. 83.



Nathan R. Smith's Anterior Splint.

plane when the suspension is vertical, and like Buck's extension when it is oblique.

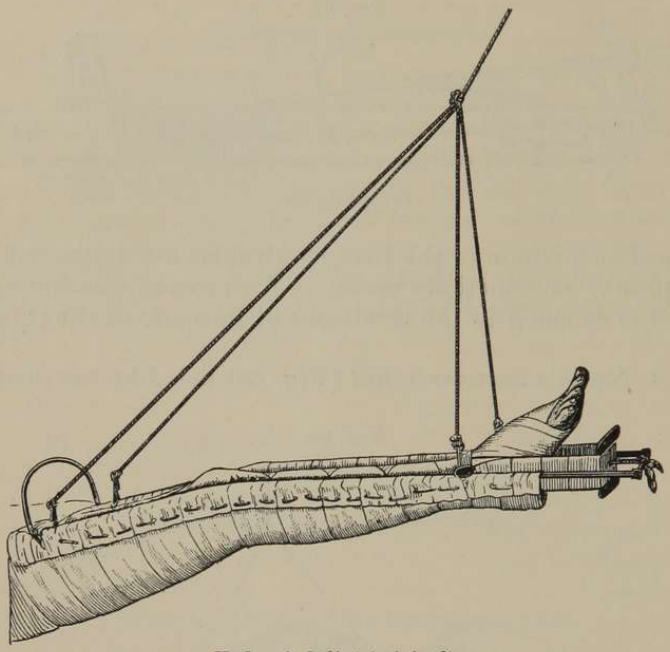
Hodgen's splint (Fig. 84) acts on the principle of Buck's extension, and has the additional advantages of slight flexion of the knee and of greater facility in moving the patient in bed. It consists of two lateral iron rods connected by a straight cross-piece at the lower end and a curved one at the upper end. Lateral strips of adhesive plaster are applied to the limb, as in Buck's extension, and their projecting ends made fast to the foot-piece. Five or six narrow compresses or pieces of bandage are run across from one rod to the other beneath the limb, and so adjusted as to give uniform support to it when the apparatus is raised from the bed. The point of attachment of the supporting cord should be at least four feet above the bed, and the cord should be inclined about ten degrees from the vertical (toward the foot of the bed, of course). The greater the inclination the greater the traction.

Treatment of Compound Fractures.—One of the chief advances made possible by antiseptic surgery is in the results now achieved in the treatment of compound fractures. Formerly they were excessively dangerous accidents from septic infection; now this danger has been almost entirely eliminated. But all depends on the proper and thoroughly antiseptic character of the first dressing.

This dressing of a **compound fracture** is often equivalent to a major

surgical operation, requiring the aid of anesthesia, the use of instruments, and the protection of antiseptic measures. After anesthetization, the surface of the limb

FIG. 84.



Hodgen's Splint (original).

all about the wound is thoroughly washed, shaved, and purified. By "purifying" is meant securing the most thorough antiseptic cleansing of the entire interior as well as exterior of the wound in every nook and corner of possible infection. This is a *sine quâ non*. If covered with machinery grease, etc., thorough rubbing with sweet oil or with turpentine and alcohol before scrubbing with soap and water greatly facilitates the proper cleansing. Blood-clots and loose splinters are removed, wounded vessels tied, divided nerves and tendons sutured, the ends of the fragments sparingly trimmed if necessary, contused tissues cut away, counter-openings made for drainage, and the cutaneous wound sutured. A thick antiseptic dressing is applied, and over all is placed such retentive apparatus as is suitable. The main indication is to secure early union of the cutaneous wound: while this is taking place it is desirable that the fragments should remain properly reduced; but this is, in a measure, of secondary importance, for a final readjustment can usually be made in the second or even the third week. But if the wound in the skin is *small and clean*, it is advisable to limit interference to its irrigation, to the setting of the fracture as if it were simple, and to the application of an antiseptic dressing, and then after the lapse of a week, when the wound will probably have healed, to remove the dressing and make permanent reduction and retention if it has been impossible to effect this at the primary dressing.

The use of *metallic sutures* and similar devices to maintain the fragments in contact with each other is rarely advisable, since sufficient support can usually be given by an external apparatus, and the presence of the foreign body appears somewhat to retard bony union.

If *suppuration* follow from prior infection, the limb must be placed in a splint that will permit the removal of the dressings with the minimum of dis-

turbance of the fragments. Some form of interrupted plaster or suspended splint may be applied, and later indications met as they arise.

Concerning the propriety of *primary amputation* or *excision* of a joint definite rules cannot be laid down; each case must be judged according to the extent of the injury, the probable usefulness of the limb if saved, and the ability to protect against suppuration and septic infection. The protection afforded by attention to the modern principles of treatment of wounds is such that in doubtful cases the patient may safely take the benefit of the doubt and be given an opportunity to show whether or not the limb can be saved.

After-treatment.—After union of a broken bone has been obtained the surgeon's attention may be directed to hastening the complete return of function, the disappearance of congestion and turgescence, the reduction of the stiffness of neighboring joints, and the strengthening of the muscles. The roughness of the skin, turgescence of the limb, and weakness of the muscles can be relieved by massage and electricity, and in the case of the leg comfort will often be promoted by snug bandaging during the day. Stiffness of joints at a distance from the fracture will usually disappear under ordinary use, but special attention may be needed at the ankle to obtain dorsal flexion within a right angle. Stiffness of the fingers in the old and rheumatic is very likely to follow simple immobilization and to be very persistent. It should be guarded against by leaving the fingers uncovered during treatment of the fracture whenever that is possible, and encouraging the patients to use them; when it is necessary to immobilize them during treatment, they should be kept flexed, since stiffness is less likely to take place in that than in the extended position.

When the fracture is in the immediate neighborhood of a joint, nothing should be done in the way of passive or voluntary motion until after union is complete or at least nearly so, and then should be done with great care. The same should be the rule also when the fracture actually involves the joint, as at the elbow. The most that is permissible is the occasional slight change of the angle at which the joint is immobilized.

As regards *passive motion*, it is rarely required or even useful, and as so often employed, under ether or with production of pain, it is actually harmful. The stiffness of a joint after fracture involving it or in its immediate neighborhood is due either to mechanical changes in the joint-surfaces or the relations of the bones, which cannot be materially changed by passive motion, or to periarticular thickening the result of the traumatism, which will disappear, if its disappearance is possible, under ordinary quiet use, and will only be increased and prolonged by forcible motion, which means the infliction of further injury.

Pseudarthrosis and Delayed Union.[1]—When abnormal mobility has not ceased after the usual lapse of time, the condition is described as **delayed union**; if this condition persists after some additional weeks, it is termed **pseudarthrosis**, or **failure of union**, or **ununited fracture**. Delayed union is not very uncommon, but failure of union is relatively rare; most of the cases occur in middle life, and most frequently in the humerus, tibia, and femur in the order mentioned. In proportion to the number of fractures of the respective bones, delayed union and failure of union occur more frequently after fracture of the shaft of the femur than after that of the tibia. Anatomically, two distinct varieties exist: in one the fragments are more or less closely bound together by solid bands of fibrous tissue, sometimes enclosing nodules of bone;

[1] The fibrous union with persistent mobility which is the rule after fracture of the patella and of some apophyses will not be here considered.

in the other similar fibrous bands enclose a central cavity containing a viscid synovia-like liquid, into which the ends of the fragments may project; and these ends may be smooth and eburnated or even covered by hyaline cartilage —a complete new joint. The clinical difference between the two varieties is important, as will appear when their treatment is considered.

The **reason** of delay or of failure of union, in the great majority of cases, lies in the arrest of the evolution of the callus before it has entered upon the stage of ossification—*i. e.* its persistence as fibrous tissue; in others the separation of the fragments is so great and the gap so broken by interposed muscle that a continuous callus, formed by granulations springing from the bones, has never existed, and the fibrous bond is composed solely of the thickened surrounding connective tissue. The ends of the fragments are variously affected in accordance with the extent of the rarefying and productive processes which follow the injury; according as one or the other predominates the ends are diminished in size, sometimes to slender conical points, or enlarged by the formation of irregular masses of bone upon them. In a very few cases the rarefying process has gone so far that a large portion, or even the whole, of the shaft has gradually disappeared. This tendency to excessive rarefaction, when present, is a serious obstacle to the success of operations undertaken to secure union, and it has seemed to some writers to be increased by the presence of metallic sutures binding the fragments together. Occasionally the fragments are in close apposition by their broad surfaces, the fibrous bond is short and complete, and the fragments are enlarged by peripheral productions of bone, and yet ossification of the short fibrous bond fails.

The resultant **disability** varies with the amount of abnormal mobility and the uses to which the limb is put: thus, failure of union in the leg or thigh may make the limb wholly useless, while in the arm or forearm it may interfere but slightly with its usefulness.

With respect to the **cause**, certain general conditions have seemed at times to delay repair, such as syphilis, pregnancy, and acute general diseases, but the common causes are local. Advanced age is not a cause. The local causes are separation of the fragments (by displacement or by loss of substance), the interposition of a foreign body or of a portion of muscle, disease of the bone, defective blood-supply, defective innervation, inflammation on the surface of the limb, and faulty treatment.

The first three act mechanically by creating a gap that cannot be filled by the granulations, and, in addition, in the third the surfaces may be so modified by the disease (syphilis, caries, cancer, etc.) that they are unfit to furnish the necessary granulations. Defective blood-supply, the result of injury to the nutrient artery of the bone or to the main artery of the limb, has often been alleged as a cause, but satisfactory proof is lacking and theoretical considerations do not furnish much support. The influence of defective innervation has been shown in some fractures of the lower limb combined with injury to the lower part of the spinal column; it appears to arise not from the same cause that produces the paralysis of motion, for such delay does not occur in paraplegia due to injury at the upper part of the spinal column, but from injury to trophic centers in the lower part of the cord. The influence of surface inflammation has been occasionally shown in the delay of repair or in the softening of a firm callus coincidently with the appearance of an erysipelas or a phlegmon of a limb.

Excluding incomplete reduction, the fault in treatment which is most likely to delay or prevent repair is insufficient immobilization. Its influence is

unquestionable, although of course it is known that union may take place in spite of it. It is thought that the relative frequency of failure of union after fracture of the humerus is largely due to this cause. The local application of cold is also thought to retard union. It has been asserted also that treatment by complete encasement of the limb in a plaster-of-Paris bandage is followed by a larger proportion of delays and failures than is the case where other methods are employed, and that the increase is due to the shutting out of air and light from the limb: a more probable explanation of the frequency, if it actually exists, is defective immobilization. Premature use of the limb may be followed by a gradual return of the abnormal mobility, as well as by distinct refracture; and a similar occurrence has been observed under the influence of intercurrent diseases weeks or even months after union appeared to be complete.

Treatment.—If a general cause exists, such as syphilis or malnutrition, measures should be taken to remove it, whether the case is one of delayed union or of failure of union. In delayed union of short duration, and with only slight mobility and displacement, much is to be hoped from time, aided by accurate immobilization by splints that will permit the patient to leave his bed.

A gratifying number of successes in fractures of the leg and thigh have been obtained by the use of orthopedic splints. In a number of cases of delayed union of the leg union has gradually become complete while the patient was using the limb under the protection of a suitable splint: it is thought that the slight irritation caused by bearing the weight upon the limb favors ossification. On the same theory percussion of the bone at the fracture has been used. If the case is of longer standing and the mobility greater, a more decided local irritation is required—one that will bring the parts more nearly to the condition of a recent fracture and start the process of repair afresh. Under anesthesia the limb is *forcibly bent* at the seat of fracture, care being taken not to injure main vessels and nerves. The bending should be nearly or quite to a right angle, and the laceration should be sufficient to permit a fairly complete reduction if there has been previous displacement. The fracture is then treated as a recent one.

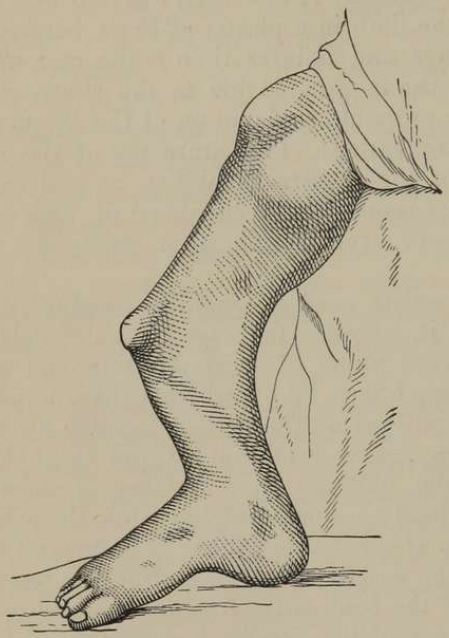
Direct irritation of the ends of the bones can be produced by subcutaneous drilling, but it seems better, and, if antiseptically done, is equally safe, to expose the bone by incision and apply the drill under the guidance of the eye and finger: it should be forced into the end of each fragment at several points. This plan is, in the writer's judgment, more efficient than the permanent introduction of metallic, bone, or ivory pins.

Excision of the fibrous tissue and of the end of each fragment is the only means that will cure old cases and those in which a joint-cavity has formed between the fragments. Under the protection of antiseptic treatment of the wound it has become a popular method, and has proved safe and efficient. The bones should be freely exposed, and their surfaces freshened and fitted to each other—preferably by a transverse section, if that does not require the removal of too much tissue—and the periosteum should be stitched together as extensively as is practicable. Buried or temporary sutures of silver wire or of strong silk are sometimes used to bind the fragments together and prevent displacement; as are also long, narrow metal plates on each side of the bone, crossing the line of fracture and secured to the fragments by long pins that are left projecting beyond the skin and are removed after two or three weeks, the plates being left to heal in.

The attempt has been successfully made in a few instances to obtain union, when there was a considerable gap between the fragments due to loss of substance,

by *filling the gap with* small pieces of *sterilized decalcified bone* or of fresh bone taken from animals: the intermediate fibrous tissue is removed, the ends of the fragments freshened, and the skin closed over the inserted pieces; perfect asepsis is necessary to success.

Fig. 85.



Faulty Union after Fracture (original).

Finally, *amputation* may be required to rid the patient of a useless and troublesome limb.

Faulty Union.—An operation may be required to relieve a disability due to union with deformity or to exuberant callus: thus, the femur may have united with an angular displacement that causes effective shortening of the leg in such manner that the foot does not rest squarely on the ground or is outside the line of support; or the bones of the forearm may unite with a callus that prevents rotation; or an exuberant callus may compress a nerve. Fig. 85, from a photograph, is an example of union with extreme deformity. The measures employed are subcutaneous refracture, osteotomy, and chiselling away of exuberant bone. (See Operations on Bones.)

SPECIAL FRACTURES.

FRACTURES OF THE SUPERIOR MAXILLA AND MALAR BONES.

These are caused only by direct violence, are generally comminuted, and unite with great rapidity. Displacements may often be corrected by direct pressure, and, except in the case of the alveolar border, require no retentive apparatus. When a portion of the alveolar border, with more or less of the adjoining bone, is loosened, it may need to be retained by wiring its teeth to the neighboring ones or by keeping the lower jaw pressed against it.

FRACTURE OF THE NASAL BONES.

This is produced by direct violence, and is often compound, either through the skin or through the mucosa. The fracture may extend to the superior maxilla or to the cribriform plate of the ethmoid; the latter is a dangerous complication because of the possibility of septic meningitis. Cellular emphysema of the face and eyelids, due to the forcing of air through the lacerated mucosa by efforts to clear the nostrils, may appear. Repair takes place so rapidly that it is necessary to recognize and reduce displacements promptly. Reduction is best made by pressure with a small stiff metal rod, like a director, passed into the nostril. Ordinarily there is but little tendency to recurrence of the displacement, but it may sometimes be necessary to oppose it. A plan that has yielded good results is to transfix the nose close beneath the fragments with a

stout pin, and steady them with a piece of india-rubber or adhesive plaster crossing the bridge of the nose and caught upon the ends of the pin.

Suppuration may be followed by necrosis of the fragments. Possibly it could be prevented by irrigating the nostrils with an antiseptic solution and plugging the passage with iodoform gauze. This should always be done very carefully if injury to the cribriform plate is suspected. (See Fractures of the Base of the Skull in the section on Injuries of the Head.)

FRACTURE OF THE LOWER JAW.

This may be single or double: single fractures are most common at or near the median line; those of the ramus and condyloid process are much rarer. Double fractures may occupy one or both sides, or one of the fractures may be in the median line. They are quite common. Fractures of the body of the bone are usually compound; those of the coronoid process are extremely rare, and have been found only in connection with fractures of the condyle, zygoma, and malar bone.

The **displacement** in fractures of the body is almost invariably such that the level of the teeth on one side of the fracture is lower than on the other, and with this is often associated an antero-posterior or lateral displacement according to the position of the fracture; sometimes there is overriding. In fracture of the ramus there is usually little or no displacement.

The common **cause** is violence received upon the chin or cheek.

The **diagnosis** is readily made in fractures of the body by recognition of the change in the relations of the teeth, of abnormal mobility and crepitus, and usually of looseness of the adjoining teeth and bleeding from the gums. In fracture of the ramus the only symptom may be pain on pressure or on tightly closing the jaws. The pain should be sought for by making pressure with the finger within the mouth as well as on the cheek.

FIG. 86.

"Four-tailed Bandage" for Fracture of the Jaw (Stimson).

The **course** is marked by swelling of the face and gums, and often by suppuration at the seat of fracture, the pus escaping into the mouth alongside the teeth, and also often opening through the skin near the lower border of the jaw. Suppuration may be maintained for a long time by necrosis, and may lead to a considerable loss of bone with consequent failure of union and great disability.

Reduction can almost always be readily effected by direct pressure, but the prevention of recurrence may be very difficult. In simple cases treatment consists in the application of a "four-tailed bandage" (Fig. 86); in the more difficult cases recourse has been had to a great variety of interdental splints and methods of wiring the bones or the teeth together. For the construction of most of these the surgeon will require the services of a dentist.

FRACTURE OF THE HYOID BONE.

This is exceedingly rare, and in the few recorded cases has been caused by direct violence and has almost always involved one of the greater cornua.

The symptoms are sharp pain, swelling, marked dysphagia, and sometimes bleeding from the mouth due to perforation of the mucous membrane by the fragments. Death from œdema of the glottis may occur.

FRACTURE OF THE STERNUM. (See also DISLOCATIONS.)

This fracture is rare; it may be incomplete, multiple, transverse, longitudinal, or oblique, but the common form is transverse and situated at or near the junction of the manubrium and body of the bone. As a complete joint sometimes exists between the manubrium and body, it may be impossible to say whether a separation exactly following the line of their junction is a fracture or a dislocation. Displacement may be absent, or may be angular or transverse with or without overriding, either piece lying in front of the other. The periosteum on the posterior surface appears habitually to remain untorn. When the fracture takes place at the junction of the first and second pieces, the second rib usually remains in contact with the manubrium. Fractures of the body are most common in its upper half; those of the ensiform process, including its separation from the body, are extremely rare.

The fracture has been **caused** in several cases by straining during labor and by lifting heavy objects; external violence may cause fracture directly, as in a blow upon the breast, or indirectly by bending the trunk backward.

The **diagnosis** is made by recognition of the displacement when it is present, localized pain, and the history of the case. There is sometimes irregularity of the heart with dyspnœa.

The **treatment** consists in reduction by direct pressure, aided, if there is overriding, by extension of the trunk and by deep inspiration by the patient, and in retention by a broad band of adhesive plaster around the chest.

FRACTURE OF THE RIBS.

This fracture is of frequent occurrence; it may be partial or complete, single or multiple. Incomplete fractures are rare, whether by bending or by fracture of a piece from one border of the bone. Complete fracture may involve one or several ribs, or one or more ribs at two points each; the ribs most frequently broken are the fifth to the ninth; fracture of the floating ribs is almost unknown, and that of the upper ribs apparently very rare, although there is some reason to think that fracture of the first rib is not infrequent, but usually passes unrecognized.

Unless two or more adjoining ribs are simultaneously broken, there is little or no **displacement**; if they are thus broken, the displacement may be angular, with the apex directed inward or outward, and overriding may be produced by the sinking in of the chest-wall. If a rib has been broken at two places, the intermediate piece may move in and out as the patient breathes. Associated *injury to the lung* by the point of a fragment is common, as shown by emphysema or bloody expectoration; and extensive laceration of the lungs or heart may be produced when the violence is great. Serious hemorrhage from a wounded intercostal artery is rare.

The common **cause** of the fracture is external violence, but it may also be caused by muscular action, especially in coughing. External violence may produce the fracture directly, or indirectly by exaggerating the curve of the bone.

The **symptoms** in the less extensive cases are pain on deep inspiration or coughing and when pressure is made upon the broken rib; abnormal mobility can often be recognized by placing a finger on the rib on each side of the

fracture and noticing that movement communicated to one fragment is not transmitted to the other: during this manipulation crepitus may be perceived, or it may sometimes be heard by listening with the ear upon the chest while the patient breathes deeply. Bloody expectoration is frequent. The presence of cellular emphysema, in the absence of a wound or other sufficient cause, is pathognomonic. In the severer cases, in which several adjoining ribs are broken, the fracture is readily recognized by the deformity; associated symptoms due to laceration of the lung may be very urgent.

The **treatment** is habitually limited to immobilization of the chest by means of a broad band of adhesive plaster placed about it at the end of expiration. Angular displacement outward can be corrected by direct pressure upon the projection; it has been proposed to raise a depressed rib by cutting down upon it or by passing a sharp hook under it, but it is unlikely that such a measure would ever be necessary. For the treatment of associated injuries of the thoracic viscera, pneumothorax and hemothorax, the reader is referred to the chapter on Injuries of the Thorax.

FRACTURE OF THE COSTAL CARTILAGES.

This may be caused by direct or indirect violence or by muscular action; it appears to occur more frequently near the junction with the rib than at other points, and to involve the seventh and eighth cartilages more frequently than others. Marked symptoms, when present, are due to associated lesions, injury of the heart or lungs, or other effects of the crushing violence that has caused the fracture. The diagnosis is made on the local pain and the deformity. The treatment is the same as that of fracture of the ribs.

FRACTURES OF THE CLAVICLE.

The clavicle is broken more frequently than any other one bone, with the possible exception of the radius, and the injury is very much more common in the young than in adults, about half the cases occurring in children under five years of age. The fracture may be partial (green-stick) or complete, simple or compound, single or multiple. The partial (in the very young) and simple complete (in the adult) of the middle third of the bone are the common forms; fracture of the outer third is second in order of frequency; that of the inner third is infrequent. The division of fractures into those of the inner, middle, and outer thirds is justified by important anatomical and resultant clinical differences, the chief of which arise from the firm ligamentary attachments of the outer third to the coracoid process of the scapula.

Fracture of the **middle third** (Fig. 65,), the most common variety, may be oblique or transverse, the latter form being found mainly in children; the line of oblique fracture runs from above downward and inward, so that the point of the outer fragment underlies that of the inner one—an important element in the production of the usual displacement; the seat of fracture is usually in the outer half of this third. The loss of support occasioned by the fracture is followed by the falling of the shoulder *downward, forward, and inward*, which presses the outer fragment under the inner one, and thus raises the broken end of the latter—a movement which is sometimes aided by the contraction of the cleido-mastoid. If the line of fracture is so nearly transverse that overriding cannot occur, the displacement is transverse or angular with the apex directed upward and usually backward.

In fracture of the **outer third**, which is much less frequent than the preceding, the line of fracture is more often transverse than oblique, and the dis-

placement is usually angular with the apex directed backward, but it may be very marked and irregular.

In fracture of the **inner third**, which is quite rare, the line is commonly oblique, and the displacement of the outer fragment is inward and downward, the inner fragment either being pressed upward, as in fracture of the middle third, or accompanying the other, thus producing an angular displacement.

When the bone is broken at two points, the intermediate piece, especially if it is part of the middle third, is liable to be greatly displaced.

Complications of simple fractures are very rare, but injuries to the large vessels, to the nerves, and to the lung have been reported, including one or two cases of aneurysm following fracture, several cases of fatal injury to the subclavian vein or the internal jugular, several of persistent or temporary paralysis of the arm, and several of perforation of the lung, shown by cellular emphysema.

Simultaneous **fracture of both clavicles** has been caused by direct violence, as the kick of a horse, each hoof striking one bone, or, more frequently, by indirect violence, the force acting upon both shoulders to press them together. Marked dyspnea, attributed to the weight of the shoulders resting on the thorax, and relieved by dorsal decubitus, was observed in some.

The **causes** of fracture of the clavicle are indirect violence, as in a fall upon the hand or shoulder; muscular action, as in lifting or striking; and direct violence.

The **symptoms** are pain, deformity, abnormal mobility, and loss of function: pain is caused by pressure on the bone or by pressing the shoulder inward; deformity varies with the extent of the displacement, and is shown not only by the change in the relations of the fragments, but also by the falling forward, inward, and downward of the shoulder, with a reduction of the distance between the acromion and the sternal end of the clavicle; abnormal mobility can be recognized by manipulation of the fragments, and is usually accompanied by crepitus; loss or diminution of function is shown especially in abduction of the arm.

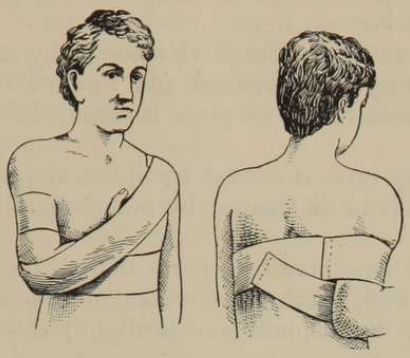
The **course** is uneventful, and union is usually complete within a month in adults, but some persistent deformity due to shortening and angular displacement is the rule; excessive size of the callus has in a few instances produced pressure-effects on the nerves of the brachial plexus or on the skin.

Treatment.—Reduction is made by drawing or pushing the shoulder *upward, backward, and outward* to its normal position, aided when necessary by pressure upon the projecting angle at the point of fracture. The subsequent indication is to maintain the shoulder in this position, for, as has been said, the unsupported weight of the shoulder is the cause of the displacement. This indication has been met, more or less satisfactorily, in a great many ways. In the transverse or incomplete fracture of children a simple sling for the forearm is often sufficient; but in the oblique fracture of adults a perfect result can rarely be obtained. Dorsal decubitus, with a firm narrow cushion between the shoulders and the forearm resting on the chest, meets the indication by removing the cause, but the confinement is too irksome to be endured except when the importance of avoiding any irregularity in the bone is great.

Sayre's dressing (Figs. 87, 88) is in very general use; it requires two strips of adhesive plaster, each three inches wide and long enough to go once and a half around the chest. The end of one strip is fixed loosely about the arm of the injured side just below the axilla, and the strip is carried around the back and the opposite side to the chest in front, so as to hold the elbow a little behind the axillary line; the second strip is then carried from the top of the shoulder

on the uninjured side, across the back, to the opposite elbow, and up along the flexed forearm to the place of beginning, meanwhile pressing the elbow

FIG. 87. FIG. 88.



Sayre's Adhesive Plaster Dressing for Fracture of the Clavicle (Stimson).

FIG. 89.

Velpeau's Dressing for Fracture of the Clavicle (Stimson).

forward, inward, and upward. It is well to leave the hand uncovered by the second strip. A few turns of a roller bandage about the arm and chest will give additional support. In this and all similar cases care must be taken not to allow the bare skin of the forearm to rest on that of the chest, in order to prevent retention of moisture, maceration of the epidermis, and even ulceration. Cotton wadding, linen, or other similar material should always be interposed between the two cutaneous surfaces.

Velpeau's dressing (Fig. 89) is made with a roller bandage; the hand is placed on the opposite shoulder, the elbow pressed upward, and a series of turns with the roller applied, which, beginning at the opposite axilla, pass upward across the back, over the injured shoulder, downward in front of the arm, and under the elbow to the point of beginning: after several turns have been thus made the bandage is carried circularly about the body, covering in the arm from below upward.

A *figure-of-8 bandage* of plaster of Paris, passing in front of each shoulder and crossing at the back, meets the indication very well, but is liable to interfere with the circulation in the arms. *Short crutches* fastened to the chest by adhesive plaster or bandages have been in occasional use for many years to maintain the shoulder in the desired position.

When the fracture is at the extreme *acromial* end, and the displacement is like that of dislocation of the acromial end upward, the method of treatment of the latter injury by a strip of adhesive plaster passing under the elbow and crossing on top of the shoulder is equally efficient.

FRACTURES OF THE SCAPULA.

These fractures may be grouped as—1, of the body; 2, of the inferior angle; 3, of the upper angle; 4, of the spine; 5, of the acromion; 6, of the coracoid process; 7, of the neck; 8, of the glenoid fossa.

Fractures of the **body** are caused by direct violence, and may be partial, complete, or comminuted; when there is a single line of fracture crossing the body directly or obliquely, either fragment may project outwardly and override the other.

The *diagnosis* can usually be made by recognition of the displacement by

touch, especially along the vertebral border of the bone; by independent mobility, recognized by grasping and moving the lower angle; and by crepitus. The *treatment* consists in immobilization of the shoulder and arm; if suppuration ensues in consequence of bruising of the soft parts, early opening of the abscess is required, with especial attention to the drainage of the portion which lies on the costal surface of the bone.

Fracture of the **inferior angle** is caused by direct violence or by muscular action; the small lower fragment is displaced forward and upward by the attached muscles, and even if it can be restored to its place it cannot be maintained there.

Fracture of the **upper angle** is very rare, is caused by direct violence, is followed by but little displacement, and is to be treated by immobilization of the arm.

The entire **spine,** including the acromion, may be separated from the body of the bone, or a portion may be broken off, leaving the acromion attached to the body. The cause is direct violence; the displacement is slight; the treatment is immobilization.

Fracture of the **acromion process** may be caused by external violence acting either directly or through the humerus; or by muscular action (contraction of the deltoid). The line of fracture is in most cases in front of the articulation with the clavicle, less frequently at the root of the process. The *symptoms* are localized tenderness, abnormal mobility, and crepitus. *Non-union of the epiphysis* at the external extremity of the spine, which is not very uncommon, may, if combined with a contusion, be mistaken for a fracture. Bony union is apparently the exception, but the failure to secure it creates no disability. The *treatment* consists in immobilization of the arm at the side of the body, with the elbow a little forward, and with the humerus pressed well upward against the acromion (the Velpeau position).

Fracture of the **coracoid process** may be caused by external violence or by muscular action, and has been observed both alone and in combination with other injuries. The *symptoms* are abnormal mobility, with or without crepitus, obtained, where present, by pressure with the finger against the tip of the process. Displacement downward by the action of the attached muscles is the rule, as is also fibrous union. The *treatment* consists in immobilization of the arm upon the side of the chest with the elbow directed a little backward.

Fracture of the *surgical neck* includes all cases in which the detached fragment comprises the attachment of the long head of the triceps. The upper portion of the line of fracture may end in the suprascapular notch, or in front of the coracoid, or in the glenoid fossa. The *symptoms* are flattening of the shoulder, due to the sinking of the humerus in consequence of the loss of support by the triceps (this is less when the fracture passes through the suprascapular notch, because the fragment is then supported by the coraco-clavicular ligament); its prompt disappearance when the arm is pressed upward, and its immediate return when the pressure is removed; the presence of a movable hard lump deep in the axilla, felt by following with the finger the axillary border of the scapula upward; and crepitus, obtained by pressing it upward and backward. Bony union with some displacement appears to be the rule. The indication for *treatment* is to prevent the sinking of the humerus. This can be effected by bandages or a strip of adhesive plaster passing under the flexed elbow and over the top of the shoulder.

Fracture of the **rim of the glenoid fossa** is a complication of dislocation of the shoulder. Some authors speak of stellate fractures of the fossa, apparently the result of crushing violence acting through the head of the humerus.

FRACTURES OF THE HUMERUS.

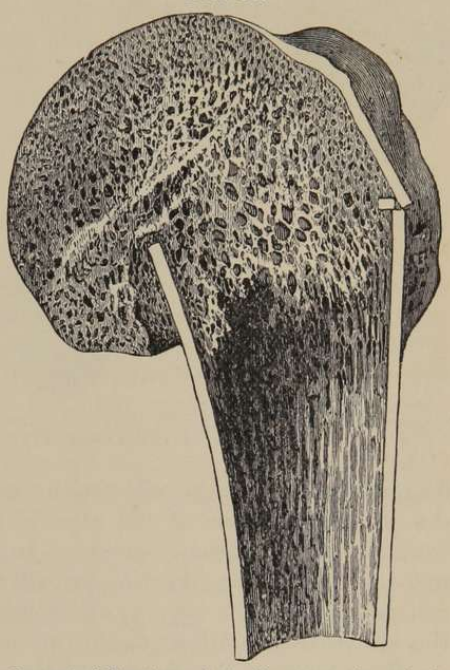
These, which constitute about 8 per cent. of all fractures, may be conveniently grouped clinically as fractures of the upper end, of the shaft, and of the lower end.

Fractures of the **upper end** include those of the head; of the anatomical neck, with or without part of the tuberosities; of the tuberosities; separation of the epiphysis; and fracture of the surgical neck.

Fracture of the **head** is very rare, if from the group are excluded those indentations which are sometimes associated with dislocation (*q. v.*). It cannot be recognized clinically.

Fracture of the **anatomical neck** is rare: the majority of cases probably occur in connection with anterior dislocation, the head being split off by the inner lip of the glenoid fossa acting as a wedge along the line of the neck. In other cases it appears to have been caused by external violence acting upon the elbow to press the humerus against the scapula, or by a fall upon the shoulder. When associated with dislocation the *diagnosis* can be made by recognizing the independent mobility of the head, but when not so associated it cannot be grasped by the fingers so as to permit the recognition of this fact, and the diagnosis cannot be made with certainty. *Symptoms* that may be present are crepitus on rotation of the arm, with preservation of the continuity of the greater tuberosity with the shaft, and pain on pressing the elbow upward, but in a case reported by Stimson there was entire absence of objective symptoms. Hutchinson's supposition that the tonicity of the scapulo-humeral muscles, by drawing the shaft upward, tended to force the head out of the socket has not been confirmed. The *treatment* is immobilization of the arm by binding it to the chest for about four weeks; a thin compress or a layer of absorbent cotton placed between the arm and the chest to absorb the perspiration will add to the patient's comfort.

FIG. 90.



Impacted Fracture of the Humerus through the Tuberosities (R. W. Smith).

Fracture **through the tuberosities** (Fig. 90), the line of fracture running partly along the anatomical neck, and usually through the greater tuberosity, is apparently less rare than pure fracture along the anatomical neck: the fragments are commonly impacted with comminution, and in some cases the upper one has been turned completely over.

The *treatment* is immobilization of the limb, aided possibly by permanent traction downward.

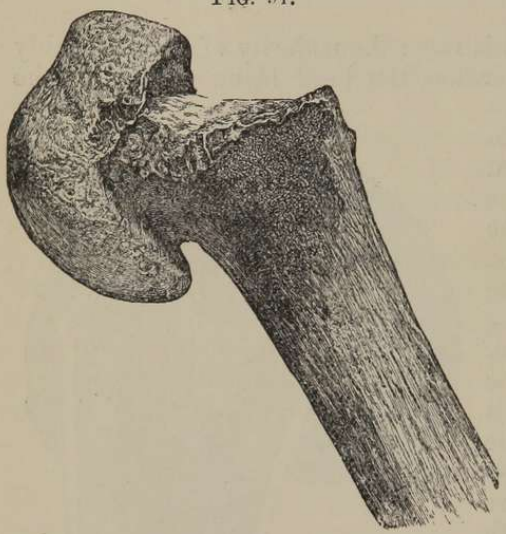
Fracture of the **greater tuberosity,** complete or partial, is rarely seen except in connection with anterior dislocation; it may be caused by direct violence or by the forcible contraction of the attached muscles. The line of fracture runs along the anatomical neck adjoining the tuberosity, down the bicipital groove, and through or below the tuberosity; the fragment may remain

partly attached by untorn periosteum or may be entirely separated and drawn backward. The *symptoms* are loss of voluntary outward rotation, pain, crepitus, and swelling.

Of fracture of the **lesser tuberosity** only three examples have been reported, two of them in connection with the very rare dislocation of the shoulder upward, the third without history.

Separation of the epiphysis (Fig. 91) is caused by external violence, and quite frequently in the new-born by traction upon the arm or in the axilla during delivery. The displacement when not complete is transverse and angular, the apex of the angle directed forward and upward; when the displacement is complete the lower fragment lies on the inner side of the upper. The epiphysis includes the tuberosities, and is so shaped that the upper end of the shaft has the form of a low cone or wedge. The *symptoms* are commonly very characteristic in this respect, that a distinct prominence can be seen and felt on the front of the shoulder about an inch below the acromion, and that a false point of motion can be recognized by grasping the head and gently rotating the shaft; when the displacement is inward this prominence is found beneath the coracoid. *Reduction* is difficult because of the smallness of the upper fragment, but may be effected by carrying the elbow forward and upward, as the posterior portion of the capsule attached to the upper fragment prevents it from sharing in the movement. In a few cases recourse has been had to open incision. Occasionally the growth of the limb at this point is arrested in consequence of the injury, either because the displacement persists or because the epiphyseal cartilage ossifies prematurely.

Fig. 91.



Separation of the Upper Epiphysis of the Humerus; Displacement Forward of the Lower Fragment (Moore).

Fracture of the Surgical Neck (Fig. 92).—The surgical neck of this bone is the part between the upper expanded end and the insertion of the pectoralis major and latissimus dorsi. This is by far the most frequent fracture at the upper end; it is commonly caused by a blow upon the upper part of the arm or by a fall on the hand or elbow. The line of fracture is usually oblique and the displacement marked, the lower fragment lying oftenest on the inner side of the upper one, drawn thither by the latissimus dorsi and pectoralis major.

Symptoms.—Abnormal mobility and crepitus are recognized by grasping the head of the humerus with the thumb and fingers of one hand and gently rotating the elbow with the other.

Treatment.—Reduction is made by traction and coaptation and slowly bringing the lower fragment into line with the upper one, and, if the deformity obstinately returns, may be maintained by permanent traction with weight and pulley combined with the support of a plaster-of-Paris gutter on the back and sides of the shoulder and arm. If the line of fracture is such that the tendency to displacement is slight, or if confinement to bed is very undesirable, splints or encasement in plaster of Paris may be used. In such a case the forearm should be flexed, and supported only at the wrist by a sling, in

order that the weight of the limb may make traction while the patient is erect, or occasionally an additional weight of not more than five pounds may be hung from the elbow. A dressing consisting of a folded towel placed against the side of the chest and extending into the axilla and a little above its borders, a shoulder cap, and a sling at the wrist, gives most excellent results. The arm should be bound to the side by circular turns of a bandage, and the shoulder cap should be held in place by a spica. A splint may be used on the outer side, resting against the acromion and the elbow, the lower fragment being secured to the splint by a bandage: it opposes the displacement of the latter inward by its counter-pressure against the acromion, but does little or nothing to prevent shortening. The scapular muscles attached to the upper fragment tend to tilt its lower end forward and outward, and when this tendency is manifested it must be met by keeping the lower fragment in a corresponding position, either by traction in bed with the arm abducted or by a triangular splint or cushion placed between the arm and the side and maintaining the arm in the desired position. If, as is usual, union is quite firm after the expiration of a month, the splint may be removed and the forearm supported in a sling for a week or two longer.

Fig. 92.

Fracture of the Surgical Neck of the Humerus (Stimson).

When the fracture is *complicated by* simultaneous *dislocation* of the head, the latter may sometimes be reduced by direct manipulation under an anesthetic, or, as recently done by McBurney, cutting down through the deltoid to the lower part of the upper fragment, drilling a hole in it, and inserting in this hole a strong right-angled hook, by means of which forcible traction and rotation can be made upon the fragment. If these fail, the surgeon has his choice between securing union of the fracture and making a subsequent attempt to reduce the dislocation and the establishment of a false joint.

Fracture of the shaft may be caused by direct or indirect violence, or by muscular action: all the varieties of fracture and displacement seen in the shafts of other long bones have been seen here. Among observed *complications* are rupture, thrombosis, and aneurysm of the brachial artery and injury of a main nerve, especially the musculo-spiral, either at the time of the accident or subsequently by inclusion in the callus. The *diagnosis* is readily made by attention to the common signs of fracture, all of which are usually present. Union takes place in from four to six weeks, but it is to be remembered that *failure of union* is more frequent after fracture of the shaft of the humerus than after that of any other long bone. The *treatment* is by an internal angular splint, a shoulder cap, and a sling at the wrist; by moulded splints; or by encasement in plaster of Paris, which should include the forearm (flexed at a right angle) and the shoulder. Unless measures are taken to prevent it, this latter dressing will show after a few days a distinct gap above the shoulder, due to the shortening of the arm—a gap that will admit one or two fingers: this may sometimes be prevented by adding a spica about the chest, but more surely and conveniently by a weight attached to the elbow. If the skin is so bruised that a permanent dressing cannot be applied, the limb must be supported on cushions in a suitable position or bound to the side of the chest.

Fractures of the Lower End of the Humerus.—In this group are included fracture close above the condyles; above and between the condyles; of either condyle; of either epicondyle; and separation of the epiphysis.

In fracture above the condyles, or supracondyloid fracture, the line of fracture passes through the expanded lower end of the humerus, and may open into the joint through the olecranon and coronoid fossæ; the line may be transverse or oblique, either laterally or antero-posteriorly, and in a few cases has been almost vertical and transverse—*i. e.* parallel to the anterior surface, crossing the bone close behind the trochlea and capitellum.

Symptoms.—The usual displacement is of the lower fragment backward, and the injury is often compound because of perforation of the skin by the sharp end of either fragment, especially the upper. The brachial artery or median nerve may be dangerously stretched across the end of the upper fragment. When the usual displacement is present the general appearance of the region resembles that of dislocation backward of the elbow. The *diagnosis* is then made by attention to the relations of the olecranon and head of the radius to the epicondyles.

Treatment.—Reduction, which is sometimes very difficult, is made by traction and coaptation with the elbow flexed at a right angle or fully extended, and is maintained by posterior and anterior rectangular splints or by a moulded posterior splint or trough that extends well around to the front on both sides; occasionally vertical suspension for a fortnight with the elbow fully extended is the best, especially if the fracture is compound; and this attitude has the advantage of being followed by less primary stiffness of the joint than is usual after treatment in flexion. In compound fractures excision of the end of one or both fragments may be needed to secure permanent reduction.

Intercondyloid fracture, sometimes called T- or Y-fracture, differs from the preceding by the addition of a line of fracture running from the transverse one downward through or between the condyles; it is usually caused by direct violence, a blow or fall upon the elbow, and is often comminuted or compound.

Symptoms.—It may closely resemble a supracondylar fracture, the condyles preserving their relations with each other, or the latter may be widely separated, with the lower end of the upper fragment and the olecranon interposed between them.

Treatment.—Complete reduction, in attempting which the aid of anesthesia should always be had, is very difficult, as is also its maintenance. It is to be expected that the movements of the joint after recovery will be seriously restricted, and it is well, therefore, to keep the limb during treatment, or at least during the later weeks of treatment, in the attitude which will be the most useful if ankylosis ensues. A broad, heavy, posterior moulded splint reaching from the shoulder to the wrist, with the elbow flexed at a right angle, extending well around to the front of the limb, and allowed to harden while anesthesia is maintained, is probably the best; it may be aided by permanent traction at the elbow in the direction of the long axis of the arm. Full extension during the first two weeks with the arm in a padded anterior splint is thought by many surgeons to prevent the displacement upward and backward which often occurs. Whatever method of treatment is first employed, after ten days or two weeks it is desirable to flex the elbow and to change the angle of flexion from time to time, in the hope of increasing the range of motion. In *compound fractures* advantage may sometimes be taken of the wound to pin the fragments together with steel drills passed through them; in other cases excision of the lower end of the humerus is advisable with the object of obtaining a movable, though weaker, joint.

Fracture of the internal epicondyle may be caused by direct violence or by forced abduction of the extended forearm; in the latter case dislocation of the elbow usually follows in consequence of the continuation of the violence,

and the fracture becomes a complication or an incident of the more important injury.

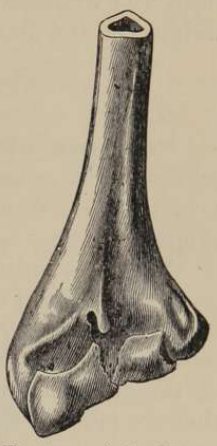
The *diagnosis* in the pure cases is made by recognition of the mobility of the small fragment, possibly with crepitus: in those in which it complicates a dislocation backward the diagnosis is made in the same manner; but in dislocations outward the fragment is liable to be drawn down below the trochlea, where it cannot be felt, and the diagnosis must then be made upon its absence.

The *treatment* is by immobilization of the joint for about a fortnight in flexion at or within a right angle, to diminish the effect of the attached flexor muscles upon the fragment.

Fracture of the external epicondyle is very rare; the diagnosis must be made upon the recognition of a small movable fragment at the seat of the epicondyle.

Fracture of the Internal Condyle (Fig. 93).—The line of fracture extends from a point on the inner side of the humerus above the epicondyle downward and outward into the joint at the center of the trochlea or between the center and the capitellum. The usual *displacement* is of the fragment upward and backward, and, even if it is but slight, the persistence produces marked deformity by changing the relations of the long axis of the arm and making the external condyle unduly prominent. The tonicity of the triceps appears to favor recurrence of this displacement, as does also pressure upon the upper part of the ulna when the elbow is flexed. This undesirable pressure may be readily exerted by a supporting sling, with or without a splint, and consequently the arm should be supported only at the wrist.

Fig. 93.



Fracture of the Internal Condyle of the Humerus, displacement upward and inward (Gurlt).

Treatment.—If care be taken to avoid such pressure and to make complete reduction in the first instance, satisfactory results can usually be obtained by treatment in a posterior rectangular or moulded splint or trough, or even in a plaster-of-Paris dressing, but it is advisable to examine the joint at the end of a week or ten days and correct the displacement if it has recurred. Treatment with the joint in full extension enables us more surely to avoid this displacement of the condyle upward, and has given many excellent results, but the attitude is not so convenient to the patient as that of flexion, and in some cases there is a tendency to displacement forward or tilting of the fragment in the extended position. If it is employed at all, it is perhaps sufficient to employ it during the first fortnight, and then to substitute flexion. The ultimate result in the young may be greatly impaired by excessive formation of callus.

A *complication* occasionally seen is coincident dislocation of the radius backward; that is, both bones of the forearm and the internal condyle are displaced backward, the ulna preserving its relations with the latter and with the radius. Recurrence after reduction is best avoided by keeping the elbow flexed at less than a right angle.

Fracture of the External Condyle.—In this the line of fracture runs from a point on the supinator ridge downward and inward through the capitellum or the outer part of the trochlea. Ordinarily the displacement is slight, but it may be considerable, with coincident displacement of the ulna from the internal condyle outward or backward, the head of the radius maintaining its relations with the capitellum and ulna. The *treatment* is immobilization in a posterior rectangular splint or immovable dressing.

Separation of the epiphysis is not a frequent accident, and there have been but few opportunities for direct examination of specimens. The lower fragment usually comprises the entire epiphysis, which is composed of several distinct pieces, but it is possible that either or both epicondyles may remain attached to the upper fragment. The *symptoms* and *treatment* are in the main the same as those of supracondylar fracture, of which the injury may be considered a low form. In order to prevent angular displacement Mr. Hutchinson has recommended treatment with the elbow fully flexed.

After-treatment of Fracture at or near the Elbow.—When union after fracture about the elbow is complete and the splints are laid aside, the elbow is usually very stiff, and much anxiety may be felt concerning its future usefulness; but in the great majority of cases the range of motion will rapidly increase under natural use of the limb, and the surgeon can do but little to hasten it. Daily forcing of the joint is more likely to do harm than good, and the best results are obtained by simply encouraging the patient to make as much use as possible of the limb, and perhaps aiding him by elastic traction from the wrist to the shoulder to increase flexion, and making him carry a weight in the hand to increase extension.

FRACTURES OF THE RADIUS AND ULNA.

Fracture of the olecranon may be *caused* by the contraction of the triceps or by external violence received upon the olecranon or upon the ulna near it, the commonest cause being a fall or blow upon the elbow. The line of fracture may be at right angles to the long axis of the bone in both planes, or oblique in either plane, or irregular. The *displacement* may be slight, the periosteum being in great part untorn, or the fragment may be drawn one or two inches upward by the triceps. The *symptoms* are localized pain, independent mobility, and crepitus when there is but little displacement, and the absence of the olecranon from its proper place and its presence at a higher point when there is much displacement.

Treatment.—If the displacement is slight and the olecranon accompanies the ulna in the flexion of the elbow, no other treatment is required than immobilization of the limb in a sling or an immovable dressing; but if the olecranon is completely detached and drawn upward, the elbow must be immobilized in full extension by a long anterior splint, and the fragment be held down by strips of adhesive plaster or india-rubber traction or the turns of a roller bandage. Of these various methods, one of the simplest and most effective is a U-shaped strip of adhesive plaster the curve of which lies on the back of the arm close above the fragment and the sides are carried down upon the forearm. In a few cases the fragments have been exposed by incision and wired together, but except in old cases with failure of union and much disability this is hardly justifiable. Union may be bony or fibrous, and even when union fails active extension is not always entirely lost.

Fracture of the coronoid process is almost unknown except as a complication of dislocation of the elbow backward; the tendency to displacement is not great, for the only muscle that is attached to the process, the brachialis anticus, is also broadly attached to the front of the ulna below it, and this broad attachment must be broken before the muscle can draw the fragment upward. The fragment can sometimes be felt as a small movable body in the flexure of the elbow. The *treatment* is by immobilization of the joint flexed at a right angle.

Fracture of the head of the radius has been observed mainly in con-

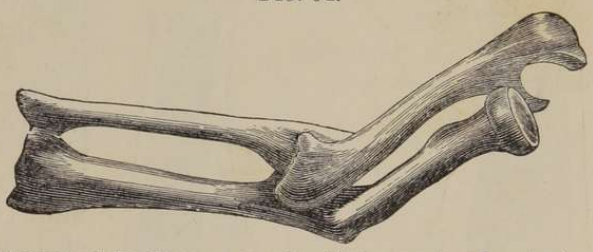
nection with fracture of the coronoid process of the ulna as a complication of dislocation of the elbow; it is partial, the fragment being the inner or anterior portion of the head. If the fragment is so far displaced that a positive diagnosis can be made, it should be removed.

Of **fracture of the neck of the radius** a few cases have been recorded: it may be followed by suppuration of the joint or by bony union. The clinical histories are not sufficient to permit a systematic description: possibly the *diagnosis* could be made by localized pain and by recognition of the failure of the head to share in rotatory movements of the shaft of the radius.

Fracture of the Shaft of One or of Both Bones of the Forearm.—Fracture of both bones is frequent in the lower and middle thirds, rare in the upper third. Usually the radius is broken at a somewhat higher point than the ulna. They may be broken by direct or indirect violence, and rarely by muscular action. Partial, "green-stick," fractures are not uncommon in the young. Fracture of the ulna alone is commonly due to direct violence, a blow upon the raised arm, but it may be caused by a fall upon the hand, and is then occasionally complicated by dislocation of the head of the radius forward and upward. Fracture of the radius alone is less frequent than that of the ulna, and may be caused by direct or indirect violence.

The *displacement* may be angular or lateral or with overriding, and is of especial importance because of its effect, if unreduced, upon the function of rotation of the forearm. Rotatory displacement of the upper fragment of the radius occurs especially when the fracture is above the insertion of the pronator radii teres; the unopposed action of the biceps supinates it, and the result, if uncorrected, is to limit supination of the limb: a study made by Callender of the specimens in the London museums showed such displacement varying between six and forty degrees. The action of the biceps may also produce angular displacement by flexing the upper fragment. Rotation of the forearm may be lost in consequence of excessive formation of callus, of the union of the callus on the two bones (Fig. 94), or of ossification of the interosseous ligament.

FIG. 94.



Fracture of the Forearm, angular displacement, and union between the bones (Stimson).

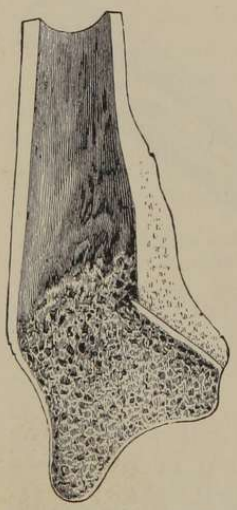
The *diagnosis* of fracture of both bones is easy, that of either bone alone may be more difficult: independent mobility in the radius may be recognized by observing that the head of the radius does not share in slight rotatory movements communicated to the lower end; in isolated fracture of the ulna there is localized pain, often a corresponding irregularity in outline that is easily recognizable, and sometimes independent mobility can be obtained. The position of the head of the radius should always be verified in case of fracture of the ulna alone, for its dislocation forward and upward is a not infrequent complication.

Treatment.—Reduction is made by traction, with or without pressure upon the projecting angle when one exists, pressure being necessary in "green-stick" fractures; and by deep pressure with the fingers in front and behind to press the bones apart if they have been approximated. Anterior and posterior padded splints, long enough to reach from below the palm to the elbow and wide enough to prevent circular constriction of the limb by the bandage that

secures them in place, are usually sufficient to maintain reduction. The forearm should be midway between pronation and supination. Frequent inspection is necessary at first to detect dangerous constriction. Gangrene has occurred from pressure of the upper end of the palmar splint against the brachial artery at the bend of the elbow. This splint may, therefore, with advantage be made from one to three inches shorter than the posterior one. For the same reason it is well to apply the splints while the forearm is flexed upon the arm. The supporting sling should not rest against the ulna. If there is reason to guard against supination of the upper fragment by the biceps, the wrist must be correspondingly supinated; this position is somewhat irksome, and has the disadvantage of bringing the bones nearer together at the center than they are when the limb is in the midway position. After two or three weeks a moulded plaster-of-Paris dressing may be substituted for the splints. In simple fracture of the radius or ulna alone without displacement moulded plaster of Paris may be safely used even earlier. If dislocation of the head of the radius forward and upward has occurred in connection with fracture of the ulna alone, the limb should be dressed after reduction, with the elbow flexed at less than a right angle.

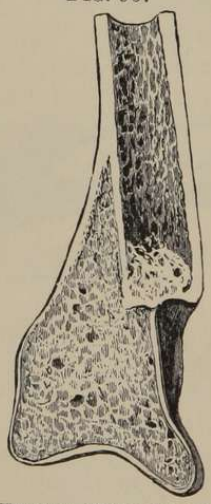
Fracture of the lower end of the radius (Colles's Fracture) is one of the most common of all fractures; it is seen at all ages, but with the greatest frequency in the old. It is generally produced by a fall upon the palm of the hand. The *line of fracture* is usually situated at from one-third to three-fourths of an inch above the articular edge, and is transverse, but may be oblique in either direction, and sometimes the lower fragment is comminuted. In the young it appears usually to follow the epiphyseal line. The common *displacement* is of the lower fragment backward (Figs. 95 and 96), with ascent of the styloid process by crushing, and of the posterior articular border by tilting or angular displacement, so that the articular surface looks downward and backward instead of downward and forward. The periosteum on the back of the bone remains untorn, but is stripped up from the upper fragment so as to form a "periosteal bridge:" the consequent formation of bone in the interval gives to specimens of old unreduced fractures the appearance of deep penetration of the lower by the upper fragment. Exceptionally the styloid process of the ulna may also be broken off, or even the shaft of the ulna broken close above its lower end.

FIG. 95.



Recently-united Fracture of the Lower End of the Radius (R. W. Smith).

FIG. 96.

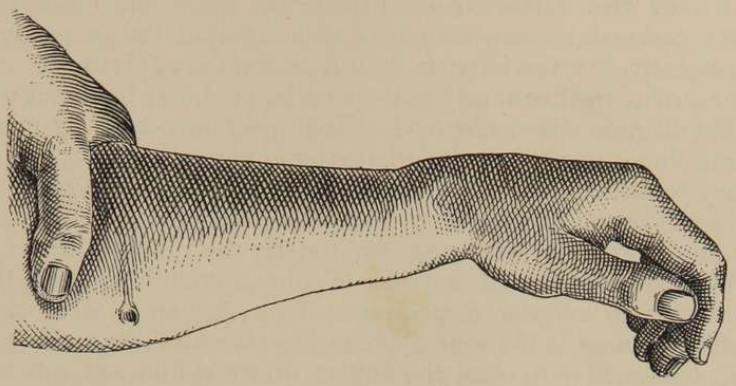


Fracture of the Lower End of the Radius, displacement of broken fragment backward (Stimson).

The *symptoms* are a characteristic deformity, consisting in a prominence on the back of the forearm close above the wrist corresponding to the lower fragment, producing what is often called the "silver-fork" deformity (Fig. 97), and a fulness on the palmar surface at a somewhat higher level, corresponding to the end of the upper fragment; the ascent of the styloid process of the radius to or above the level of that of the ulna; pain on pressure along the line of

the fracture posteriorly; and swelling of the front of the wrist, with deepening

FIG. 97.



"Silver-fork" Deformity of Colles's Fracture, photographed half an hour after the accident (original).

of the transverse lines between it and the hand. Crepitus and abnormal mobility are often absent.

Treatment.—Reduction, which at times is very difficult and even impossible, should be first attempted by traction upon the hand and direct pressure upon the fragments; if that fails, the wrist should be placed in forced extension and the fragment pressed downward by the surgeon's thumbs while his fingers grasp the forearm above the fracture. If this also fails, an anesthetic should be given, and the fragment mobilized by pressing it backward, and then forced forward into place. It is of great importance to the appearance of the limb that the posterior displacement should be fully corrected: that which is due to the crushing of the spongy tissue and shortening of the outer border of the bone cannot be corrected. If reduction is well made, there is but little tendency to recurrence. The limb is then placed between short anterior and posterior splints, the former padded lightly at the point corresponding to the end of the upper fragment, and the latter more thickly where it rests against the lower fragment, and the splints fastened by a circular strip of adhesive plaster near each end and at the middle, or held in place by a roller bandage. The posterior splint should end at the wrist; the anterior one may end at the same level, or may be carried to the palm with a pad at its lower end, over which the fingers may partly close. Similar anterior and posterior moulded splints of plaster of Paris are very convenient and equally secure. Many surgeons prefer after reduction to place the hand in flexion on a Levis's metallic splint. In cases where there is little tendency to displacement of the lower fragment a Bond's splint with the wedge-shaped compresses, as above, will give excellent results. The dressing of Barton is that preferred by some surgeons, and varies a little from the one just described. Two wedge-shaped compresses and two light, well-padded splints, long enough to reach from the elbow to the tips of the fingers, are employed. The compresses are placed over the region of the fracture, one on the dorsum of the wrist with its base upward and resting on the upper end of the lower fragment, the other on the front of the wrist, its base downward and corresponding to the lower end of the upper fragment. They are held in place by a few turns of a roller; the anterior splint (the shorter of the two) is next put in position, and the roller is carried over it while extension is kept up by an assistant, and then the posterior splint is applied. The arm is kept midway between pronation and supination; the thumb is left free. Passive motion of the fingers

should be constantly made. In the young, growth of the bone may be arrested by the traumatism, with a resultant deformity resembling that of a fracture with much crushing of the spongy tissue.

Fracture of the anterior or posterior lip of the lower end of the radius is an occasional accompaniment of dislocation of the carpus forward or backward respectively; the latter is known as *Barton's fracture.*

Fracture of a metacarpal bone may be produced by direct or indirect violence; the diagnosis is made by localized pain increased by pressing the corresponding finger upward, and perhaps by abnormal mobility and crepitus. The tendency to displacement is slight, and no special treatment is required other than a palmar splint padded to preserve the concavity of the metacarpus.

Fractures of the phalanges are usually the result of direct violence, and are often compound. In fracture of the proximal phalanx there is a marked tendency to angular displacement with the apex directed forward, which if left unreduced is the source of considerable disability. A convenient and efficient *treatment* is to close the fingers over a cylindrical roller bandage of suitable size, and bind them there with longitudinal strips of adhesive plaster or another roller bandage outside; or a padded palmar splint may be employed.

FRACTURES OF THE PELVIS.

These fractures include complete fractures at one or more points of either or both innominate bones, and fractures of any of the three bones constituting the innominate.

Fracture of the ring of the pelvis is caused by great external violence, such as the passage of the wheel of a wagon across the bone, the fall of a heavy object, the caving in of an embankment, the kick of a horse, or a fall from a height. It may be single, double, or multiple. The most frequent *seat* is in the pubic bone, the line of fracture passing through the upper ramus just internally to the ilio-pectineal eminence, and through the lower ramus near its junction with the ischium. With the anterior fracture may be associated a posterior one (double vertical fracture of the pelvis), either in the ilium behind the acetabulum or in the sacrum, or partly in either bone and partly along the sacro-iliac synchondrosis, or another anterior one through the opposite pubic bone. *Separation of either symphysis* is the practical equivalent of a fracture, but *separation of the pubic symphysis* alone may be occasioned by much slighter violence than that which is required for a fracture; *separation of both symphyses* is caused only by great violence, and is usually described as dislocation of the os innominatum. The pubes is sometimes broken in two places or comminuted. An exceptional form of fracture of the lateral portion of the ring is that in which the violence is exerted through the femur and produces a radiating fracture of the acetabulum.

Associated injuries are common and severe: the most frequent in the male is rupture of the membranous portion of the urethra (see Injuries of the Urethra), the laceration extending in severe cases through the perineum and around the rectum and anus; rupture of the bladder is next in frequency, and then injuries of other abdominal viscera.

The *displacement* is sometimes very marked, so that it is easily recognized by the finger and eye; in other cases the diagnosis must be made by localized pain caused by direct pressure or by pressure inward or backward upon the wing of the ilium. The patient is unable to raise the leg from the bed. Rupture of the urethra is indicated by bleeding from the meatus.

The *treatment* of the fracture consists in immobilization of the pelvis by a

girdle, aided in double vertical fracture by traction upon the limb, as after fracture of the thigh. If the fracture is compound, ample drainage must be provided, and if the urethra is injured, perineal section must be made.

Transverse fracture of the sacrum is very rare, and has always been caused by direct violence. It is frequently associated with paralysis of the bladder, rectum, and lower limbs. The displacement is angular, with the apex directed backward, and can be corrected by pressing the coccyx forward.

Fracture of the coccyx, which is very rare, resembles in symptoms and treatment dislocation of the same bone.

Fractures of the wing and processes of the ilium are comparatively frequent. The crest of the ilium may be broken off by direct violence, the size of the fragment varying greatly in the different cases. The anterior superior spinous process has been broken off by direct violence and by muscular action; the posterior inferior and the anterior inferior, by direct violence. The diagnosis is made by recognition of a movable fragment with crepitus. No special treatment other than rest in bed is required.

The **ischium** has been broken in a few cases by direct violence, as a fall upon the buttocks; the fragment in some cases has included almost the entire bone, in others only the tuberosity.

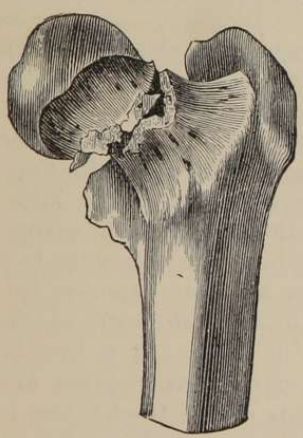
Fracture of the pubes not extending across both rami is rare: we have seen one case in which the upper half of the body and the adjoining part of the horizontal ramus were broken off; the fracture was compound, and the fragment was removed.

Fracture of the rim of the acetabulum is a complication of dislocation of the hip.

FRACTURES OF THE FEMUR.

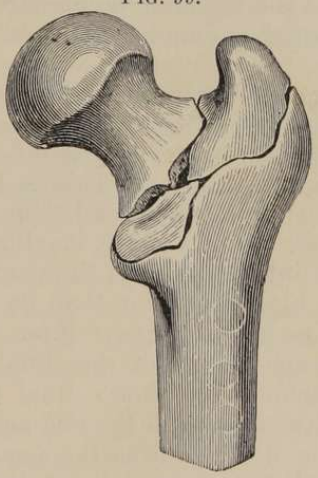
Fracture of the Neck of the Femur.—This is far more common in elderly people, especially in women, than in the young or middle-aged, and is

Fig. 98.



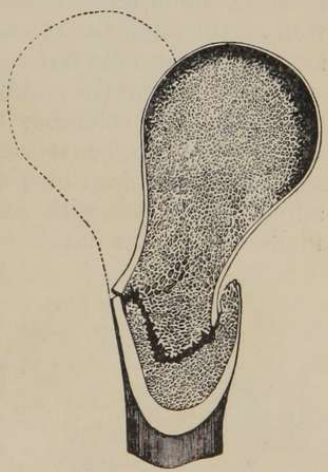
Fracture at the Small Part of the Neck of the Femur (Stimson).

Fig. 99.



Fracture at the Base of the Neck of the Femur, with splitting of the great trochanter (Stimson).

Fig. 100.



Impacted Fracture at the Base of the Cervix Femoris, with bending of the head backward (Bigelow).

generally caused in them by comparatively slight violence, as a fall while walking, a misstep, or even the effort to avoid a fall. The old classification as **intra-** and **extra-capsular** fractures, which was always unsatisfactory and took no account of the large group of "mixed" fractures in which the

line lay partly within and partly without the capsule, has now in great part given place to a division into *fractures at the base of the neck* and *fractures at the small part of the neck.*

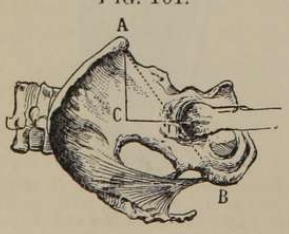
In **fractures at the small part of the neck** (Fig. 98) the line of fracture crosses the neck transversely or obliquely, and is rarely impacted: a portion of the periosteum, usually on the anterior and inferior surface, commonly remains untorn and aids in supplying blood to the head. Bony union is possible, but unlikely. Separation of the epiphysis, which is constituted by the head alone, occasionally happens, and belongs in this group.

In **fracture at the base of the neck** (Fig. 99), the more common variety, the line of fracture follows more or less closely the junction of the shaft and neck; the fragments are often impacted (Pl. XII, Fig. 2), and the great trochanter split; the crushing or impaction appears commonly to be greater at the back than at the front, so that the neck is inclined backward from its normal position with reference to the shaft, or, in other words, the shaft is in outward rotation upon the neck (Fig. 100). Bony union is the rule, and often with excessive production of bone about the fracture and the trochanter.

The *symptoms* of both varieties are inability, often complete, to use or move the limb; but occasionally the patient has been able to raise the limb from the bed or even to walk a short distance. As a rule, however, the limb lies straight and helpless on the bed, the foot is everted, the upper part of the thigh is fuller and rounder than usual. Complaint is made of pain at the hip, and often in the anterior and inner part of the middle of the thigh. Pain is caused by pressure in front of or behind the neck, against the trochanter, or upward at the knee or ankle; but sometimes the limb can be pressed quite forcibly upward without causing pain. If eversion of the foot is absent, it will nevertheless be found that passive inversion is less complete than normal. Occasionally the foot is fixed in inversion. Pressure over the front of the neck shows that the tissues are less depressible than on the other side—a valuable sign in obscure cases. On gentle rotation of the limb the trochanter is found to share in the movement, and occasionally crepitus is felt.

Measurement (in making which care must be taken to place the limbs symmetrically with reference to the pelvis, as mentioned on page 284) shows the injured limb to be shorter than its fellow, the difference varying between a small fraction of an inch and two inches. This is best done by marking the site of the spines with an aniline pencil, and then measuring from the fixed malleolus to the mark over spine without touching the skin at the latter point. Similarly, the trochanter is found to occupy a higher position than its fellow with reference to a line drawn across it from the anterior superior spinous process of the ilium to the tuberosity of the ischium (Nélaton's line) (Fig. 101). If a line be drawn through the two anterior superior spines, and the distance from the summits of the trochanters to this line be measured, it will be found shorter on the injured side (Bryant's line) (Fig. 101).

Fig. 101.



A C D, Bryant's Ilio-femoral Triangle; A B, Nélaton's Line (Owen).

The **diagnosis** between the two varieties cannot always be made with certainty: a positive sign of fracture at the base of the neck is enlargement of the trochanter, due to its splitting; and it is thought that in fracture of the small part of the neck the shortening is more likely to be slight

at first and to increase suddenly and rapidly during the first few days from separation of the interlocked fragments. The opinion once very widely held, and even now occasionally encountered, that the differential diagnosis can be made by consideration of the age of the patient (intracapsular fractures in those more than sixty years old) or of the way in which the violence was received (intracapsular by a fall on the knee or foot, extracapsular by a fall upon the trochanter) has proved to be wholly untrustworthy.

It may even be impossible to say with certainty that a fracture is present, but in any case in which an *elderly* person, especially a woman, has fallen and complains of *pain* at the hip, with *inability* to use the limb, a fracture is probable, and the case should be treated as such for at least three weeks and until all pain and soreness have ceased. It has happened, often enough to justify great caution in giving an opinion, that the positive signs of fracture have not appeared until after a number of days, perhaps after the patient has been assured that he has suffered no serious injury and has been encouraged to use the limb. In not a few cases the patient has remained disabled long after the surgeon has ceased his attendance, and has sued the latter for malpractice.

The indications for **treatment** are, in the order of their importance, in the case of the old and feeble, to guard against the danger to the life of the patient arising from the traumatism and the necessary confinement, to secure firm union, and to have the minimum of deformity. The vital indication requires that the patient's strength should not be further taxed by dressings that cause pain or by prolonged confinement to bed if its ill effects become manifest and threaten to become serious. In the latter case, if necessary, union of the fracture must be sacrificed to the preservation of life. Special attention must be given to securing comfort and good nourishment and to the avoidance of bed-sores. Local treatment is limited to making only so much reduction of the shortening as can be effected by moderate traction, and to immobilization by traction and cushions or by a fixed dressing. Complete removal of the shortening is liable to break up an impaction that would be valuable in securing union. Traction by Buck's extension (Fig. 80) with a weight of five, or at most ten, pounds prevents further shortening and promotes comfort, and small firm cushions or sand-bags placed behind the trochanter and along the outer side of the thigh aid the immobilization. Hodgen's suspended splint (Fig. 84) is even better than Buck's. For immobilization without permanent traction either a long side-splint, extending from the side of the chest to the foot, or a plaster-of-Paris dressing, including the entire limb and the pelvis, may be employed. Lateral pressure in non-impacted fractures is of great importance in securing bony union, and on this account Senn recommends with the latter dressing the use of direct pressure inward against the trochanter, made through a fenestra by a pad at the end of a screw that passes through an iron support imbedded in the plaster. A well-applied plaster dressing appears to meet the indication sufficiently well. The dressing should be worn for about two months if the patient's condition permits.

It is to be expected that some shortening and outward rotation of the limb will persist; and the range of motion of the joint may be considerably restricted by the consequences of the arthritis or by an exuberant callus. Even if union fails or is fibrous, the patient may still be able to make fair use of the limb, the support being given by the Y-ligament, which secures a bearing against the ilium in the ascent of the shaft. In a few cases in which union has failed and the disability has been great and the condition painful, operations have been done to obtain union by freshening the surfaces and suturing or pinning the fragments together, or to remove the detached head.

Fracture of the great trochanter has been occasionally caused by direct external violence. The patients have usually been able to walk notwithstanding the injury. In the specimens obtained after death the fracture has always been found to be entirely outside the joint. The fragment may be large or small, and in the young may comprise the entire trochanteric epiphysis, separated along the conjugal cartilage. The *diagnosis* must be made on the independent mobility of the fragment and localized pain. The *treatment* is rest, aided perhaps by a bandage to oppose the retraction of the fragment upward and backward by muscular action.

Fracture of the shaft may be caused by direct or indirect violence or by muscular action. All the varieties of fracture of the shafts of long bones are found here, but the commonest is oblique fracture, often with the splitting off of a lateral piece, and with either or both main fragments ending in a long sharp point: transverse fracture appears to be quite common in children.

Symptoms.—Angular displacement and overriding are greatly favored by the contraction of the muscles, both those connecting the lower fragment with the pelvis and those that flex and abduct the upper one. Outward rotation of the lower fragment may be produced by the unsupported weight of the foot, which turns to the outer side; outward rotation of the upper fragment may be caused in like manner by the unsupported weight of the upper and outer portion of the thigh, the foot being meanwhile held upright. The latter displacement is equivalent to inward rotation of the lower fragment, and when the patient begins to walk he finds that the toes turn in. Compound fracture and associated injury to the large vessels are infrequent. Distention of the knee-joint by an effusion immediately after the injury is the rule, and is probably due to a concomitant sprain.

The *diagnosis* is made by pain, loss of function, shortening, abnormal mobility, and crepitus. Measurement is made, as in fracture of the neck of the femur, from either the malleolus or the knee to the anterior superior spine of the ilium, and the same precautions are needed to ensure symmetry of position. The fact that the shortening has occurred in the shaft, and not in the neck, is shown by the normal relation of the trochanter to Nélaton's line. Abnormal mobility can be recognized by passing the hand under the limb at the suspected point and gently raising it, or by grasping the upper part of the thigh firmly and moving the foot inward and outward, or by observing that the trochanter does not share in gentle rotatory movements communicated to the lower portion of the limb. Steady traction overcomes or diminishes the shortening. The thickness of the overlying muscles usually prevents recognition of the details of the fracture and displacement. Sometimes the sharp end of one fragment perforates the muscles and the skin, commonly the upper fragment in front; the penetration can be relieved by flexing the thigh upon the pelvis and the leg upon the thigh, the movement drawing the muscle down past the fragment.

Treatment is commonly by one of the methods of continuous traction, Buck's extension by weight and pulley (Fig. 80) or suspension by Hodgen's (Fig. 84) or N. R. Smith's anterior splint (Fig. 83) in adults, or vertical suspension in infants and young children. Hodgen's splint is especially useful in compound fractures, because of the facility with which it permits the dressings of the wound to be changed. The methods of applying Buck's extension and the suspended splints have been already described. The plaster-of-Paris dressing, including the pelvis, is still in use, but its results are not so satisfactory as those obtained by the other methods. Vertical suspension in young children is very useful, because of the ease with which the position can be maintained

and the child kept clean. The suspension is made by two india-rubber cords attached to a cross-bar above the bed and one to each leg by adhesive plaster, as in Buck's extension; the limbs are kept parallel by attaching the feet to a short foot-piece. The traction should be just sufficient to raise the buttocks slightly from the bed.

Union is complete in the adult in from six to eight weeks; in young children, in three or four. It is advisable to keep the patient in bed for a week after the dressings have been removed, and to insist upon the use of crutches for a week or two thereafter. Usually some shortening persists.

Fractures at the Lower End of the Femur.—In this group are included the supracondylar, intercondyloid, fracture of either condyle, and separation of the epiphysis.

Supracondyloid fracture is commonly produced by indirect violence, as a fall upon the feet; the line of fracture is oblique or transverse; and the usual displacement is of the lower fragment backward. Flexion of the lower fragment upon the tibia by the action of the gastrocnemii, by which its fractured surface is directed somewhat backward, occasionally occurs, but is by no means so frequent as has been alleged. A dangerous complication is sometimes found in rupture or stretching of the popliteal vessels. The *diagnosis* is easily made by recognition of the common signs of fracture. *Treatment* is by the plaster-of-Paris dressing or by suspension in Hodgen's or Smith's anterior splint.

Fig. 102.

Intercondyloid Fracture of Femur (Bryant).

Separation of the epiphysis is commonly caused by torsion or hyperextension of the leg. The *treatment* is the same as in the preceding variety.

In **intercondyloid fracture** (Fig. 102) the condyles are separated from the shaft and from each other. It is caused by great violence, as in a fall from a height, and is consequently often compound and accompanied with much displacement. It is always a serious injury, and if compound, a grave one. Continuous traction by Buck's extension or a suspended splint is advisable for the first two or three weeks, after which, if all is going well, the limb can be put in plaster. If compound, it is, of course, to be treated antiseptically.

Fracture of either condyle may be caused by direct violence, as in a fall upon the flexed knee, or by lateral flexion of the leg: the line of fracture runs from the intercondyloid notch more or less obliquely upward. The fragment remains attached to the tibia by its lateral ligament, and the displacement is therefore usually slight, although the fragment is sometimes carried forward or backward by rotation of the leg. The *course* is usually simple and the result good, but in a few cases suppuration of the joint or necrosis of the fragment has followed. The *diagnosis* is made by the recognition of abnormal mobility and crepitus; sometimes the only sign is localized pain on pressure, or on lateral flexion of the leg toward the injured side. The *treatment* is reduction of the displacement, if any, by bringing the leg to its proper position in full extension, and immobilization, preferably in plaster.

Fracture of the patella is an injury of frequent occurrence between the ages of twenty and fifty years, especially in males. It is usually the result of muscular action, but sometimes of direct violence, and sometimes of forcible flexion of the partially stiff knee when the descent of the patella is prevented by adhesions; the latter is the common method of production of refracture. Dull pain is occasionally felt in the patella for some days before

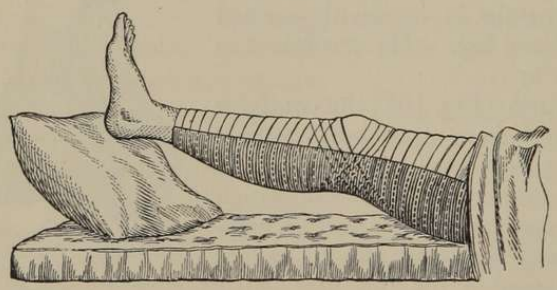
it breaks. Simultaneous fracture of both patellæ has been reported a number of times.

The *line of fracture* is almost always transverse, and, while generally near the middle of the bone, may be close to either end; exceptionally it may be oblique. In fractures by direct violence it is more or less comminuted, and is likely to be compound, or to become so by the sloughing of the bruised skin The upper fragment is drawn upward by the quadriceps to a greater or lesser distance, but in some cases, and especially in fractures by direct violence, so much of the periosteum remains untorn that the separation is very slight. As a rule, the periosteum ruptures at a different level from that of the fracture, and thus is produced a narrow fringe which lies between the fragments when they are approximated, and to which much importance has been attributed as a cause of failure of bony union. The capsule is torn transversely on each side to a distance that varies with the separation, and the cavity of the joint promptly fills with blood and synovia, which still further increase the separation by distention.

The *symptoms* are loss of the power of active extension of the leg, independent lateral mobility of the fragments, and usually a distinct transverse gap between them which can be closed by pressing them together.

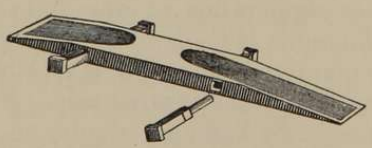
The *treatment* is immobilization of the extended knee for about two months, usually combined with dressings arranged to keep the fragments in contact with each other. When the periosteal covering is not torn and the separation is slight, a plaster-of-Paris dressing, extending from the ankle to the upper third of the thigh, is sufficient, but in other cases special dressings are needed. Of these the variety is great. The simplest form consists of turns of a roller bandage, with a long posterior splint, applied obliquely above and below the fragments, so as to press and hold them together (Fig. 103); the patient should be kept in bed with the foot raised. Agnew's splint (Fig. 104) consists of a piece of pine board thirty inches long, five inches wide at the top, and four at the lower end, with four lateral pegs. Fig. 105 shows the manner of its appli-

Fig. 103.



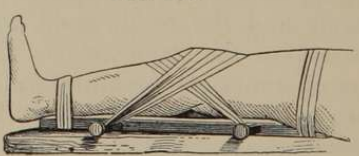
Hamilton's Dressing for Fracture of the Patella. The final turns of the roller in front of the knee are not shown in the cut.

Fig. 104.



Agnew's Splint for Fractured Patella.

Fig. 105.

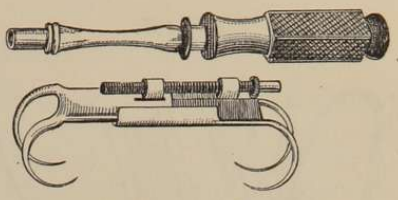


Agnew's Splint Applied.

cation, the fragments of the fractured patella being drawn together by the adhesive plaster strips. Another method is by elastic traction applied to the upper fragment: a piece of rubber tubing is made fast to each end of a strip of adhesive plaster about eight inches long and two inches wide; the adhesive plaster is then placed transversely close above the upper fragment, and the rubber cords

are stretched down on each side of the leg and made fast to the posterior splint. Malgaigne's hooks (Fig. 106) are used by forcing one through the skin into the upper border of the upper fragment, the other into the lower border of the lower fragment, and then bringing them together by means of the screw. Treves employs them after a preliminary exposure and freshening of the fragments, as in the operation of suturing, over which he thinks this procedure has some advantages. In any of these methods the effusion in the joint may often be promptly removed by the use of a rubber bandage, or the joint may be primarily emptied by aspiration of its contents.

FIG. 106.



Malgaigne's Hooks.

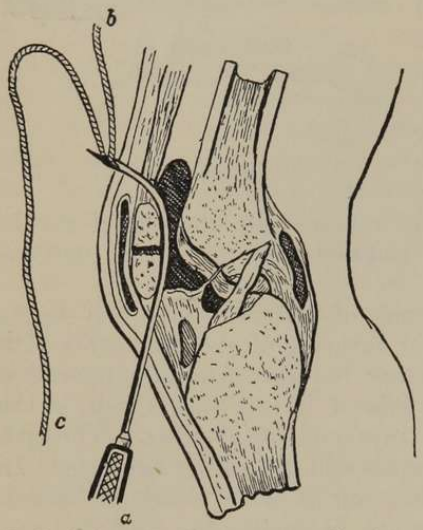
Operative measures include various forms of suture. The first to be employed was an open arthrotomy with direct suturing of the fragments with silver wire: it has given many brilliant successes, but also cases of suppuration of the joint, some with loss of the limb or loss of life—a risk which, in the opinion of some surgeons, the nature of the injury rarely justifies. The operation should only be done under strict antisepsis and in healthy subjects. In compound fractures it is not only permissible, but is often clearly indicated. The operation is done by exposing the fragments, freshening the fractured surfaces if the fracture is an old one, or dissecting away the fibrous tissue and fragments of periosteum or synovial membrane often found interposed, and drilling the bones in the median line, the drill-holes running obliquely from the anterior surface of the attached border of each fragment toward the posterior edges of the fractured surfaces. Silver wire is then introduced and the fragments are approximated, the wire being cut short and the ends hammered into the bone, or else left to protrude from the wound to be withdrawn later.

The substitution of a silk ligature through the tendon of the quadriceps and the ligamentum patellæ for the wire suture through the bone is preferred by some. The joint must not be invaded by the ligature. An antiseptic dressing is applied, and the limb kept on a posterior splint for a week. If all has then gone well, a plaster-of-Paris dressing is applied and worn for a month; after that, for another month it is worn only in the daytime and removed at night. The silk should be boiled and all antiseptic rules should be most rigidly followed; if suppuration occurs, free exit should be promptly given to the pus, to diminish the risk of invasion of the joint. The ligature may be employed subcutaneously by means of a long, slightly-curved needle introduced and brought out in turn through four small incisions, two above and two below the patella, or, better (Stimson), through a longitudinal median incision four or five inches long, fully exposing the bone and the tendons. After the joint has been emptied and the fringe, if present, raised from the broken surface, the silk ligature is passed by means of a curved needle transversely through the tendon of the quadriceps and the ligamentum patella close to the bone, drawn tightly to bring the broken surfaces into contact, tied and cut short. The fibrous layers between it and the patella should be smoothed out, and, when necessary, catgut sutures applied to close the lateral rents in the capsule.

Among other methods that have been recommended may be mentioned subcutaneous longitudinal drilling of the fragments and the use of a silver suture; transverse drilling of each fragment, the drills being left in place and

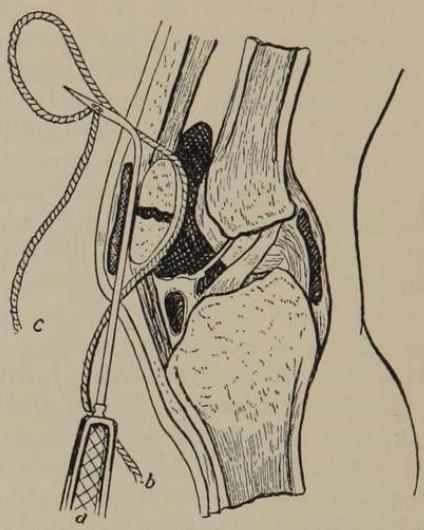
tied together on each side. Barker's operation (Figs. 107, 108), which has found much favor with many surgeons, is done as follows: The lower fragment of the

Fig. 107.



Barker's Operation for Transverse Fracture of the Patella (first stage).

Fig. 108.



Barker's Operation for Transverse Fracture of the Patella (second stage).

patella is steadied by the finger and thumb, and a narrow-bladed knife thrust into the joint, edge upward, in the middle line of the ligamentum patellæ at its attachment to the lower fragment. Through the wound thus made a stout-handled pedicle needle is thrust into the joint behind the lower fragment, and pushed up behind the upper fragment and through the quadriceps tendon in the middle line as close to the border of the bone as possible, the upper fragment at this time being forced down and steadied. When the point of the needle becomes apparent beneath the skin, the latter is drawn upward and an incision made upon the needle, the eye of which is then threaded with sterilized silk and the needle withdrawn, carrying the thread behind the fragments. The needle is next unthreaded and passed through the same skin wound below and out of the upper wound, but this time in front of and close to both fragments. Here it is threaded with the upper end of the suture and withdrawn. The two fragments are then brought together, friction is made to displace clots or other foreign material, and the ligature tied tightly over the lower border of the patella. The two ends of the ligature are cut short and the wounds closed. Union of the skin-wound is by first intention. Passive motion is begun on the tenth day.

Union is almost invariably fibrous in cases treated without the suture, and the bond of union habitually lengthens somewhat under use, but this does not materially affect the usefulness of the limb. In cases treated by the suture the union is closer, and may occasionally be bony.

Rupture of the bond or *refracture* of the bone at another point occasionally happens: the common cause is forcible flexion of the knee, in which the upper fragment is prevented from moving by adhesions that unite it to the femur or by shortening of the capsule on each side, which does not allow it to pass below the condyles. The injury may become compound by rupture of the adherent skin along the line of fracture.

In old cases, in which the disability is great because of the wide separation

of the fragments, open arthrotomy with suture has been done many times. Since modern aseptic methods have come into use, the proportion of successful cases has been much larger than formerly.

FRACTURES OF THE LEG.

Fractures at the Upper End.—The tibia may be broken at its upper end by direct or indirect violence, and the fibula may be simultaneously broken or its upper end dislocated, or it may be uninjured. The fracture may be transverse, oblique, or comminuted and impacted, or the line may run from the side of the head into the joint, separating only one condyle, or it may follow the epiphyseal line (separation of the epiphysis). In fractures by direct violence, usually by a heavy blow upon the front of the bone, there may be marked angular *displacement*, the apex directed backward, or backward displacement of the lower fragment, with the possibility of serious injury to the main vessels. In fracture by a fall upon the feet the lower fragment is driven into the upper one, splitting it and opening the joint. When the fibula is neither broken nor dislocated, displacement of the tibia is slight. The prognosis is serious because of the probability of implication of the joint in the inflammatory reaction, and it has been noted that repair of the fracture takes an exceptionally long time. After separation of the epiphysis the growth of the bone may be arrested.

The *treatment* consists in the reduction of the displacement, and in extension by continuous traction, or by splints, according to circumstances.

Fracture of the Upper End of the Fibula may be caused by muscular action (vigorous contraction of the biceps), by forced adduction of the leg, or by direct violence. The fragment may remain in place or may be drawn upward by the biceps. In several cases the external popliteal nerve has been injured, either in the accident or in the process of repair, with consequent paralysis of the anterior and peroneal groups of muscles. The *treatment* is immobilization, with the knee flexed to relax the biceps.

Fracture of the Shaft may be caused by direct or indirect violence, and in the latter case is more frequently situated at or near the junction of the middle and lower thirds. It may be transverse, oblique, V-shaped, or comminuted, and is frequently compound, either by the direct action of the violence upon the overlying soft parts or by perforation of the skin by the sharp end of one of the fragments, especially the upper one. When both bones are broken the fracture of the tibia is commonly at a lower level than that of the fibula. The common *displacement* is angular with overriding, the lower end of the upper fragment being displaced forward. The injury can be readily recognized by palpation of the subcutaneous surface of the tibia; abnormal mobility, which is greater when both bones are broken; and crepitus. Fracture of the fibula alone is shown by localized pain, and sometimes by abnormal mobility.

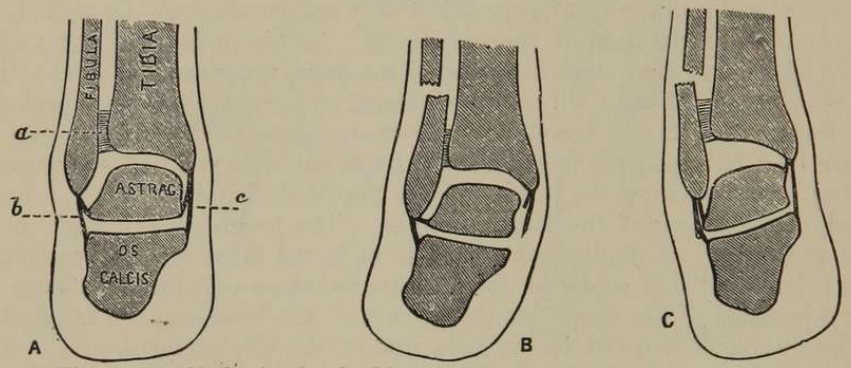
Treatment.—After reduction by traction and coaptation the limb may be secured by lateral splints or in a Volkmann splint or fracture-box for a few days until the swelling shall have subsided, and then in a plaster-of-Paris dressing, or it may be secured at once in moulded plaster-of-Paris splints, posterior and lateral. Care must be taken to prevent angular displacement by the sinking of the foot, and it is always advisable to remove the dressings and inspect the fracture after the first fortnight, when it is still possible to correct angular displacement. Union commonly takes place in about six weeks, but sometimes is long delayed.

Compound fractures should be dressed in accordance with general principles, and the limb placed in a fracture-box or Volkmann splint; if the

fracture has not become simple by the end of the first fortnight, interrupted plaster splints arranged for suspension will be found convenient. Delayed union and failure of union are not uncommon if there has been much loss of substance of the tibia by splintering; and if the fibula has maintained its length a piece should be cut from it in order that the fragments of the tibia may be brought together.

Fractures at the Lower End.—Of these the most common and important is the one known as **Pott's fracture** at the ankle, which is caused by

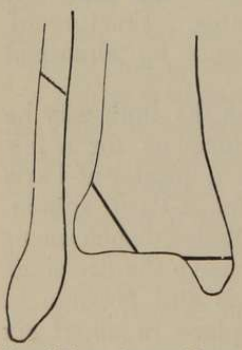
Fig. 109.



Diagrams to Illustrate the Mechanism involved in Fracture of the Lower End of the Fibula: A, parts in normal position: *a*, tibio-fibular ligament; *b*, external lateral ligament; *c*, internal lateral ligament; B, fracture of fibula due to eversion of foot; C, fracture of fibula due to inversion of foot (Treves).

forcible eversion and abduction of the foot; rarely by inversion and adduction of the foot. Fig. 109 shows the mechanism of both varieties. In a typical case there are three separate lines of fracture (Fig. 110): one of the fibula about three inches above the tip of the malleolus, and commonly extending obliquely downward for an inch or more; one of the internal malleolus; and one of the outer lower edge of the tibia; but in the place of the last two there is often rupture of the internal lateral ligament of the ankle and of the ligaments of the lower tibio-fibular articulation respectively. The essential feature of the injury is the separation of the external malleolus from the tibia and its displacement outward in company with the foot. When the injury is caused by pure eversion of the sole the fibula is broken less obliquely and the internal malleolus is broken square across; when abduction of the front of the foot is associated with eversion, the fracture of the fibula is more oblique and rupture of the internal lateral ligament is much more frequent than fracture of the internal malleolus; if the latter occurs, it is oblique, the anterior portion only being broken off.

Fig. 110.



Usual Three Lines of Fracture in Pott's Fracture at the Ankle (Stimson).

The *symptoms* are the characteristic deformity (Figs. 111, 112), consisting in outward displacement of the foot and prominence of the internal malleolus, the existence of three points of localized pain on pressure corresponding to the three lines of fracture or the equivalent injuries, and the possibility of moving the foot from side to side within the widened tibio-fibular mortise. Occasionally the (broken) internal malleolus is forced through the skin and the joint thus opened, or if the displacement remains unreduced the skin overlying the malleolus may slough in consequence of the pressure. The foot has a decided tendency to slip backward, sometimes

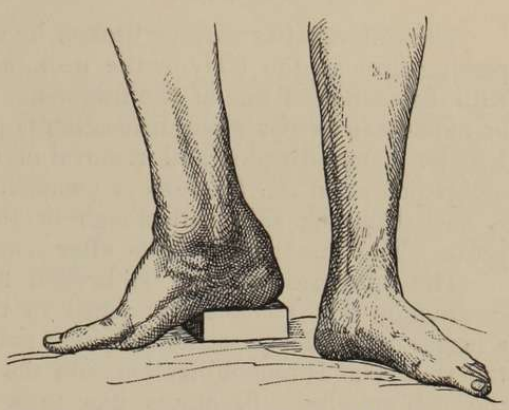
so far that the body of the astragalus lies entirely behind the tibia; and this displacement is frequently overlooked.

The essential point in *treatment* is to reduce the displacement completely and prevent its recurrence; the former is easy, and so too is the latter if suit-

Fig. 111.

Pott's Fracture, showing Outward Displacement.

Fig. 112.



Pott's Fracture, showing also Backward Displacement.

able dressings are used, but each requires close attention and full appreciation of the needs. Reduction is made by grasping the leg firmly with one hand and the foot with the other, and then, after lifting the latter forward, pressing it forcibly inward until the external malleolus is felt to rest against the tibia. An efficient dressing is made of moulded plaster-of-Paris splints, one of which is placed posteriorly from just below the knee, along the calf, the heel, and the sole, to and beyond the toes; the other begins on the dorsum of the foot, crosses the outer border and the sole, and is carried up the inner side of the leg; circular turns are placed above the ankle and at the upper ends of the splints. It is advisable to invert the sole of the foot, in order to make sure that the lateral reduction is complete. While the splints are hardening the foot must be held in place by the surgeon or by an assistant who appreciates the necessity and the means of maintaining the reduction, both inward and forward. This dressing is to be preferred to complete encasement in plaster, because it permits inspection of the region. Good results can also be obtained, though with less security, by the use of an internal lateral splint (Dupuytren's splint) projecting below the foot. A wedge-shaped pad is placed between this splint and the leg, the base of the wedge being just above the internal malleolus. The foot is then secured to this internal splint in adduction. Great care must be taken to protect the skin from too great pressure.

Fracture of the External Malleolus is caused by an inward twist of the foot, by which the astragalus is so turned in its mortice as to force the malleolus outward and break it. The line of fracture is lower than in Pott's fracture, and lies within the lowest inch or inch and a half; sometimes separation of the fibula from the tibia at the lower tibio-fibular articulation is produced instead of fracture, as shown by pain on pressure over the front of the joint; and, much more rarely, the tip of the internal malleolus is sometimes broken off by the pressure of the astragalus against it in the same twist of the foot. The diagnosis of the fracture of the fibula is made by local tenderness on pressure at its seat and on twisting the foot inward, and possibly by abnormal mobility

recognized by pressure inward against the tip of the malleolus; it is supported by the history of the accident and the appearance by the second or third day of an ecchymosis below the malleolus. No treatment is needed except rest and the support of a dressing to prevent the occurrence of another twist of the foot.

FRACTURES OF THE BONES OF THE FOOT.

The **astragalus** may be broken by a fall upon the foot, the line of fracture passing through the body or the neck, and the injury is frequently associated with dislocation of one of the fragments. An exact diagnosis may be difficult or impossible except when dislocation is present. The choice of treatment lies between immobilization and removal of one or both fragments; the latter is obligatory when the fracture is compound or when the associated dislocation is such that the skin will slough or that the subsequent disability will be great. The functional results after removal of the astragalus are very good.

The **calcaneum** may be broken by a fall upon the foot or by forcible contraction of the muscles attached to the tendo Achillis. In the latter case a larger or smaller posterior fragment is torn off and may be displaced upward; the treatment is immobilization with the knee and ankle so flexed as to relax the calf-muscles. Fractures due to a fall are usually comminuted, with depression of the central part of the bone; the diagnosis must be made upon the flattening and broadening of the sole and heel (which can be best seen by making the patient kneel and then comparing the soles of the two feet), and by the relaxation of the tendo Achillis. The treatment is by massage and immobilization, but the patient should be encouraged to use the limb as soon as possible.

Fracture of the Metatarsal Bones is commonly caused by direct violence, and is frequently compound; the first and fifth are the most frequently broken. The diagnosis is made by pain on pressure at the seat of fracture or on pressing the corresponding toe directly backward, and by abnormal mobility in the case of the first and fifth or when several toes are broken. In simple cases no treatment is required except rest, with the foot elevated, and massage.

CHAPTER IV.

DISEASES AND INJURIES OF THE MUSCLES, TENDONS, AND BURSÆ.

SECTION I.—DISEASES AND INJURIES OF THE MUSCLES.

The muscles, with very few exceptions, are situated beneath the external layer of the deep fascia. By virtue of their contractility they bind together and move the parts of the skeleton, contract and compress organs to which they are attached, and aid in the protection of vessels and nerves, and of the viscera in the great cavities. Their essential sarcous elements are held in place and maintained in proper relation by connective-tissue investments; their power is transmitted through inelastic fibrous bands—the tendons—in part inserted into the bones, in part blending with the periosteum or the great fascial planes. Like other structures, they are at times the seat of disease and injury, though much less frequently than might be thought probable from their number, size, and location.

MYALGIA.—Pain located in a muscle, and to a greater or less extent preventing its use, is of very frequent occurrence, and depends upon the action of many causes, such as strain, twist, or slight laceration of the fibres, acute infectious disease, poisoning, as by lead or syphilis, etc. Muscle-pain is the one common symptom. In the majority of cases it is neuralgic, but may at times be inflammatory. It is easily diagnosticated, and usually quickly subsides, either spontaneously or in consequence of the employment of heat, electricity, anodynes, or anesthetics; or it disappears with the removal of the exciting cause.

RUPTURE.—Blows from without or undue and sudden unopposed contraction may cause laceration, varying in degree from a tear so slight as not to be distinguishable from simple stretching to a complete pulpification; and in result from speedy and perfect recovery to destruction of the part or even to loss of life. Spontaneous rupture of healthy muscle can occur only when the contraction is sudden, unexpected, or of unusual character, as in the "lawn-tennis leg" or "arm" of those unaccustomed to that form of exercise. But when, in consequence of disease, especially typhoid fever, and, much less frequently, scarlet fever, yellow fever, or other acute grave pyrexia, the fibers have undergone granular or vitreous degeneration, their extreme brittleness makes it possible for rupture to follow voluntary movement of slight extent. The rectus abdominis, the rectus femoris, the adductors of the thigh, the calf muscles, the psoas, and the flexors of the forearm are those most frequently affected, and in the order given. Except in cases of laceration occurring in the progress of general diseases, the occurrence of rupture is generally indicated by a sudden sharp pain, accompanied with the sensation of snapping or of the "giving way" of something in the injured region, by a well-marked depression or a wide gap at the seat of injury, and by extravasation of blood, with the subsequent color-changes in the skin. The ability to use the muscle is either wholly or in great measure lost. Complete recovery may be expected when the laceration is but slight, and even when quite extensive the ultimate damage may not be great. When the abdominal muscles are the ones injured, intestinal obstruction, simulating strangulated hernia or peritonitis, may be developed.

In the **treatment** of these injuries the chief reliance must generally be placed upon rest and the approximation of the edges of the laceration by position and due compression. In rupture of healthy muscle sutures may advantageously be employed, but are of little or no value when the muscle has undergone degenerative changes, since the stitches will ordinarily quickly tear out.

HERNIA OF MUSCLE.—Occasionally, in consequence of the imperfect healing of a wound of the overlying deep fascia, limited protrusion of the muscle is observed to take place, with resulting impairment of muscular power. Such a hernia is readily recognized by the marked fulness in the region at the time of muscular contraction, disappearing when relaxation occurs, and by the detection of an opening in the aponeurosis, the rounded edges of which may readily be felt through the skin. In recent cases rest and methodical pressure will generally effect a cure. When the hernia has long existed the edges of the opening should be freshened and united by stitches. If, as is often the case, the inconvenience resulting from the presence of the hernia is but slight, the wearing of a bandage may be all that will be required.

MYOSITIS.—Muscle inflammation is almost always due to traumatism, to contiguous inflammation, to diathetic states, or to the presence of parasites. If consequent upon injury, it is usually a matter of but little importance in comparison with the other conditions dependent upon the traumatism. Sup-

puration rarely takes place unless the injury be of the psoas muscle, and when it does occur is usually followed by recovery. Occasionally, and especially in badly-nourished individuals, there occurs a diffused inflammation of great severity, almost always of septic origin, in which the affected muscle quickly breaks down, the patient generally dying speedily of septicemia. Only rarely can it be cut short by early free incision.

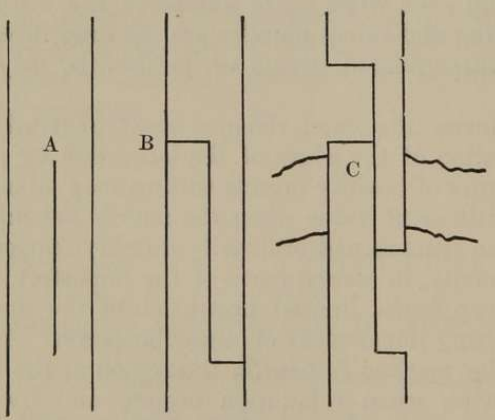
So-called rheumatic myositis (*myositis a frigore*, muscular rheumatism) often affects the muscles of the back, the chest, or the neck, and is generally attributed to sudden chilling of an exposed part. It is probably, in the great majority of cases, not an inflammation at all, but the result of a sprain or a twist of the muscle, the symptoms and treatment being those of myalgia.

During the course of a gonorrhea myositis has occasionally been observed, generally in the muscles in relation with an inflamed elbow or knee, such inflammation differing from the ordinary one only in its cause, which is probably a mild sapremia.

Unless associated with joint or bone disease, a slowly-developed chronic myositis is almost always syphilitic in origin. Generally in these cases the affected part is so much indurated that the hardness has been characterized as "woody." An exceedingly annoying myositis of the sphincter ani has been observed in syphilitics, in women more often than in men.

CONTRACTURES. (See also Orthopedic Surgery.)—Persistent shortening of a muscle—that is, the fixed approximation, more or less, of its points of origin and insertion, with resulting change in the position of the parts to which it is attached—may be due to the action of very many causes. Among these may be mentioned loss of substance, intra- or extra-muscular, followed by cicatricial contraction; inflammation, either traumatic, infective, specific, or toxic; contiguous bone or joint disease, with associated deviation from pathological causes or from gravity; weakened action of its proper antagonist; paralysis, with resulting connective-tissue sclerosis, due to a central lesion, either cerebral or spinal; reflex irritation from local injury, with or without retention of a foreign body; or it may be but a symptom of a general nervous affection, hysteria, chorea, etc.

FIG. 113.



Anderson's Method of Lengthening a Tendon.

As ordinarily met with in non-traumatic cases, it is associated with disease of the cord or brain, with infantile paralysis in children, or, much more rarely, with cerebral paralysis and intracranial hemorrhage in adults. In the former it is of late appearance, and is observed most commonly in the legs, chiefly because of diminished resistance by opposing groups of muscles. In adults it is either early, transitory, variable, increased upon voluntary motion, absent or greatly lessened in sleep, and irritative in character; or late, degenerative, increasing, permanent, and especially affecting the upper extremity. The face and neck, occasionally also the lower extremities, may be contractured, but never so alone. It produces, as a rule, abnormal flexions in the upper extremity, but extension

at the knee and ankle; when, however, the contractions occur in connection with chronic spinal inflammation there is strong flexion at the hip and knee.

When it is due to or indicative of an inflammation of a neighboring joint and is developed early, it is protective in character, producing such fixation of the articulation as is likely to lessen the disease in it by affording rest. Not seldom when unassociated with joint disease or paralysis a contracture will be found to be of syphilitic origin; and this is especially true of that affecting the biceps cubiti.

Lately Anderson and several other surgeons have simultaneously proposed to lengthen tendons by a definite amount in cases of contracture. Fig. 107 shows very well how this is accomplished by splitting the tendon, sliding one end up or down, and then suturing the ends, thus securing a definite amount of lengthening of the tendon.

Hypertrophy.—The enlargement of a muscle may be real, the sarcous elements being increased in number or in size; or apparent, due to change in the amount of fat or connective tissue or to an overgrowth of the lymphatics and blood-vessels. It may be physiological and consequent upon increased action of the affected muscle, as in certain classes of workmen, or associated with pathological states, when, as in the enlarged heart or the thickened bladder, it may be compensatory, and therefore to some extent salutary. Lessened use of the part, or rest, aided by compression, may effect a reduction in size.

In adults there has occasionally been observed a progressive muscular hypertrophy affecting chiefly the upper extremity, as a rule on one side only, which is usually attended with lessened rather than increased functional strength.

Atrophy.—Diminished size of muscles is of frequent occurrence, and may be due to disuse, to diseases of joints, to nerve-injury, to disease of the spine or the brain (rarely observed except when the pons is affected), or to a general depraved or poisoned state of the blood. As met with in connection with lesions of bones or joints, it is in great measure, if not wholly, due to reflex disturbance of the trophic nerves, and not to the enforced quietude of the affected part. Very often it is associated with degeneration, granular, pigmentary, fatty, or waxy, the latter two being the more common and the more important.

In the fatty degeneration there may be a substitution of fat for the true muscular elements, or, still oftener, for the connective tissue, occurring slowly and of limited extent, or, as in cases of phosphorus-poisoning, rapidly developed and largely generalized; or, as is much oftener the case, the fat may be present as an infiltration or accumulation in relation with the connective-tissue framework of the muscle. In the former, though the deposit may be absorbed and muscular redevelopment follow, there is generally permanent destruction of the affected fibers; while in the second either no effect is produced upon the contractile substance or it is affected only through pressure.

In certain of the acute infectious fevers, especially yellow fever and typhoid, in not a few cases of tetanus, and occasionally, though rarely, after nerve-injuries, the muscular elements appear as a transparent, waxy, very brittle mass which breaks up into cuboidal blocks, the connective tissue at the same time taking on increased growth. Pain, weakness, impaired function, and liability to rupture are the effects of this vitreous degeneration. It is always destructive to the affected fibers,—which may be few in number or may constitute the greater part or the whole of the muscle. In three diseases (progressive muscular

atrophy, pseudo-hypertrophic paralysis, and infantile paralysis) muscle atrophy is a strongly-marked symptom, of medical rather than surgical interest, except so far as resulting weakness and deformity, especially in infantile paralysis, necessitate the use of supporting and correcting mechanical appliances with or without operative interference.

Ossification.—Inflammation following long-continued irritation may result in the formation of bone in the belly of a muscle, or, as is more often the case, in its tendon, such, for example, as the bone-plates in muscles close to exuberant callus after a fracture, or as the so-called exercise or rider's bone, the latter being of not infrequent occurrence in the upper or lower tendon of the adductor magnus femoris. At times the ossification is of syphilitic origin. If it is in one of the superficial muscles, the bone-plate can readily be felt when near the attached end of the tendon, the only question being whether it is tendon, bone, or a true exostosis; but if deeply placed its existence remains undetected during life. To whatever cause it is due, the bony growth is permanent unless removed by operation. This may occasionally be rendered necessary by existing pain or impairment of function, which at times is consequent upon the size or location of the osseous mass.

A few cases have been observed of an early-commencing, slowly-advancing, general muscle inflammation, starting usually in the neck and back, in which after a time the atrophied parts become the seat of bone-formation, *myositis ossificans*, the cause of which is as yet undetermined. Generally very protracted in its course, it resists all treatment, death resulting from involvement of the respiratory muscles or from simple exhaustion.

Tumors.—These may be either benign or malignant, located in the belly of the muscle or in its tendon. The majority of those which are not sarcomatous or carcinomatous are of syphilitic origin, the specific disease affecting any muscle, but particularly the sterno-cleido-mastoid and the biceps cubiti. The malignant tumors are very rarely primary. In an interesting, though fortunately seldom observed, class the developing cause is parasitic—*i. e.* the presence in the muscle of the echinococcus, the cysticercus, or the trichina. The **diagnosis** will be based upon the history of the case and the recognition of a more or less well-defined swelling intimately connected with the muscle or the tendon; in the parasitic form the microscopic examination of an excised portion of the tumor will establish the diagnosis. The **treatment** will depend upon the nature of the growth, which will either be left untouched or taken out of the muscle, or removed with the part in which it has grown.

Wounds.—These may be either subcutaneous or open wounds. The former are sometimes accidental, but usually operative; the latter are most frequently incised or lacerated. Hemorrhage and separation of the edges are the chief symptoms, the latter, of course, being much more marked in complete than in partial transverse section. If protected from septic infection, their gravity is very slight, and unless there has been extensive loss of substance the repair functionally is very good, union taking place ordinarily through the medium of a connective-tissue scar, though when the wound is small and its edges have been early and closely approximated true muscular regeneration may occur.

The **treatment** consists in securing close apposition and in the maintenance of rest. Incised wounds and lacerated and contused ones in which the parts can be brought together, after trimming of the torn edges if necessary, should be united with catgut or silk buried sutures rather than treated simply by strapping and bandaging, since, when sepsis is prevented, the stitches do not readily tear out, and a quicker, closer repair is secured.

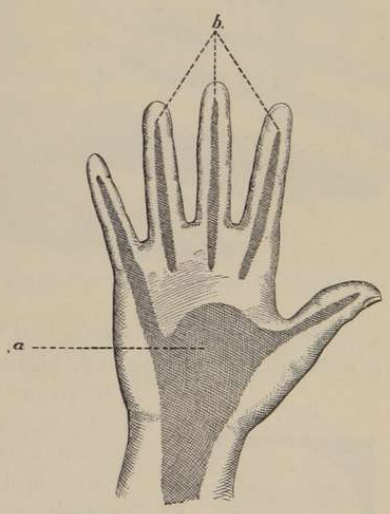
SECTION II.—DISEASES AND INJURIES OF TENDONS.

TENO-SYNOVITIS, OR THECITIS, AND PALMAR ABSCESS.—Inflammation of a tendon sheath may be either acute or chronic. The acute form is chiefly due to traumatism, and is suppurative or non-suppurative according to the presence or the absence of pyogenic microbes; the chronic form is of tubercular origin.

The *acute* form may follow a wound or a slight but frequently repeated contusion, as in certain classes of workmen, or it may result from a strain or be connected with rheumatism, syphilis, or gonorrhea. In the *non-suppurative* variety there are present pain and swelling along the course of the tendon, with early-developed crepitation, due to the rubbing of the exudation-lined surfaces. Such crackling disappears as the sheath becomes distended with fluid, to reappear again for a while as absorption takes place. The associated constitutional symptoms are ordinarily slight, except in cases of the special diseases mentioned, when they are those of such diseases. The duration of the affection varies, according to its severity and to the treatment, from a few days to three or four weeks, terminating commonly in complete recovery, though at times some dry crackling remains for a while. Rest and pressure by splint and bandage are usually all that is required in the way of *treatment*, though hot- or cold-water applications are often of service at first, and the use of the tincture of iodine is thought highly of by many. Opiates may be needed to relieve pain.

When the thecitis is *suppurative* the severity of the inflammation is great: unless free incision is promptly made, destruction of the sheath and its contained tendon will take place, often with wide extension of the disease along the tendon and in the neighboring connective tissue, followed, it may be, by general infection. The pain is intense and throbbing, the tenderness excessive, the swelling marked and rapidly developed, the overlying skin red, the constitutional symptoms of high grade. Elevation and rest of the part, as complete as possible, must be secured, and hot applications made; but the first and most imperative demand is for free opening of the sheath, curetting, and thorough antiseptic drainage and dressing. If, notwithstanding these measures, the suppuration extends, other and more free incisions must be made, and thus destruction be limited as far as possible.

FIG. 114.



Synovial Sheaths of Flexor Tendons of Fingers: *a*, general sheath common to the tendons in the palm and those of the thumb and little finger; *b*, separate sheaths of the fore, middle, and ring fingers (original).

The disease often affects the flexor sheath of a finger, and, unless promptly arrested, **palmar abscess** is very likely to follow. This danger is much greater if the disease attacks the thumb or the little finger rather than the other three fingers, since, while the proximal closed end of the sheath in the index, middle, and ring fingers (Fig. 114 *b*) is separated from the cavity of the general synovial sheath of all the tendons in the palm (*a*) about half an inch, the sheaths of the thumb and the little finger communicate directly with it. Whether secondary to teno-synovitis of the finger, or primary and due to direct infection and inflammation of the palmar fascia and the connective tissue under it, it is a serious matter.

It may be limited or general, according to the intensity of the infection, and is indicated by the presence of symptoms similar to those already mentioned as characteristic of thecitis—pain, swelling, restrained at first by the firm fascia, high fever, etc. Frequently a small superficial serous or purulent effusion early shows itself in the palm, which has often been mistaken for the real affection, to the serious injury of the patient because of the resulting delay in freely laying open the parts. If untreated, or it may be in spite of treatment, the pus may pass between the bones to the dorsum of the hand or under the anterior annular ligament, upward beyond the palmar pouch into the connective tissue of the forearm, along the planes of which it may be carried to or even beyond the elbow. Here, again, free incision must be made in the line of a metacarpal bone and disinfection and drainage secured. The incision may be made fearlessly up to a line transverse to the web of the thumb, as the palmar arches both lie above this line. Beyond that the vessels should be avoided, or if divided *both* ends must be tied. At the best, some stiffness of the fingers and impairment of the functional value of the part not seldom results, and the hand is often "griffed" (claw-hand). Necrosis of the carpus may occur, necessitating, at times, amputation; there may be troublesome, even dangerous, hemorrhage from the vessels of the hand or forearm; and in a small proportion of cases death takes place because of exhaustion or septic infection.

Chronic teno-synovitis, as has been stated, is a tubercular disease, presenting itself either as a firm swelling (Fig. 115) consequent upon the presence of a thick mass of granulation-tissue in and upon the sheath; a more or less distinctly fluctuating swelling in which there is less deposit upon the walls, but fluid in considerable quantity in the cavity of the sac; or a similar swelling containing in addition small firm bodies resembling rice-kernels (*riziform*, or *melon-seed bodies*, Fig. 116) attached to the walls or floating free. Tubercle bacilli in greater or less number are almost invariably present in each form of the affection.

Fig. 115.

Chronic (Tubercular) Teno-synovitis or Thecitis of the Sheaths of the Extensor Tendons (original).

Fig. 116.

Rice-kernel or Melon-seed Bodies from the same case (Fig. 115; original).

It is observed most frequently, indeed in nearly four-fifths of the cases, in the forearm. It may be developed in connection with any of the tendons, but especially those of the fingers and those in the vicinity of the knee and ankle. Though very slow in its course, particularly in the cystic varieties, its tendency is to extend upward and downward along the affected tendon (which in the fungous variety is invaded and in part or wholly destroyed), to attack other tendons in close proximity, and to pass into underlying joints. Frequently it is secondary to joint tuberculosis. As it is attended by little or no pain, for a long time it may cause

no material functional impairment. Very rarely it spontaneously disappears. The contents having broken down the sheath and escaped externally (and this is very much more common in the fungous variety), an ordinary tubercular abscess generally follows, the spontaneous or non-aseptic opening of which permits of infection by pyogenic organisms with resulting extensive suppuration.

The locality of the swelling, its more or less spindle shape, its slow course, and the little attendant inconvenience are the **diagnostic signs** of the disease in general; the degree of resistance to touch and the absence or presence of fluctuation, those of the variety, fungous or cystic; a peculiar crepitation elicited by pressure or upon movement indicates the presence of the riziform bodies. When located in the palm of the hand, affecting the several flexor tendons and extending up to the wrist, the swelling of this so-called "compound ganglion" is more or less hour-glass in shape because of the constriction made by the anterior annular ligament.

The **treatment** to be effective must be operative, by tapping and injection, by evacuation and scraping, or by excision. When there is but little thickening of the sheath and the contents of the sac are simply fluid, aspiration or limited incision, with injection of iodoform, will generally bring about a cure; when the melon-seed bodies are present the sheath must be laid open to such extent as to permit a complete evacuation and thorough scraping of the walls (in the palmar ganglion the annular ligament, if necessary, being divided and later reunited); when the case is fungous, relief can be afforded only by complete removal of all the infected tissue outside the sheath, in the sheath itself, and in the tendon. The parts should be rendered bloodless by the Esmarch bandage, so as to permit of the recognition and careful dissection of what must be taken away, and great care should be exercised to do as little damage as possible to contiguous healthy structures. If it becomes necessary to remove any considerable part of the tendon, much benefit will follow suturing to the upper end of the lower fragment a piece secured by splitting from the upper fragment and turned down. Relapses very often occur, and not seldom the patient ultimately dies of one form or other of visceral tuberculosis, In all operations for teno-synovitis and in the after-treatment it is of extreme importance to prevent sepsis, since pyogenic infection is very dangerous to the part and to life.

Paronychia, Whitlow, or Felon is an inflammation of a finger, rarely of a toe, consequent upon traumatism, usually of slight character; it may be but a scratch or prick or little abrasion, permitting of the entrance of septic germs. It may be of moderate or great severity according to the virulence of the organism and the general state and resisting power of the individual affected. It is more common upon the right than the left hand, and usually commences upon the last phalanx. It may be superficial or deep, in the latter case beginning as such or becoming so by extension from the under surface of the derm, favored in the pulp of the finger by the fibrous threads that tie it down to the bone.

The *superficial variety* is the more common and the least troublesome, affecting one finger or several in succession or at the same time, as is often the case in debilitated subjects, especially children, and located generally around and under the nail. The inflammation may be slight and subside quickly; or somewhat more severe, causing subepidermal serous or purulent effusions. The former is absorbed in a few hours or days; the latter is associated with ulceration, but soon heals, though often leaving a scar which is red and tender for some time. In much-enfeebled individuals the inflammation may be of a high grade, the pain intense, the swelling decided, the suppuration abundant, and may cause loss of

part or the whole of the nail and the development of fungous granulations, the disease often in neglected cases lasting for weeks or months until the necrosed nail is thrown off. The **treatment** varies with the severity of the inflammation. Rest and elevation of the part and cold applications are all that is required in the milder cases. The use of hot fomentations, simple or medicated, together with prompt and complete evacuation of the pus, is indicated when suppuration occurs. In the graver cases early incision and the administration of tonics and anodynes are necessary. Change of residence, if it can be effected, is useful. The nail must be removed as soon as it is evident that it must be lost, and iodoform, corrosive sublimate, carbolic acid, nitrate of lead, or other similar agent may be applied to the ulcerated surface.

The **deep whitlow** usually commences on the palmar aspect of the last phalanx, though it may originate in an injury of the second or first phalanx, or, more rarely, upon the dorsum. In a few hours it may be, or more commonly within a day or two, after the receipt of the injury, the finger becomes painful, tense, hot, and throbbing, with accompanying elevation of temperature and acceleration of pulse. These symptoms rapidly increase in severity, especially the pain and tension, and are both aggravated by the dependent position. Resolution rarely occurs, suppuration usually taking place. Associated with the deep collection of pus there is often a superficial abscess that may be mistaken for the real disease.

Though at times the application of cold, of the tincture of iodine, of carbolic acid, or of a blister has afforded relief, in the great majority of cases such **treatment** is of no value. Carbolic acid has been known to produce gangrene of the finger. So strong is the probability of the formation of pus, that it is better to employ hot antiseptic solutions or fomentations from the beginning, and if within two or at most three days decided improvement does not take place, free incision should be made—to the bone when it is the last phalanx that is affected, to the tendon when the first or second, since in the former locality the disease is almost certain to have gone down to the periosteum, while in the latter it very probably is as yet only a teno-synovitis, and the integrity of the tendon may be preserved by opening the sheath. The after-treatment should be thoroughly antiseptic. Often in spite of early incision and proper dressing necrosis of the last phalanx occurs. When it does, it is likely to stop at the epiphyseal line, and the dead bone can be removed later without opening the articulation. Necrosis of the second or first phalanx will generally necessitate amputation, though a tolerably useful finger may at times be secured by simple removal of the necrosed bone.

Ganglion.—Closely connected with a tendon, especially upon the back of the hand, there is often found a small round swelling, firm to the touch, at times almost as hard as bone, slowly developed as a rule, and causing little inconvenience except when in consequence of the occupation of the patient the tendon has been largely exercised. The contents of this swelling are a viscid honey-like fluid. At any period of its development the little swelling may disappear or cease to grow. Formerly regarded as a dropsy of the tendon sheath (hence a common name, "weeping sinew"), it is probably an outgrowth of the synovial follicles of these sheaths, more rarely of the synovial pouches or the subsynovial bodies of Henle, or perhaps it is a new growth, a colloid cyst, having nothing to do with the tendon sheath except that it lies in close apposition with it. It is **diagnosticated** by its shape, location, and feel, and is to be **treated** by subcutaneous evacuation or by excision. Generally the former method is adopted, though refilling of the sac often occurs. By pressure of the thumb a thin-walled ganglion may be readily burst, and even a somewhat thick-walled

one, by a smart blow. Preferably, however, the sac should be subcutaneously divided by a small knife or spear-pointed needle, and the contents pressed out alongside the instrument or into the surrounding tissue, when rapid absorption ordinarily takes place. When the tumor is very hard or very large, or there have been several recurrences, excision should be done, the sac being freely exposed and carefully dissected off the tendon. Under proper antiseptic dressing primary union may be expected.

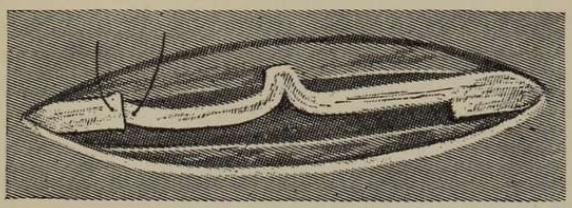
Rupture of a Tendon.—Sudden violent efforts are at times followed by rupture of a tendon, indicated by a snap which may be both felt and heard, by pain, by cessation of the action of the associated muscle, and often by a fall when the tendon is in the lower extremity. A gap at the seat of injury, increased upon extension, may frequently be recognized on palpation, and a depression may be seen. At the knee there will soon be marked effusion into the joint, and if the ligamentum patellæ is ruptured the patella may be more or less displaced upward. The rupture may be complete or partial, generally the former. The tendon of the rectus femoris above or below the patella, or the tendo Achillis in the lower extremity, and those of the triceps or biceps in the arm, are the ones usually torn. The **treatment** consists sometimes of approximation by position of the separated ends as much as possible, and maintenance of the same by splints, bandages, or apparatus until reunion takes place, which commonly occurs in from four to eight weeks. Generally, however, the better method is by suture, especially when the existing gap is a wide one or the tendon is that of a muscle in which contraction can be controlled only imperfectly or with great difficulty. In the leg especially operation is indicated unless great age or other contraindication exists. The old-time objections to exposing and operating upon a tendon no longer hold good, since septic infection can very generally be prevented. This is especially important at the knee, as the joint may be opened at the operation.

Wounds of Tendons.—These are either punctured, subcutaneous, or open. The former are of no importance unless accompanied by the entrance of pyogenic organisms, when they may be very destructive from the inflammation of the tendon, its sheath, and the surrounding parts. Subcutaneous wounds, when complete, as in the operation of tenotomy, are attended with a snap and separation of the ends, causing the formation of a depression both seen and felt; they are accompanied ordinarily with but slight hemorrhage and little pain. Repair takes place readily without any decided local or general disturbance, the connective-tissue callus being shorter or longer according to the amount of approximation secured. When formal tenotomy is done apposition of the ends is not wanted, and by position considerable separation is maintained, the functional value of the part ultimately becoming nearly or quite perfect. Open wounds are dangerous or not according as they do or do not become infected. If aseptic, they are quickly recovered from, and modern experience has so clearly demonstrated this that to-day, by preference, most such operations are performed openly in cases in which until recently the greatest care was exercised to prevent any extensive division of the overlying soft parts. After operative tenotomy the **treatment** is by position and pressure. After accidental division, however, the treatment should invariably be by suture, the stitch being of buried catgut or silk. At the wrist, where several tendons may be simultaneously divided, care must be taken that the two ends of the same tendon are united.

Tendon-suture may be done also in **old cases of rupture** or **wound,** even when extensive dissection is required to find and free the widely-separated ends buried it may be in a mass of scar tissue. If the freshened fragments

can be applied to each other, either end to end or overlapping, they should be stitched together, the sutures being drawn only sufficiently tight to maintain the apposition without making undue constriction of the included parts. If there has been too great loss of substance to permit such direct attachment, but the sheath ends can be united, this should be done, as redevelopment of the tendon will occur in the canal thus formed; or long catgut stitches may be used which will serve as a framework upon which the new formation can take place; or one of the pieces of the tendon may be longitudinally split for the necessary distance nearly to the end, and the detached half turned down and united to the other part of the tendon, the ultimate result being the formation of a tendon sufficiently strong fully to perform its physiological function (Fig. 117). Where this cannot be done, transplantation may be effected, either of another tendon from the same individual when there has been extensive injury of the part, or of one taken from a lower animal: in the latter case usually, if not always, the graft is absorbed and its place taken by a new formation. When only one end can be found and separated from the surrounding cicatricial tissue, it may with advantage be united to an adjoining uninjured tendon having the same general anatomical course; as, for example, the flexors or extensors of the hand and fingers or those of the foot and toes. In all cases of tendon-suture much advantage will be derived from the use of the Esmarch bandage during the operation, which will prevent the blood from obscuring the field of operation.

Fig. 117.



Czerny's Method of Tendon-suture when the Ends cannot be Approximated.

Displacement of Tendons.—Unassociated with fracture or dislocation, displacements of tendons are of rare occurrence. Consequent upon sudden muscular action or extreme violence the tendon is forced from its normal position, is quickly and spontaneously replaced, or remains luxated until returned by manipulation. The tendons of the peroneal muscles are those most usually affected, especially that of the brevis, which is not very seldom found thrown out of its bed behind the external malleolus and carried forward so as to be readily felt and easily moved upon the malleolus. Slight pressure will return it to its proper place, but it is held there with much difficulty and only imperfectly as a rule. The parts should be immobilized and a retentive dressing kept on until repair of the torn sheath or lateral ligament has taken place, if this can be secured. An aseptic suture or two may assist in retaining it in place. The late Dr. James R. Wood devised and carried into effect an operation for the relief of dislocation of the tendon of the peroneus, viz., tenotomy followed by fixation with plaster of Paris. Dislocation of the tendon of the long head of the biceps flexor cubiti occurs occasionally; White has reported and figured a case.

SECTION III.—AFFECTIONS OF BURSÆ.

In connection with some tendons and in close relation with most joints there are to be found bursæ, which are either normally present or acquired. The former are present at the time of birth or soon after; the latter are developed later in life in consequence of muscular action and friction. They may be superficial or deep-seated; many of the latter communicate directly

with neighboring articulations, especially in adults. As the result of injury and of diathetic affections these bursæ are frequently the seat of disease, giving rise to simple excess of fluid; to suppurations; to deposits, tubercular, syphilitic, or malignant; to thickenings; and to fibrous and calcareous degenerations.

BURSITIS.—The inflammations are acute, subacute, and chronic, the last at times succeeding to the second, but generally such from the beginning. When it is one of the superficial pouches that is affected, the prognosis is ordinarily good, though at times, because of neglect of proper treatment, extensive and destructive cellulitis results: when a deep-seated bursa is affected the prognosis is much more grave, since there is danger of the extension of the inflammation to the joint as the result of the affection itself or of the measures adopted for its relief.

Acute bursitis, due ordinarily to injury, at times to over-use, when superficially located, is indicated by pain or at least tenderness, skin-redness of varying intensity, and, particularly, by swelling, coming on rapidly and consequent upon excess of secretion, and, oftentimes, blood in considerable quantity. The peculiar location in relation to a tendon and the limited extent and globular form of the swelling serve to distinguish the disease from an ordinary cellulitis. The associated general symptoms may be of high grade. If suppurative, unless promptly arrested there is strong probability of extension to the connective tissue outside the bursa, with resulting increase in the severity of symptoms local and general. The deep-seated inflammations will often be mistaken for those of the joints near by; and, indeed, in a considerable proportion of cases they actually become articular after a little time, the bursa and the synovial sac either directly communicating or being separated by a thin wall that soon breaks down. Many of the extra-articular inflammations also doubtless originate in bursal disease.

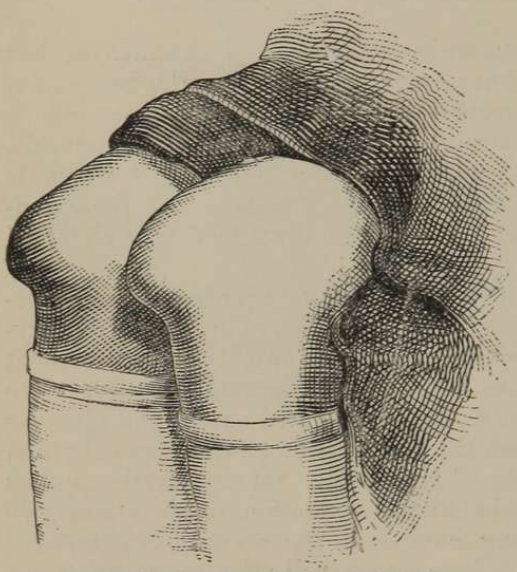
The local **treatment** is at first by rest, elevation, pressure, and cold applications; later, if the effusion does not rapidly diminish and the inflammatory symptoms do not subside, the sac should be aspirated, or, if pus is present, freely laid open, disinfected by pure carbolic acid, and dressed antiseptically until obliteration of the cavity has been secured. If the patient is rheumatic, gouty, or syphilitic, the ordinary general treatment of the particular diathetic state should be employed.

Chronic bursitis, of much more frequent occurrence than the acute variety, generally gives rise to little or no distress, and is characterized chiefly by swelling, due to sac distention, or to this combined with much thickening of the wall. At times the swelling is solid and of fibrous character, it may be, though rarely, bony. A very common locality is on the front of the knee, the prepatellar bursa being the one usually affected (Fig. 118). It is due to long-continued pressure and irritation, as in those who kneel much, and is known as **housemaid's knee**, as a similar affection of the olecranon bursa is spoken of as *miner's elbow*. The enlargement of the prepatellar bursa is median in position, is globular, usually fluctuates, and, unless it has become acutely inflamed, is painless or nearly so, though some weakness of the knee is often complained of. The subligamentous bursa is sometimes diseased, when the swelling shows itself on the sides of the ligament, the tension of which causes a central depression.

The **treatment** of the prepatellar enlargement is by aspiration or free incision; the latter, when aseptically done and when the resulting wound is aseptically treated, gives the best result. Instead of a median cut, small openings may be made on the sides and a drainage-tube carried through. When

suppuration has occurred lateral incisions low down are to be preferred to a central one, as they much more certainly secure drainage of the pockets on the sides where the bursa overlaps the inner and outer edges of the patella. If the sac has very thick walls or the mass is solid, it should be dissected out, care being taken in the removal to keep as close as possible to the outer surface of the swelling.

FIG. 118.



Double Housemaid's Knee (original).

The deeper *subligamentous bursal swelling* will ordinarily be treated by rest, together with pressure or the application of small blisters, and relief may be expected only after considerable time. The likelihood of existing communication with the knee-joint makes aspiration the preferable form of operative treatment.

Occasionally the bursa beneath the *semimembranosus tendon* is diseased, and when it has enlarged so much as to cause marked swelling, not only, as at first, near the inner border of the knee, but well out to or beyond the median line, the affection may easily be mistaken for an intra-articular one or for an aneurysm. The very general connection of this pouch with the synovial cavity, at least in adults, as a general rule contraindicates any operation other than aspiration.

As the result of abnormal pressure combined with malposition of the articulating surfaces there is frequently observed a bursal tumor over the metatarso-phalangeal articulation of the *great toe*, much less frequently over that of the little toe or over one of the other toe-joints. This is known as a "bunion" (Fig. 134). It may cause but little inconvenience, but almost always there is some tenderness in the part, and it is quite likely to become acutely inflamed. Then the pain is decided—and it may be excessively severe—the skin is reddened, the fluid in the sac much increased, and walking becomes difficult, and, it may be, impossible. When suppuration occurs the pus may break through the wall and cellulitis be developed, or a joint inflammation be excited and cause more or less destruction of the articulating surfaces. The treatment is that of acute bursitis in general—rest, cold, discutient lotions, tapping, or incision and prompt evacuation of pus. If either the surrounding connective tissue or the underlying joint has become infected, free incision should be made and the wound dressed antiseptically. Should the bone have become diseased, it must be removed by the sharp spoon or the gouge forceps, and the previous malposition of the toe corrected during the period of healing.

CHAPTER V.

ORTHOPEDIC SURGERY.

ORTHOPEDIC SURGERY has to do, properly, with the treatment of *deformities and contractions*, especially by some form or other of mechanical appliance, though of late its field has been somewhat extended so as to include the consideration of many deformity-producing joint affections.

TORTICOLLIS, or WRY-NECK, is a contracted state of one or more of the muscles of the neck, producing an abnormal position of the head. As ordinarily observed it affects, either wholly or chiefly, the sterno-cleido-mastoid muscle (Fig. 119), though the deep muscles are at times at fault, and in long-standing cases they are apt to be in greater or less measure involved. It is occasionally acute, and is then commonly due to either cold or trauma. But it is more commonly chronic, and is then spastic in character and dependent upon nerve-irritation. It has been produced by an habitual malposition of the head, assumed because of existing ocular defect. It is noticed commonly in young children: though rarely, it may be congenital and due to vertebral deformity or to injuries received at time of birth. If it first appears in adult life, as it does occasionally, though fortunately not often, instead of being spastic it is intermittent, spasmodic, and generally affects one or more of the muscles innervated by the spinal accessory nerve. When acute it generally passes away under the influence of rest, heat, and time, or it may become chronic and permanent. The spasmodic variety may disappear without treatment or after the employment of baths, friction, and massage, electricity, tonics, quinine (for it may be of malarial origin), change of locality, etc., or it may remain until stretching, section, or removal of a portion of the spinal accessory nerve be done; and even these operations may leave the patient little or no better than before.

FIG. 119.

Torticollis (original).

The **diagnosis** of the commonly observed spastic contraction of the sterno-cleido-mastoid muscle is easy: the head is turned to the opposite side, the chin is extended, the ear of the affected side is drawn downward toward the shoulder, and the muscle is in strong relief and abnormally firm. At times only one of the divisions of the muscle, and that more commonly the sternal, is markedly contracted. When the disease has been of long duration there is often decided atrophy of the corresponding side of the face. The posterior rotator muscles of the neck are probably involved, together with the sterno-mastoid. Pain is not usually present. Rectification of the malposition can often be effected, at

least to a considerable extent, voluntarily or by manual pressure, but at once recurs when the pressure is removed. When the deeper muscles are diseased there may be a question as to the existence of caries of the cervical spine, but the history of the case, the absence of bilateral rigidity, and the character of the deformity will generally suffice to indicate the nature of the trouble.

Having no tendency to get well of itself, the *spastic form* should always be treated either mechanically or by operation, followed by the application of proper retentive apparatus. Collars and braces of various kinds have been devised with the intention of holding the head in the improved position secured by forcible manipulation, and the plaster-of-Paris bandage over head, neck, and shoulders has been used for the same purpose. Often in the milder cases relief of the deformity may, in time, be secured by such appliances, but whenever the muscular contraction is well marked the tendon and the adjacent fascial bands should be cut, either subcutaneously or through an open wound. Until recently the former method was almost uniformly employed, being much safer and leaving but a very slight scar; but, aseptically made, the open wound is attended with little or no risk, and has the advantage of permitting a more complete division of the contracted tissues. The subcutaneous method will, however, often be preferred. The head being so held as to render the tendon tense, a small incision is made low down over its internal border; through this a blunt-pointed tenotome is carried to and along the under surface of the sternal portion, its cutting edge turned forward, and section made, after which, in the same manner, the clavicular portion may be divided if necessary. At times the sternal tendon can be cut upon the bone, thus avoiding the danger of wounding the anterior jugular vein as it passes behind the muscle a short distance above the sterno-clavicular articulation—an accident, however, of little moment, as the hemorrhage can be easily controlled by pressure and the clot will soon be absorbed. The internal jugular vein has been wounded, the knife having been carried too far back in the first stage of the operation.

As has been stated, for the relief of *spasmodic wry-neck*, affecting the sterno-cleido-mastoid muscle, the *spinal accessory nerve* may be stretched, cut, or in part removed, the latter being much the most promising procedure. To expose the nerve an incision may be made along the posterior edge of the sterno-cleido-mastoid muscle at its middle or along the anterior edge, beginning at the mastoid process and carried downward for about three inches: the muscle being drawn aside, the nerve can be readily lifted and a piece of it cut away. Exsection of one or more of the upper cervical nerves when the posterior muscles are affected necessitates careful dissection and somewhat extensive division of the trapezius and complexus muscles, and will not often be performed.

Contractures.—As has already been stated, there are at times observed in adults, as late phenomena of hemiplegic paralysis, contractures of the muscles of the arm, forearm, and hand, especially of the flexors: such contractures increase in intensity in proportion as the parts to which the muscles are supplied are farther removed from the trunk. As commonly seen, the arm is adducted, firmly held against the side (though occasionally it is abducted), the forearm is flexed upon the arm, the hand upon the forearm, and the fingers upon the palm; these flexions cannot be entirely overcome by either passive or active movements in extension. The deformity produced is proportionate to the degree of contracture, and ordinarily is not relieved by any treatment. Traumatic contractures due to wounds, not seldom to burns, and those consequent upon extensive cellulitis with loss of tissue and the formation of strong

cicatricial adhesions, are so variable in locality, extent, and force that each case must be treated according to its special indications, mechanically or operatively, by the use of apparatus or by stretching, rupturing, dividing, or by the plastic insertion of healthy tissue taken from a near or a remote part of the body or from a lower animal. At times the disability consequent upon the irremediable deformity is so great that amputation is done. For the treatment of contractures by lengthening of the tendon, see p. 328 (Fig. 113).

Contraction of the Palmar Fascia (*Dupuytren's contraction*) (Figs. 120 and 121), producing permanent flexion of a finger or fingers, is at times

Fig. 120.

Dupuytren's Contraction of the Palmar Fascia (Keen).

Fig. 121.

The Same Hand after Operation (Keen).

met with, generally in individuals beyond the middle period of life, much more frequently in men than in women. It affects indifferently either hand, sometimes both. The ring or the little finger or both are most frequently flexed; next the middle finger; the thumb and the index more rarely. The degree of flexion varies with the case and the length of time that the disease has existed.

It is not the flexor tendons that are contracted, as was formerly believed to be the case, but the palmar fascia and its digital prolongations, together with the fibrous bundles uniting the fascia and the overlying skin, which latter is involved only late and secondarily if at all. Beginning usually as a small hard nodule at or near the line of the metacarpo-phalangeal articulation, the disease extends more or less slowly both downward and upward, with corresponding drawing down of the affected finger or fingers, until in very severe cases the finger-tip is strongly and steadily held against the palm. Its occurrence has

been attributed to the action of various causes,—slight traumatisms frequently repeated, the rheumatic or gouty diathesis, reflex nervous irritation, etc.; but which of these is its real cause, or whether it depends upon any single cause, has not been determined. It certainly seems to be most frequent in those who are rheumatic or gouty. A recently-reported cure by hypnotic suggestion, as far as it goes, gives support to the nervous theory.

The **diagnosis** is easily made: the thickened elevated band in the palm extending to the sides of the finger, the marked flexion resisting strong efforts at extension, the absence of pain, the slow development of the condition, the age of the individual, the non-existence of cerebral or spinal disease, or of injury of the extremity followed by loss of substance and resulting scar-contraction,—all taken together render it impossible to mistake the nature of the affection.

Treatment.—Left to itself, the palmar contraction always gets worse, and it can be relieved only by operation. Such operation may be either subcutaneous or open. If the former, the contracted bands are divided by a tenotome at a sufficient number of points, and the attachments to the skin separated until full extension of the fingers can be secured, after which a retaining splint and bandage are applied and worn until healing has taken place, and for a considerable time longer during at least a part of each twenty-four hours. The fingers for a few days should be slightly flexed, and later completely extended. In the open operation the skin may be divided by a linear wound or reflected in a V-shaped flap, base downward, and the contracted tissue dissected out, or the bands divided sufficiently freely by cross cuts at different levels—an operation which of late years has been frequently done with entire success.

Club-Hand (Fig. 122) may occur congenitally as the result of defective osseous development, or later because of wounds attended with much loss of substance in the soft parts or the bones of the forearm or carpus, or of paralytic contractions. There is a deviation, lateral, anterior, or posterior (very rarely the latter), similar to that in the lower extremity constituting club-foot, and hence known as club-hand. Generally the hand is drawn over in flexion and toward the radial side. It is often present at birth, or has followed extensive resection of the lower part of the radius or ulna or of the carpus. Little or no relief can usually be afforded, though early and persistent manipulation, with the use of a retentive dressing, plaster or instrumental, has occasionally been followed by decided improvement in the position and usefulness of the hand. Always after bone-removal, especially of the lower end of the radius, care must be taken for many months to prevent the deflection of the hand, otherwise likely to occur, by passive and active movements, and, if necessary, by the employment of a suitable apparatus. Tenotomy ordinarily has done little good, and at times has done harm.

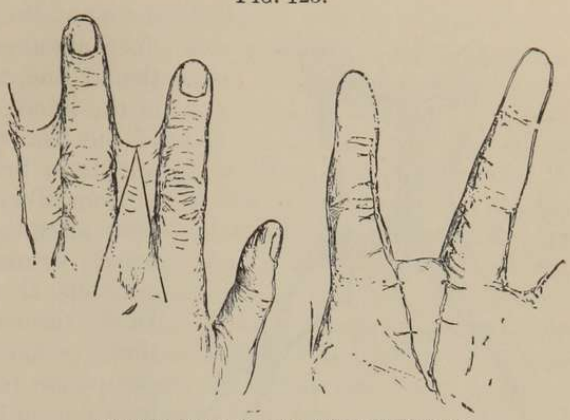
Fig. 122.

Double Club Hand (original).

Webbed Fingers (Syndactylism) is a congenital affection. It may affect two or more fingers on one or both hands, the union extending to any point, even to the tips. There may be a wide web of skin with but little connective tissue within, or a narrow and thick one, or the phalanges of the two fingers may be in close apposition. Frequently the deformity is a family peculiarity, running back through three, four, or more generations. If only two fingers are united, they are usually the ring and middle ones. The strength and use-

fulness of the hand are often but little impaired. Simple division of the web rarely gives other than temporary relief, the web re-forming from the bottom as the wound heals. To prevent such re-formation a flap of skin may be fixed in the angle between the separated fingers (see Fig. 123), or a small hole may at first be made at the level of the edge of the normal web, in which a thread or a button may be placed and retained until the edges of the cut have healed, after which the remainder of the web may be cut through.

Fig. 123.

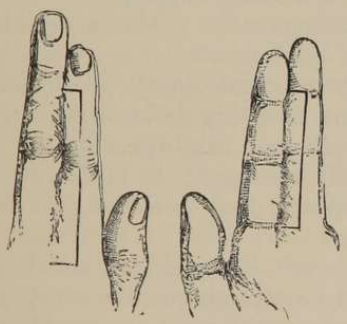


Agnew's Operation for Webbed Fingers.

The most satisfactory operation is Didot's, in which a flap the length of the finger and half its width, with the added width of the web, is taken from the dorsal surface of one finger and the palmar surface of the other (thus splitting the web and separating the fingers), and each carefully applied over the denuded portion of the finger to which it is attached, securing a normal skin covering of the surfaces that are to be in apposition (Figs. 124, 125).

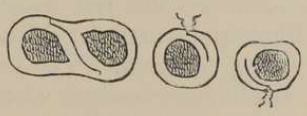
Supernumerary Digits (Polydactylism) are also congenital, are not infrequent, and, like webbed fingers, in many cases are hereditary. They are generally symmetrical, and often present on both hands and feet. Usually there is but a single digit in excess, commonly on the side of the little finger or little toe; though not rarely the thumb, much less often the great toe, is double. The development may be complete, even to an extra supporting metacarpal or metatarsal bone, or it may be more or less imperfect, so that the supernumerary digit is scarcely more than a rudimentary nodule connected with the side of a phalanx. When perfect it is most often attached at a greater or less angle to the broadened end of the metacarpal or metatarsal bone of the normal finger or toe, though at times the normal and extra digit are very closely apposed, or even fused, and held in a common envelope of skin. At times the connection with the hand or foot is by a fibrous band of varying length and firmness. It may be amputated at any time, but if not closely fused with the adjoining digit it is best to remove it very soon after birth; and even if so fused, it should be taken away while the child is still quite young, to lessen the resulting deformity. If there is a completely formed hand or foot, with an extra metacarpal or metatarsal bone and corresponding digit, no operation need, or indeed should, be done.

Fig. 124.



Didot's Operation for Webbed Fingers (Walter Pye).

Fig. 125.



Transverse Section, showing flaps before and after suture.

Genu Valgum, or Knock-Knee (Fig. 126).—This is the result of overgrowth of the internal condyle and curving inward of the shaft of the femur in its lower part, with associated relaxation and elongation of the internal lateral ligaments of the knee-joint. These changes produce an abnormal inclination of the interarticular line, more or less close approximation of the knees, and more or less wide separation of the feet, the individual in standing being unable to bring the heels together.

Fig. 126.

Genu Valgum, or Knock-Knee (Bradford and Lovett).

It usually manifests itself in early childhood, soon after the child begins to walk, but may not do so until about the period of puberty, or even, though rarely, much later in life. In the former case it is a rhachitic manifestation; in the latter, it is consequent upon an occupation requiring long-continued standing by a person of feeble muscular and ligamentous development. Often there is associated flat-foot, which, indeed, at times may be the primary and causative lesion. It may affect one or both knees, may be so slight as to escape detection except upon very careful examination, or so severe as to cross the knees, separate the feet very widely, and render locomotion difficult and the gait wabbling. In children other evidence of the existence of rickets will commonly be found.

The **diagnosis** is made on sight, except in the mildest cases.

Left to itself, when not severe it often spontaneously improves as the rhachitic state passes away and the general strength increases. This favorable termination is common in the static knock-knee of adolescents.

The earlier, however, that **treatment**, general and local, is begun, the speedier will be the recovery and the less the resulting deformity. The ordinary medicinal and hygienic treatment of weak and rhachitic subjects is the appropriate one for young children. The local treatment is mechanical, supplemented by baths, frictions, massage, electricity, and preceded, in the severer cases, by osteotomy.

If the rickets is still active and the bones are soft and yielding, standing and walking should be forbidden, the limb should be straightened as much as possible by manipulation, and maintenance of the correct position should be secured by an outside splint and bandage. Later, when the bones have become firmer, great benefit often follows the use of such a splint with a counter-pressing pad on the inside, the resulting change in the relative positions of the articular surfaces of the femur and tibia permitting the increased growth of the external femoral condyle with restriction of that of the internal. Plaster of Paris is an excellent material for this splint, or the limb may be completely enveloped in it.

Immobilization with the leg flexed at a right angle with the thigh is, by many, preferred to that in the straight position, as the deformity is much lessened by the flexion. Forcible rectification followed by immobilization has often been followed by great improvement, there being produced in the rapid straightening an epiphyseal separation of greater or less extent or a laceration of the external lateral ligament. But if sufficient force to produce such condition is required, it is better instrumentally to break the thigh at a determined level or to divide the bone with saw or chisel, especially as severe injury to the soft

parts and the joint structures has at times been produced by the former method. Braces of various kinds have been devised, all intended to correct the deformity and allow the patient to go about, and many of them are of much service in very young children.

If the knock-knee is great and the bones are firm, no material change for the better can be effected without operation, either fracture (osteoclasis) or section (osteotomy), of which the latter is to be preferred, fracture requiring the use of a special apparatus, and not always being produced at the desired place. Section may be so done as to separate the internal condyle or divide the lower portion of the femur, which latter is the operation ordinarily performed. A small longitudinal incision being made down to the bone, half an inch or a little more above the adductor tubercle, the osteotome is introduced, turned at a right angle, and by successive blows of the hammer driven toward the outer side, being so moved upward and downward as to secure division of the entire thickness of the bone for three-quarters or four-fifths of its transverse diameter, the uncut portion being readily broken by moderate force. The limb is then to be straightened, an antiseptic pad applied, a layer of cotton put on, and immobilization made by plaster of Paris. Little or no reaction ordinarily follows: in about a month the dressing may be taken off, and after two or three weeks' additional rest the patient is allowed to walk. Though the operation is not altogether devoid of danger, since there may be serious hemorrhage from a divided popliteal or anastomotica magna artery, or from the bone itself, or a resulting aneurysm or gangrene, causing death or necessitating amputation, or damage inflicted upon the external popliteal nerve, yet the likelihood of these accidents is very slight, and may be practically disregarded in deciding upon the advisability of making the section. (See Osteotomy.)

Genu Varum, or Bow-Legs (Fig. 127), the opposite of genu valgum, is a deformity usually affecting both limbs, in which the knees are more or less widely separated, the joint surfaces are in such relation to each other that the angle between them points outward, and the chief pressure is between the internal condyles. Except in a very few cases there is outward curvature of the femur and tibia, or of the tibia alone, with at times an anterior bend of the latter bone. The curves of the two legs together may form an almost complete circle. A line drawn from the center of the femoral head to the ankle is internal to the knee. The disease begins in early childhood and is of rhachitic origin, and the deformity is the direct result of the weight of the body and muscular action. Inspection at once reveals its existence, which is further indicated by the turning in of the feet and the rolling walk. In elderly persons suffering from osteitis deformans there may be a bow-legged condition which is a part of the general bone disease, and is irremediable.

Fig. 127.

Genu Varum, or Bow-Legs (Bradford and Lovett)

Treatment.—Spontaneous correction sometimes occurs, much more frequently than in genu valgum; but if the case is at all severe and the child so young that the bones have not become firmly set in the abnormal curves, mechanical treatment should be employed to bring the limbs in toward the median line. This may be by plaster or braces, according to circumstances. In older patients the bones are too strong to yield to any such pressure, and correction of the deformity can be made only after fracture or section. Though

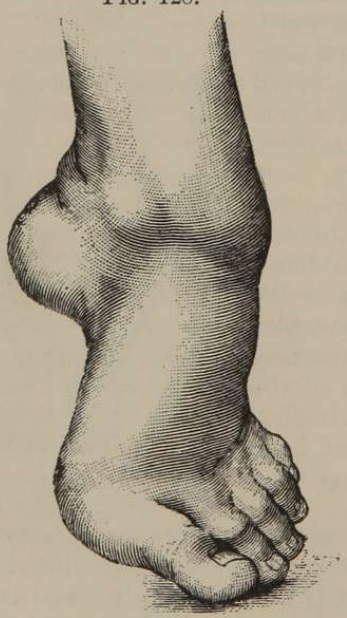
osteoclasis by the aid of one or other of the instruments now employed gives better results than in cases of genu valgum, yet osteotomy is the operation that is generally done, linear division being effected at such levels as the condition of the individual case may indicate. The method of operating and the after-treatment are the same as in knock-knee.

Turning in or turning out of the knee consequent upon paralysis or vicious union after fracture requires no special consideration. Each case must be treated according to its character, medically, mechanically, or operatively.

Antero-posterior Curvature of the Legs is another of the deformities due to rickets which in its aggravated form can be relieved only by operation. When slight and detected early, it may be expected to disappear, either without treatment or more probably under rest and appropriate fixation dressing; but in neglected cases, in some of which there is excessive bowing, linear or often cuneiform osteotomy must be done on one or both bones according to circumstances. In the performance of the latter the summit of the curve in the tibia is freely exposed by a longitudinal incision of sufficient length. By a saw or chisel a wedge, with its base anterior, is cut out of the tibia, after which, if necessary to the straightening of the leg, the fibula is broken or instrumentally divided. Tenotomy of the tendo Achillis also is generally needed. Proper adjustment having been made, the limb is immobilized and quietude maintained until repair and consolidation are completed. The operation and dressing must be done aseptically, that suppuration may not take place, which will always materially lengthen the period of treatment. There is a risk, but not a great one, of wounding the anterior tibial vessels or nerve.

Club-Foot, or Talipes, is a non-traumatic deviation of the foot in the direction of one or other of the four lines of movement—extension (*T. equinus*, Fig. 128), flexion (*T. calcaneus*, Fig. 129), adduction (*T. varus*), and abduction (*T. valgus*),—or of two of these combined, as in equino-varus (Fig. 130). It is due either to under- or over-action of muscles or to abnormal position,

Fig. 128.



Talipes Equinus (Albert).

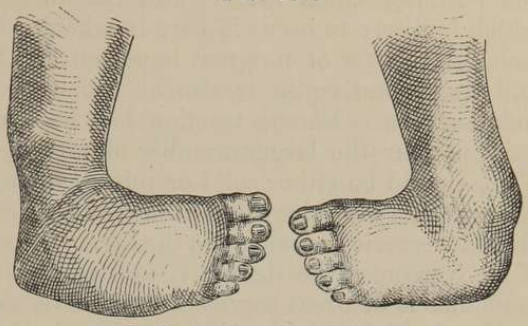
Fig. 129.

Talipes Calcaneus (Albert).

shape, or relations of one or more parts of the skeleton of the foot. It may be either congenital or acquired, in the latter case being generally developed in early childhood and the result of infantile paralysis (acute anterior poliomyelitis).

In the congenital variety the displacement is almost always one of adduction, with commonly some elevation of the heel (TALIPES EQUINO-VARUS, Fig. 130). Generally affecting both feet, it may be confined to one, the right oftener than the left. The inner border is raised, the sole turned toward the median line of the body, the heel more or less lifted, the distal part of the foot flexed upon the proximal part at the mid-tarsal articulation. The degree of deformity varies from that which is but little in excess of the natural inclination of the foot of the new-born infant up to so great rotation that the weight in the erect posture is borne upon the upper and outer part of the dorsum. At the time of birth and for some months afterward the deformity can usually be easily corrected by manipulation, but later, if left to itself, it becomes in greater or less measure fixed, in consequence of muscular contraction and developmental changes in the shape of the bones.

FIG. 130.



Double Equino-varus (original).

As to its **cause**, there has been much question. It has been attributed to uterine pressure, to intra-uterine disease of the cerebro-spinal axis with resulting paralysis and arrests of development (it is not seldom associated with malformations of the head, the face, the spine, the abdominal wall, or the pelvis), and to persistence of the earlier fœtal position of the foot, the later normal rotation of the leg and foot, or at least of the latter, not having taken place—an explanation that seems, at present, the most likely to be correct. In a considerable number of cases it is a family peculiarity, either in the ascending line or affecting several children of the same parents.

The **diagnosis** is easy, and the **prognosis** good if proper treatment is promptly adopted and steadily maintained for a sufficient length of time, though even under the most favorable circumstances the ultimate development of the foot is not what it would have been had the deformity not existed.

The **treatment** must be either manipulative or mechanical, or both. In those cases—and they are the majority—in which at birth and soon afterward the foot can readily be brought into proper position by hand-pressure, such pressure, could it be steadily maintained, would in time relieve the deformity. As this cannot be done, some substitute for it must be found, and that is best which most nearly approaches it in evenness and gentleness of pressure. Simple bandaging or the application of adhesive straps has been used, and, at times, with success, but immobilization of the foot and leg by plaster of Paris or gutta-percha is very much better, the parts being protected by cotton and the dressing carried sufficiently high up to prevent its ready displacement. Frequent removals and reapplications of the plaster will be required. Very rarely in these young subjects is there such tendon contraction as to necessitate section. The earlier the deformity is corrected and the foot held in right position the better. If the case has been neglected and nothing done until the child has begun to stand and walk, the malposition may

still be corrected by manipulation and overcome by immobilization, but with much more difficulty. Decided retraction of the heel may often in this way be relieved, but considerable time will be required—time which may be saved by tenotomy. The tenotome is introduced by the side of the tendo Achillis (rendered as tense as possible by flexion of the foot), carried underneath it, its cutting edge turned against it, and division made by pressure and a slight sawing motion. There are but two dangers in this operation, that of wounding the posterior tibial artery, and that of freely dividing the skin, neither of which is likely to occur if care is taken. If either accident does happen, it is usually a matter of no great importance. Pressure will stop the flow of blood, and under antiseptic treatment the open wound will quickly close without inflammation. Elastic traction has been employed with much benefit.

Upon far the larger number of these patients club-foot shoes are applied. They should be either solid or jointed opposite the middle tarsal articulation to permit of any required lateral movement of the parts in front. The side-pieces should be carried nearly up to the knee. If properly made, adjusted, and watched, if it overcomes the deformity and maintains the correction, such mechanical appliance is of great service. But as very often used it is of little or no benefit, frequently a positive injury, since it is put on by an instrument-maker or dealer uninformed in anatomy or pathology, and makes uneven pressure, produces callosities and ulceration, fails to hold the foot in proper position, frequently breaks and gets out of order, thus necessitating expense that can be ill afforded, and is often worn long after it should have been thrown away and a new one applied. Much better results will be secured by the average practitioner, and especially among the poor, by plaster-of-Paris immobilization than by the use of a club-foot apparatus.

Before a proper mechanical appliance can be put on, forcible correction under anesthesia may have to be made, together with tenotomy of the tendo Achillis, of the tibial tendons, anterior or posterior or both, and of the plantar fascia. In the aggravated long-standing cases in which there has taken place marked change in the shape of the bones, in the length and position of the ligaments, and in the connective tissues of the foot, rectification cannot be effected except after operation upon the bones or soft parts or both. A wedge-shaped piece may be taken out of the tarsus (cuneiform osteotomy), or the cuboid, the scaphoid, or the astragalus may be removed, or a free transverse incision may be made through all the soft parts of the sole of the foot, which has been done many times of late and with great benefit (A. M. Phelps). Removal of the astragalus gives an excellent result, preferable to that secured by osteotomy. Always after operation a proper retentive apparatus must be applied and its use continued for a long time.

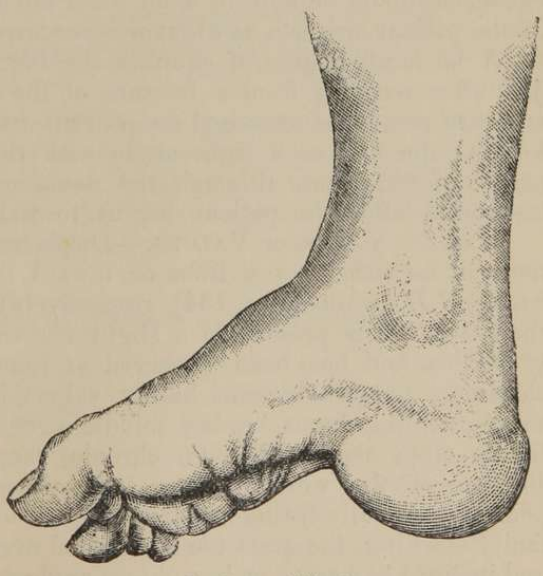
Non-congenital Talipes, as has been stated, is almost always of paralytic origin. It may affect one foot or both, and when double, unlike what is true of the congenital variety, the deviation may be in opposite directions. It may be noticed as soon as the child begins to walk, or may appear later, according to the time at which the spinal disease occurs. There is usually decided elevation of the heel, with less lateral deviation than in the congenital cases, or, it may be, none at all, and passive movements at the ankle and middle tarsal joints are readily made until spastic contractures of the muscles limit or prevent them. This freedom of movement, together with the coldness of the parts and marked atrophy of the leg and foot, and at times the associated paralytic or paretic state of the upper extremity, serves to differentiate the affection from the congenital form. The **prognosis** is less favorable than in the latter, because of the causative muscular paralysis.

The **treatment** is much the same: rectification of the malposition by manipulation, gentle, forcible, or after tenotomy according to circumstances; and maintenance of the proper position by immobilization or by apparatus. The latter has the advantage of permitting the employment of massage, the douche, electricity, and supplementary elastic traction; all of which should be combined with the operative and mechanical treatment.

Talipes Valgus, generally non-congenital, is characterized by flatness of the foot, abduction of its anterior part and more or less elevation of its outer border, from yielding of the arch. It occurs ordinarily in feebly-developed persons, especially children, being the result of weight coming upon a foot unable to sustain it, and may be associated with rickets, spinal curvature, knock-knee, or badly united fracture. In the aggravated cases decided displacement of the tarsal bones occurs, especially of the astragalus and the scaphoid, together with changes in the ligaments uniting the os calcis, the astragalus, and the scaphoid. In children pain is commonly absent, but in adults it is often complained of after long standing or walking, and upon pressure there is generally found to be tenderness in front of the inner malleolus, over the junction of the astragalus and scaphoid, and over the proximal ends of the inner and outer metatarsals. The **treatment** is both general and local, consisting of tonics, gymnastics, frictions, massage, and the douche, and especially the use of a supporting steel plate as a substitute for the normal arch. Under such treatment the prognosis is good. When there is present simply a weakness of the ankle, support should be given either by a leather or steel anklet or a brace shoe.

Talipes Calcaneus (Fig. 129) is not seldom seen as the result of infantile paralysis, and occasionally at the time of birth. It consists of a deviation in the direction of flexion, the patient walking upon the heel with the anterior part of the foot raised, with or without some associated abduction. Relief may often be afforded by manipulation alone, and generally by fixation by bandages, a shoe, or a shoe and brace. Tenotomy will seldom be required. In a few very severe cases a portion of the tendo Achillis has been removed and its shortening thus secured.

Fig. 131.



Pes Cavus (Albert).

Pes Cavus, or Hollow Foot.—As the result of contraction of the peroneus longus or of the deep muscles of the foot, or of paralysis of the calf muscles, marked exaggeration of the arch, with approximation of the heel and the heads of the metatarsals, is occasionally produced. This is known as pes cavus (Fig. 131)—a condition which may be somewhat relieved by a steel sole-plate with counter-pressure over the dorsal prominence. In the comparatively few cases in which the deformity is the result of disease or injury with subsequent contraction, cicatricial or otherwise, the deviation varies with the cause, and may require for its relief the use of some mechanical

appliance or operative treatment—tenotomy, section of the plantar fascia, free incision, resection, or amputation.

Pes Planus, or Flat-Foot is due to an obliteration of the normal arch of the foot, and is therefore the opposite of pes cavus. The **diagnosis** of these two conditions is generally easily made, not only by observing the arch of the foot, but also by wetting the foot-sole with a colored solution and making the patient step once squarely on a piece of white paper. In the normal foot-sole (Fig. 132) the broad impression of the ball of the heel and that of the balls of the toes is connected by a moderately wide isthmus along the *outer* border of the foot. In pes cavus this isthmus disappears, and in pes planus (Fig. 133) it is greatly broader than it ought to be. The condition is often associated with talipes valgus and lateral curvature of the spine.

Fig. 132. Fig. 133.

Print of a Normal Foot-sole. Print of a Flat Foot-sole. (Albert.)

The **cause** is usually general weakness, combined, as a rule, with long-continued standing, as in mill-girls. Walking, unless very excessive, rarely produces it, as this tends to strengthen the foot. The chief **symptom** is pain, which is produced and is aggravated by standing, and often makes this posture impossible for any length of time. The best **treatment** is a general constitutional tonic treatment, looking to greater vigor of frame, less by drugs than by hygienic means. Locally, a steel artificial arch under the sole, with an internal lateral offshoot, will generally give much relief, and may even cure.

Hysterical Club-Foot is at times observed, and the possibility of its existence should be kept in mind when the age, sex, and neurotic temperament of the patient are such as to favor its occurrence.

A moderate degree of equinus, the pointed toe, is frequently met with just after recovery from a fracture of the lower extremity, and care should be exercised to prevent its development by keeping the foot at a right angle with the leg during the period of treatment, although the deviation ordinarily soon disappears after the patient begins to walk about.

Fig. 134.

Hallux Valgus and Bunion (Bradford and Lovett).

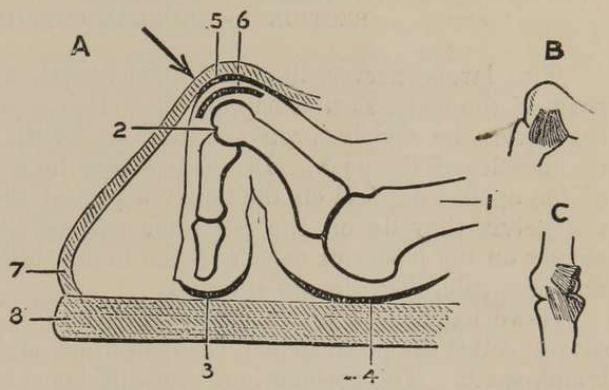
Hallux Varus, or Valgus.—Displacement of the great toe may be either away from or toward the other toes (*H. varus* or *H. valgus* (Fig. 134), respectively), most frequently the latter. It is present to a slight degree in the majority of adults, and has been observed at times even in young children; but troublesome hallux valgus is met with, as a rule, only in persons beyond middle age, and in advanced life is often associated with chronic rheumatoid arthritis. Because of the wearing of a too narrow, too short, too pointed, or badly-fitting shoe, or not seldom of a similarly faulty stocking, the great toe is crowded over upon the others and inclined at a more or less obtuse angle with the inner border of the foot. As a result, the normal relations of the bones of the metatarso-phalangeal joint are disturbed, and the pressure of the shoe causes bunion and periosteal irritation, and may even give rise

to destructive inflammation of the soft parts and bone. Pain and disturbed locomotion are common in the more severe cases.

The **treatment** is either mechanical or operative. In the first case an apparatus is applied to draw the toe to its proper place and hold it there, and at the same time protect the bunion from pressure; in the second the articular extremities of one or both bones are removed with the saw or the cutting forceps—*i. e.* complete exsection of the joint. Another plan of treatment which often gives good results is division of the metatarsal bone, often the only satisfactory method of treatment. A properly-shaped and well-fitting shoe should always be worn afterward. The use of such a shoe from childhood on will prevent the production of the deformity.

HAMMER-TOE.—There is observed at times a permanent angular flexion of one or more of the toes, especially the little and second, at the first phalangeal articulation, the third phalanx being either in line with the second or in extension or flexion on it. The first phalanx is usually extended. Thickening over the phalangeal joint is generally present, bunion may be developed, and partial luxation often occurs (Fig. 135). This is known as hammer-toe, and is the result of contraction of the plantar fibres of the lateral ligaments of the joint (Shattuck). Beginning usually in later childhood, and oftenest in boys, the deformity is the cause of much inconvenience, and at times of actual suffering. Relief is afforded only by operation. The lateral ligaments have been divided, and subcutaneous and open division of the soft parts on the under surface of the first phalanx done, but, as a rule, without satisfactory result. Either the toe should be removed or, what is better, the joint excised. A similar disorder exists in the hand, known as *hammer-finger*.

FIG. 135.



Hammer-Toe: A, a diagram of the position of lines in hammer-toe: 1, metatarsal line; 2, head of the first phalanx; slight groove corresponding to position of dorsal border of second phalanx; 3, 4, 5, callosities due to boot pressure; 6, bursa over contracted joint; 7, 8, shoe (the arrow indicates the direction in which the pressure of the upper leather tends to force downward the head of the metatarsal line toward the sole); B, dissection of first interphalangeal joint in hammer-toe; C, the same preparation after section of plantar fibres of lateral ligaments (Anderson).

CONGENITAL DEFORMITIES BY EXCESS AND DEFICIENCY.

In both the upper and the lower extremities there are occasionally observed errors of development producing abnormal enlargement of a part or the whole of a limb, or, more frequently, deficiency, due either to arrested growth or absence of an anatomical segment, or both combined, the result being a malformation affecting the functional value of the extremity in any degree from the slightest to the most extreme. The hypertrophies other than of a finger or toe are not amenable to treatment. The use, if necessary, of a raised shoe may overcome the asymmetry in length of the lower extremities. The finger or toe of excessive size, in which generally not only the bones but also the soft parts, especially the blood-vessels and lymphatics, are affected, should be removed at as early a time as practicable. Deformities from non-development, interest-

ing as they may be anatomically and teratologically, are surgically of interest only when enough of the limb has been developed to permit of the application of some form of prothetic apparatus, or when one of the two bones of the forearm or leg is either entirely wanting or so defective as to permit of deviation of the hand or foot from muscular action, in which case a supporting and restraining apparatus is of much value.

CHAPTER VI.

SURGERY OF THE NERVES.

SECTION I.—GENERAL CONSIDERATIONS.

The larger nerves, like the blood-vessels, as a rule, lie in the protected parts of the body, so that happily they often escape injury. Thus in the neck the nerves lie deeply, protected in front by the collar-bone and laterally by the muscles of the neck. In the arm they lie in the armpit, on the inner side of the upper arm, and on the flexor aspect of the forearm. In the trunk and the pelvis they lie on the posterior wall of these cavities, and in the leg, chiefly on the posterior aspect of the limb, while those on the anterior aspect are, as a rule, very deeply situated.

If we examine a nerve of any size, we find that it has on its exterior a sheath, called the perineurium, between which and the nerve proper is a narrow lymph-space. The perineurium sends offshoots into the interior of the nerve, making partitions which enclose similar bundles of primitive nerve-tubules, the partitions themselves constituting the endoneurium. Nerves are also supplied with blood-vessels and with *nervi nervorum*.

It will be seen, therefore, that, however small, each nerve has within it all the elements necessary for inflammatory changes, and in the connective tissue of the perineurium and endoneurium all the possibilities for such new growths as may be derived from this tissue. Waller has called attention to the degenerative changes which follow section of a nerve, and which constitute the "Wallerian degeneration." It follows the course of the nerve-current. Hence, if a sensory nerve be cut, the Wallerian degeneration will start at the point of of section and travel toward the spine; while if a motor nerve be cut, the degeneration will extend from the point of section toward the periphery. This process begins within a day or two after the section and becomes complete in two or three weeks. It consists in the destruction of the myeline, and eventually of the axis-cylinder, with multiplication of the nuclei of the sheath. In addition to this there is more or less atrophy with other degenerative changes, which extend not only toward the spinal cord, but even into it; in some cases, for instance after amputation, such changes have been traced all the way to the brain. The muscles supplied by such a divided motor nerve soon show the "reaction of degeneration." By this term is meant a peculiar change in the response of the muscles to the galvanic current. In the normal condition it will be found that the kathodic closure contraction (KCC)—that is, the contraction which follows closure of the electrical circuit by the application of the negative electrode (kathode)—is greater than the anodic closure contraction (ACC)—that is, the contraction following the similar application of the positive electrode

(anode)—a condition which is expressed by the formula KCC > ACC. If the muscle have its motor nerve destroyed, the ACC quickly increases until KCC = ACC, and finally KCC < ACC.

After division of a nerve, even in cases in which the two ends have not been brought into apposition, reunion with true regeneration of the nerve-structure will often take place, the axis-cylinder having been redeveloped and the myeline also, in varying amounts. If, however, the nerve-ends are united, this process is not only hastened, but is also much more apt to be permanent than where no such union has been effected.

SECTION II.—NEURITIS, OR INFLAMMATION OF A NERVE.

Causes.—A neuritis may be idiopathic; that is, arising from no perceptible cause. By far the commonest cause is exposure to wet or cold. Gout, rheumatism, syphilis, typhoid fever, diphtheria, and the exanthemata may also give to rise such an inflammation. Of course it follows wounds and injuries of nerves. Occasionally, but rarely, it assumes the dangerous form known as multiple neuritis, or, better, diffused neuritis, which may even cause death.

Neuritis may be either acute or chronic. In *acute neuritis* there will be a marked increase of the connective-tissue elements of the nerve, with œdema of the sheath from the exudation. The nerve-tubules become softened as a result of granular and fatty changes, as well as from the inflammatory exudate, and in some cases even pus may be present. Occasionally there will be hemorrhage into the nerve substance.

In *chronic neuritis* there is apt to be sclerosis from the development of the connective tissue of the endoneurium with pressure on the tubules, which, as a rule, results in their atrophy. In such a nerve the fibrous tissue may be so developed as to make the nerve almost as tough as a tendon. In spite, however, of such complete changes, there may almost always be seen single nerve-tubules, which are perfectly normal, associated with others in every stage of degeneration. It is very important to observe that a neuritis may extend in both directions along the trunk of the nerve. Such a progressive neuritis is called either an "ascending" or a "descending neuritis," as the case may be. Its commonest pathway, however, is upward toward the spine, and hence if, for example, the ulnar nerve be the seat of the neuritis, the inflammation may creep upward till it reaches the brachial plexus and there involves another branch of the plexus by continuity of structure. On the other hand, it is a remarkable fact that a nerve may lie in the midst of inflamed tissues, and even be surrounded by pus for a long time, without any inflammatory change extending to the nerve itself.

Symptoms.—The first symptom of neuritis, as a rule, is an aching pain, which follows the course of the affected nerve, and often prevents sleep. This pain is apt to be remittent, is markedly worse at night, and is increased by motion of the limb or by pressure or friction over the nerve. Not uncommonly it will extend, it is thought by a reflex action, to neighboring nerves or to corresponding nerves upon the other side of the body; for instance, we are all familiar with the fact that a carious tooth sometimes causes pain in the corresponding tooth on the opposite side. With the pain there are apt to be headache and fever, and occasionally even rigors. The nerve if superficial can be traced as a thick cord which will present a continuous or an interrupted swelling, and its course is sometimes marked by a red line, as in phlebitis or angioleucitis. The local temperature will sometimes rise. There may be sensations of numbness or tingling in the area supplied by the sensory filaments.

This will very likely give rise to a marked hyperesthesia, but if the neuritis persists and is followed by atrophy of the nerve, hyperesthesia will give place to anesthesia. The motor filaments also will be affected, producing twitching and tremors of the muscles, very soon followed by paresis, and finally by complete paralysis, and, as a consequence of this, by muscular wasting. A good example of these symptoms is often seen following inflammation of the seventh nerve as it passes through the canal of Fallopius.

Diagnosis.—From rheumatism a neuritis can be recognized most readily by the fact that the pain occurs in the track of a nerve, and later it can also be differentiated by the sensory, motor, or trophic changes which set in. In ordinary neuralgia the pain is of a very different order, being sharp and shooting and more diffused over the affected area. There is no rise either of the general or of the local temperature, nor is there apt to be any muscular spasm, though occasionally this is seen in neuralgia of the fifth nerve.

Treatment.—The most important remedial measure is absolute rest—not by putting the arm in a sling and the patient on a lounge or in bed, and enjoining rest, but by enforcing rest by the application of a splint. This should be used in all cases unless absolutely impossible. With this, of course, there should be elevation of the part, with the application of heat or cold, whichever is the more grateful to the patient. Sometimes blistering, or even the actual cautery, over the course of the nerve, will be found of value. The constant galvanic current is an excellent remedy. Deep injections of morphine, atropine, cocaïne, or chloroform, especially in cases of sciatic neuritis, have proved of great value, while morphine by the mouth may be exhibited in sufficient quantities to give reasonable sleep. But it is precisely in these cases of chronic neuritis that the greatest care must be exercised lest we form and encourage the morphine habit. If anesthesia sets in instead of hyperesthesia, the application of the faradaic current by the electric brush on a carefully dried and dusted skin is the best treatment. Of course the general health must be looked after, with attention to diet, the state of the bowels, sleep, habits, and exercise when this latter is permissible. If the patient is of a rheumatic, gouty, or syphilitic constitution, appropriate treatment must be used for whichever of these conditions may be found. Meantime the muscles must be kept in good trophic condition until the neuritis subsides and the nerve resumes its normal function of conveying the stimulus to the muscles. This is best effected by hot and cold douches, massage, and electricity, continued in many cases for weeks or even months, until the nerves resume their abandoned work. Sometimes, especially in sciatic neuritis, stretching the nerve gives good results when all other means have failed.

SECTION III.—NEURALGIA.

Neuralgia may be described as an acute paroxysm of pain in the area of distribution of a nerve, not uncommonly radiating from this as a center to neighboring parts. The ordinary forms of neuralgia are medical rather than surgical, but they often require treatment by surgical means.

Cause.—The disorder is apt in most cases to follow debility, and especially anemia caused by conditions that affect the constitution, such as fever, neurasthenia, long-continued lactation, etc. Hence neuralgia has well been called "the prayer of the nerves for blood." Malaria, gout, rheumatism, and occasionally syphilis, will often be found at the bottom of it. Persons of neurotic temperament, and especially those coming from a neurotic family, often fall victims to it. Not uncommonly in such patients the joints suffer; and in young women, especially if the menstrual function is disordered or if there is

any uterine trouble, there may be a serious neuralgia of the breast, which is chiefly annoying by reason of the pain and the frequent suggestion of malignant disease. Local conditions also may occasion it. A carious tooth is often the cause of a severe neuralgia, which, it must be remembered, will manifest itself not uncommonly in the corresponding tooth either of the opposite side or of the other jaw. An aneurysm of the aorta or any other tumor which may press upon an intercostal or other nerve will cause it, and disease of the kidney is often attended with neuralgia of the testicle. The variety of the causes which give rise to neuralgia will suggest to us that a most careful examination should be made of the personal and family history in order to determine the appropriate treatment.

The neuralgias which are most frequently brought to the attention of the surgeon are that form of neuralgia of the fifth nerve known as trifacial neuralgia or tic douloureux, sciatica, and the neuralgia of stumps and scars.

Tic douloureux is so called to distinguish it from "tic convulsif," or spasm of the facial muscles, which is sometimes painless and sometimes a symptom of tic douloureux.

Cause.—As the disease manifests itself most commonly in the face and teeth, if no cause is found in the face it is apt to be attributed to the teeth. It is not uncommon for patients to be brought to the surgeon who have already lost most or even all of their teeth in the vain hope of arresting the relentless pain. As a rule, as soon as one tooth in which the neuralgia has seemed to be worst has been removed another immediately assumes the prime importance, and so tooth after tooth is needlessly sacrificed. The cause must be sought in the condition of the nerve or its blood-vessels. Microscopical examination will often show a neuritis accompanied even with hemorrhage into the substance of the nerve, but more commonly it will reveal a marked senile sclerosis (Putnam, de Schweinitz, and Horsley). This is in accordance with the fact that the disease rarely attacks persons before middle life, when the changes incident to age have begun. Dana has recently published some investigations which seem to indicate that the cause is not to be sought so much in the connective tissue of the nerve-trunk as in its vessels which have been subject to obliterating arteritis, itself the result of advancing years. Carless has called attention to the fact that the foramen ovale differs greatly in size from nearly a circle seven or eight millimeters in diameter to a mere slit not more than two millimeters broad. This narrowness of the foramen and a similar contraction of the lumen of the infraorbital and inferior dental canals may easily exert increasing pressure as the patient grows older, and so cause a progressive neuralgia. In view of the influence of age as a cause of tic douloureux, it is not surprising that very frequently after an operation on the nerve has given relief for a time, the disease, whether due to sclerosis or to obliterating arteritis, will recur in the nerve stump and require another and more radical operation. Similar alterations have been traced in some cases even to the Gasserian ganglion. Cold and dampness are also factors in the production of the disease.

Symptoms.—Scarcely any disease, except possibly tetanus, is more calculated to arouse the sympathies of the attending surgeon than severe tic douloureux. The pain is usually described as burning, boring, cutting, or darting. It is evoked by the slightest cause: a breath of air, mastication of the simplest food, attempts to speak or to laugh, even the lightest touch or a slight noise, will produce the most fearful paroxysm of pain, in which the patient will suddenly protect rather than grasp his face with his hands, and will writhe about, moaning or crying aloud with the fierce pain. Each meal

costs him frightful suffering. Only liquid food can be taken, for the slightest attempt to masticate brings on a paroxysm of pain; even the swallowing of liquid is endured only because of the imperious demand of the body for food and drink. While his days are days of misery, his nights are nights of sleepless agony. Sometimes he will be free from the pain, it may be for days or even weeks, but it is sure to return, at longer or shorter intervals, until life becomes a burden.

The **diagnosis** is easy, for there is nothing with which such a terribly painful disease can be confounded.

Sciatica, or neuralgia of the sciatic nerve, often from a true neuritis, is not unusual. Its symptoms are obvious, and the diagnosis, as a rule, is easy.

Neuralgia of Stumps and Scars.—Sometimes after an amputation or an operation the stump or the scar will become the seat of severe neuralgic pains. While not so severe as those of tic douloureux, they are sufficient to render life miserable. The wearing of an artificial limb is sometimes made impossible, as even light touching of the stump will produce severe pain. Gradually increasing pressure is often better borne than light pressure. In stumps it is the general rule that the cut ends of the nerves become bulbous—that is, develop neuromata (Fig. 136)—and it is believed that these are probably the cause of the pain. In scars the entanglement of small terminal filaments of the nerves is thought to be the cause. Occasionally in either case a true neuritis is set up.

Treatment of Neuralgia.—The first thing to determine is the cause, if this be possible. If the patient be the subject of malaria, quinine in full doses, up to 20 or even 30 grains a day, and in anemia iron, quinine, and cod-liver oil generously given will often be of use. If these fail, arsenic may be pushed to its physiological effect, while strychnine and gelsemium will be found of value. If the patient be subject to gout or rheumatism, colchicum, the alkalies, the salicylates, or the iodide of potassium will be indicated, and in syphilis the iodide of potassium, and sometimes mercury, will give relief. Locally much can be done to benefit the patient. If the nerve itself be tender, sometimes leeching will bring relief. Heat or cold, whichever is more grateful to the patient, even the application of freezing mixtures over the nerve, especially at the tender spots, may be useful. The application of the ointment of belladonna or veratrine, the menthol pencil, the application of croton chloral, and occasionally the Paquelin cautery, will be of use. The long-continued daily use of the constant galvanic current has often done good. Of course the whole system should be built up by the best and most easily digested food, with regulation of the bowels and the secretions and attention to the habits of the patient. In women the menstrual function and the condition of the uterus and ovaries should be ascertained and any necessary treatment be adopted. Occasionally, however, the patient may be more benefited by a change of climate, surroundings, occupation, etc. than by treatment with drugs. There is a great temptation in rebellious cases to resort to the use of alcohol or morphine, either by the mouth or hypodermatically, but these remedies are dangerous, and the latter too often makes the patient the victim of the morphine habit, the consequences of which are worse than the disease for which relief is sought.

In neuralgia of the joints, absolute rest by means of a splint, or more commonly exercise, massage, the hot and cold douche, and electricity in some of its forms, are the best remedies. In neuralgia of the breast it is very important to calm the patient's fears as to malignant disease. Nervous tonics and sedatives, such as valerian, the bromides, asafetida, strychnine, iron, arse-

nic, and quinine, will be found useful, as will also gentle massage with any of the simpler ointments.

I. **Surgical Treatment of Tic Douloureux.**—Most of the drugs above mentioned will probably have already been tried. If not, they should be used fearlessly, combined, as a rule, with heat or cold and the constant current or other form of electricity. The extraction of the teeth, as a rule, is to be condemned. Ordinarily all that is left for the surgeon to do is to proceed at once to operation.

The operation for the removal of the nerves will be described later. Though sometimes permanent, the relief obtained by such an excision, as a rule, will be only temporary; yet it is such a boon to the exhausted sufferer that it should always be given when other means have failed. One, two, or three years after the operation the patient will return with his neuralgia almost or quite as bad as before. But the case is by no means hopeless. Sometimes internal remedies or local applications, especially of the constant current, will again give relief, and if not, a second operation can be done for the removal of the stump of the nerve. In some cases where there is no stump of the nerve left, simply the seizing of the fibrous tissues at the point of the former excision and their avulsion will bring a prolonged freedom from pain. This may be repeated more than once. If the entire trunk of the superior maxillary has been removed far back in the orbit, the second operation will consist in the removal of Meckel's ganglion. Recently Rose, Hartley, and others have gone even farther back and removed the Gasserian ganglion itself. (See Operations on Nerves.)

II. **Surgical Treatment of Sciatica, Neuralgia of the Brachial Plexus, etc.**—In cases of inveterate neuralgia—for instance, of the brachial plexus or its branches or of the sciatic or other nerves—the remedies and drugs above described are first to be employed. When these have failed, surgery still offers relief. Nerve-stretching (neurectasy) has been adopted in very many cases with excellent results. (See Operations on Nerves.) Even when this has failed we are not at the end of our resources. In a few cases where the pain has resisted all other means of cure the spine has been opened, the cord has been exposed, and the posterior or sensory roots of the implicated nerves have been exsected, by Abbe and others. (See chapter on the Spine.) But the number of cases is as yet too small and the time that has elapsed too short for the expression of any final opinion as to the advisability of the operation. The pain in such cases is so severe, however, that any operation that holds out even a slight prospect of cure should be deemed admissible unless further experience should show it to be unwise.

III. **Surgical Treatment of Neuralgia and of Scars and Stumps.**—If a known nerve is caught in a scar an incision should be made and the nerve liberated from the cicatrix. If mere incision and liberation bring no relief, a second operation should be done for the excision of the nerve. If no known nerve is involved, but the pain probably comes from a small unnamed filament entangled in the meshes of the irregular scar following, for example, a lacerated wound, a burn, or a scald, the entire scar should be excised. The linear scar which replaces the irregular and contractile cicatricial tissue of the original scar is much less likely to give rise to such neuralgia.

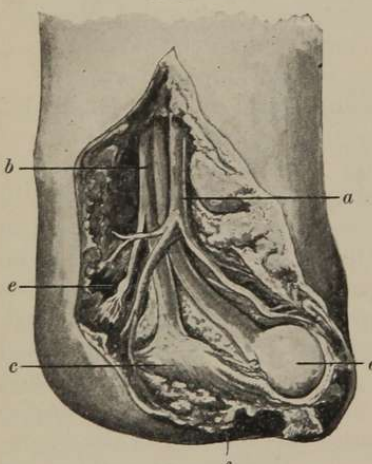
In stumps two methods of treatment may be adopted, of course after the medical means above described have been exhausted. The cicatrix of the stump should be excised and the bulbous ends of the nerves be sought for, drawn down, and severed with a clean cut of a sharp knife. If this does not give relief a re-amputation should be done. Sometimes, as, for instance, after amputation of the distal phalanx of the thumb, where the part is supplied by

known nerves, a portion of each of these nerves should be exsected; if this does not relieve, as is too often the case, a re-amputation may be required. Not uncommonly, however, such secondary stumps themselves will be painful, and the resources of the surgeon will be taxed to the utmost to effect a cure. It is very likely that in these cases an ascending neuritis has been developed, and if this can be diagnosticated a portion of the painful nerve may be exsected in its continuity as high up as the tenderness is traced, unless such high excision of the nerve would produce results so serious as to contraindicate operation.

SECTION IV. TUMORS OF NERVES.

A distinction must be drawn between tumors which are *in* a nerve and tumors which are *on* or *attached to* a nerve, for some tumors are developed in the nerve-fibrils which make up the nerve, while others are mere extrinsic growths. The first class cannot, as a rule, be removed without entire excision of the nerve itself. Those developed on the outside of the nerve may be removed without injury to the nerve. If, however, severe neuralgic symptoms have continued after removal of the growth, it will be best, as a rule, to exsect the portion of the nerve to which it is attached, stretch the two ends of the nerve, and reunite them.

FIG. 136.



Neuromata in a Stump after Amputation of the foot: *a*, posterior tibial artery; *b*, posterior tibial nerve; *c*, flat neuroma of internal plantar nerve; *d*, round neuroma of same nerve; *e*, another small neuroma; *f*, cicatrix of stump (Duplay and Reclus).

Tumors developed in the nerves themselves are called **neuromata** (Fig. 136). True neuromata, other than the bulbous ends of cut nerves, made up of nerve-fibers themselves, are very rare. They are usually made up of amyelinic fibers—*i. e.* fibers which have no myeline within the sheath. After the division of a nerve, either by exsection of a portion of it or in an amputation, the proximal ends almost always become bulbous: so frequently does this occur that it may be regarded as a rule. These tumors have been called false neuromata—*i. e.* tumors not made up of nerve-tubules, but of fibrous tissue; but Bowlby has shown that at least in some cases a number of true nerve-fibers are found in them. The neuromata occurring in the trunks of nerves are generally composed of fibrous tissue. Occasionally they are sarcomata or cysts. While they are usually single or exist in very small numbers, instances have been recorded in which even hundreds existed.

Symptoms.—When occurring in the course of a nerve such a tumor frequently gives rise to no symptoms whatever, and may even be unsuspected until revealed by a post-mortem. More commonly, however, it excites such neuralgic pains as to lead to an examination of the part, and if the nerve lie superficially the tumor may be detected. If not, it causes spasms from irritation or paralysis from pressure, while trophic lesions of the muscles, skin, and other parts supplied by the nerves are often seen. (See Injuries of Nerves.)

Treatment.—If such neuromata produce no pain or other serious symptoms, they should not be interfered with. If any serious symptoms arise, the tumor, with the portion of the nerve in which it is developed, should be removed. If the two ends can be approximated by stretching, immediate suture should be practised, but if they cannot be brought together the gap may be supplied

by the transplantation of a suitable portion of a nerve from one of the lower animals or from a newly-amputated limb. It is even possible, when the ends cannot be approximated, that if they can be sutured together with catgut threads, thus bridging the interval between the two ends, the nerve may be regenerated. Van Lair makes use of a cylinder of decalcified bone to carry the catgut between the ends. In the painful neuromata which develop in nerves after their section or in stumps after amputation, after exhaustion of the medical means the part should be opened, the nerves dissected out, and the bulbous extremities resected.

Painful Subcutaneous Tubercle.—A peculiar form of tumor connected with a nerve is known by this name. It is generally single; as its name indicates, it is small, often about the size of a pea; it lies immediately under the skin and is connected with a sensory filament of a cutaneous nerve. It is usually made up of fibrous tissue. One symptom which distinguishes it from all other tumors is its excessive tenderness and pain. This pain extends up and down the limb, and is sometimes generalized, occasionally accompanied with spasm of the muscles. The pain appears in paroxysms of greater or lesser duration. The **treatment** is excision of the tumor, together with the portion of nerve-twig in which it grows. The resulting anesthesia will disappear in time.

SECTION V.—WOUNDS AND INJURIES OF NERVES.

These are not uncommon. They are seen more frequently in the upper extremities than in the lower, the nerve-trunks being anatomically more exposed in the arm and also more frequently subjected to violence. Contusion and compression are the most frequent injuries. Wounds may be either clean-cut incised wounds or more or less extensive lacerated or contused wounds, such as those caused by missiles of war, those which result from railroad and machinery accidents, punctured wounds, and the like.

I. Contusions and Compression of Nerves.—Nerves suffer from contusions, occasionally from direct blows, as on the ulnar nerve at the bend of the elbow or on the brachial plexus in the neck. In addition to this, dislocations, especially of the head of the humerus in the axilla, often produce serious contusions and compression, as will also, though more rarely, the attempt at reduction by placing the unbooted heel in the axilla. Dislocations, and especially fractures near the elbow, are liable to produce contusions and sometimes laceration of the ulnar or musculo-spiral nerves. In fracture of the humerus the musculo-spiral nerve is apt to be contused, compressed, or wounded, and the brachial plexus may be similarly injured in fracture of the clavicle. Fracture of the pelvis through the sciatic notch has resulted in like injury to the sciatic nerve at its point of emergence. There are also some forms of steady or repeated compression which produce trouble. Sometimes, though rarely, the excessive growth of callus has been thought to cause the pressure. Tumors cause it not very uncommonly, especially thoracic aneurysms. The use of crutches, especially if not well padded, produces a form of palsy known as "crutch palsy." This will be more common, of course, in heavy persons. Lying in peculiar positions, especially with one or both arms under the head, particularly in the deep sleep of drunkards, will sometimes give rise to a similar palsy. The pressure of the forceps on the seventh nerve during delivery sometimes produces facial palsy in the child, and in addition to this the pelvic nerves of the mother may be injured from prolonged pressure by the fœtal head in delayed deliveries. In all these cases the nerve suffers mechanically to a greater or lesser extent, and the fibers are apt to be torn or pressed together; occasionally hemorrhage

into the substance of the nerve occurs, while the myeline is more or less mechanically disturbed. In severe cases of contusion or compression there will be of course entire mechanical destruction of the nerve.

Symptoms.—These will vary in accordance with the severity of the injury. If it be slight the symptoms will resemble the common phenomena produced when the ulnar nerve is struck at the elbow, which is known as striking the "crazy bone" or the "funny bone." This is generally attended with tingling and a sense of "pins and needles" in the ulnar distribution. Loss of function is not apt to follow immediately unless the contusion has been violent. Occasionally, however, apparently a severe neuritis will follow, with pain in the distribution of the nerve and possibly palsy of the muscles supplied, and trophic alterations in the skin and its appendages.

Treatment.—This will depend on the cause. If it be the pressure by a tumor or by the dislocated head of the humerus or from a fracture, first of all the cause must be removed if possible. The next most important indication is that the nerve shall have absolute rest,—not rest merely by non-use of the part, but rest by means of a splint, and, if the contused nerve be in the lower extremity, rest in bed in addition to the splint. In cases of moderate injury this perhaps is all that will be required, with possibly the local abstraction of blood by means of leeches and cups. If the injury be more severe, the injection of morphine, with or without atropine, or its administration by the mouth, in order to quiet the pain, is generally indicated. Arsenic is sometimes of value, and the repeated application of galvanism in obstinate cases may give relief. The remote symptoms, motor, sensory, and trophic, are to be treated as is described under the head of Wounds.

II. Wounds of Nerves.—Formerly division of the small nerves at the bend of the elbow was very common from the promiscuous bleeding then in vogue. At present by far the commonest wounds of nerves are from glass—as, for instance, from thrusting the hand through a pane of glass or from the breaking of a glass bottle—and from knives, scythes, etc., while the ordinary accidents of civil life, such as punctured wounds by needles, scissors, and splinters, and the more extensive lacerated wounds following railroad and machinery accidents, are of frequent occurrence. In military practice and occasionally in civil life the nerves are implicated in gunshot wounds. The damage done to motion and sensation is most severe after wounds of the larger nerve-trunks; but the reflex symptoms from such wounds are more commonly seen when the smaller filaments are implicated, and more often after laceration or puncture than after a clean cut.

Symptoms.—The symptoms of a nerve wound are not distinctive of the nature of the injury, whether it be a contusion, a clean incision, or a lacerated or gunshot wound. The immediate symptoms are both local and constitutional, and vary to the greatest possible degree in their severity. The pain may be so slight in some cases that the wound will escape notice, or at most the patient will imagine he has been struck by a stick or stone. In other instances the pain even from the wound of a small nerve will be so severe that he will lose consciousness from it. This condition of shock will sometimes be very great, especially in gunshot wounds. It need not be described here, for it resembles the shock of other wounds.

In one respect, however, a further statement is necessary,—namely, as to the so-called "reflex palsies." In a number of instances it has been noted that the wound of a small nerve (for it is more common in a small nerve than in a large one), for instance, on the right side of the neck, will produce a palsy of the left arm or left leg or of both; or a wound of the thigh may produce paral-

ysis of the arm or leg of the opposite side of the body, or sometimes of all four limbs. This has been explained by Brown-Séquard on the theory of reflex paralysis or spasm of the vessels of the paralyzed limb or limbs themselves, but the theory advanced by Mitchell, Morehouse, and Keen, that it is due to exhaustion of the nerve-centers of motion and sensation, seems to be the better explanation.

Shock and pain, with loss of motion or of sensation, or of both, are then the immediate symptoms of nerve wounds. Such wounds are of course attended with more or less hemorrhage, and are subject to the same danger of infection and inflammation that attends wounds elsewhere or of other organs.

It is, however, the remote symptoms and results of nerve wounds that are by far the more important and interesting and constitute their peculiarity. They were first carefully studied in our late civil war by Mitchell, Morehouse, and Keen. Sensation and motion are sometimes equally affected; but sensation is apt to be less affected than motion, and if both are affected, sensation, as a rule, will return earlier than motion. If the nerve be a motor or a mixed nerve and its function be destroyed, the muscles which it supplies will soon show marked wasting, together with increasing feebleness of action, or not uncommonly complete palsy; and as a later result contracture of the muscles will follow, giving rise not only to inability to use the part, but also to serious deformity. Combined with the motor disturbances there will be marked alterations of sensation, and the skin supplied by the nerve will become anesthetic or frequently hyperesthetic and painful.

A third series of changes in the nutrition of the parts supplied by the nerve follows, usually at a considerable time after the sensory and motor changes. These trophic changes do not take place at the seat of the wound, but at a distance from it, in the area to which the nerve is distributed. They manifest themselves first in a curious appearance of the skin, which looks as if it were varnished. It is usually red and is very apt to be dry, though sometimes it will be bedewed with perspiration, which is often acid and foul-smelling. Along with this there is sometimes developed a burning pain, which Mitchell has named "causalgia." Frequently even to point at the injured hand of such a patient will evoke such a paroxysm of pain that he will draw his hand away in fear. In many cases he obtains relief from wetting the injured hand or foot, and may even wear a cotton glove which he will constantly wet, or may pour water into his boots in order to keep the burning foot in even moderate comfort. The hair is commonly greatly diminished in amount. The nails become strangely curved, both in the axis of the limb and transversely, showing furrows and ridges, and very often ulceration of the matrix occurs. Sometimes gangrene of the terminal phalanges of the fingers and toes will set in, and may extend more widely, but not often beyond the fingers or toes. There is often also an eruption like chilblains or eczema. Sometimes the larger joints will become inflamed, swollen, and tender after a wound of the main nerve or nerves of a limb. These neural arthropathies follow not only wounds or other lesions of nerves, but also injuries to the central nervous system, either in the spine or in the brain. They resemble rheumatic arthritis to a marked degree.

Diagnosis.—(1) *As to Motion.*—In making a diagnosis of the loss of motion that follows injury to any nerve it is only necessary to determine what muscles have lost their function and to compare these muscles with the nerves which supply them. In order to test the strength of the muscles of the forearm as a whole, the dynamometer must be used. This is simply an oval spring with a graduated disc and a movable pointer. On grasping it the registration by the pointer on the graduated scale shows the relative strength of the two

arms. There should be similar instruments to test the force of the motions at the elbow, wrist, shoulder, and leg, but none such have been devised.

(2) *As to Sensation.*—Here the problem is a much more difficult one, not only because the nerve-supply of the skin is by no means so constant as that of the muscles, but also because the methods involved require greater attention. The loss of sensation in the skin varies considerably in its character. In a certain area there will be absolute loss of sensation, or anesthesia. Between this and the area of normal sensation is a zone of irregular outline in which sensation is not absent, but perverted. This is the region of *dysesthesia* or *paresthesia*, and will vary much in different cases. It must be remembered that there is also what has been called "supplementary sensation." By this is meant that the entire area ordinarily supplied by a certain nerve, which should be entirely anesthetic after division of its nerve, is still found to possess a more or less complete sensation after such division. Whether this is from anastomoses of neighboring nerves or not is a problem which is as yet not solved. To aid in its solution, in all cases in which a nerve has been purposely cut or has been divided by accident the areas of full sensation, paresthesia, and anesthesia should be carefully mapped out by the methods described below and the areas indicated, that of total anesthesia by dark shading, that of paresthesia by lighter shading. Only by collecting and comparing numerous reports of such cases can the physiological anatomy of the nerves be determined.

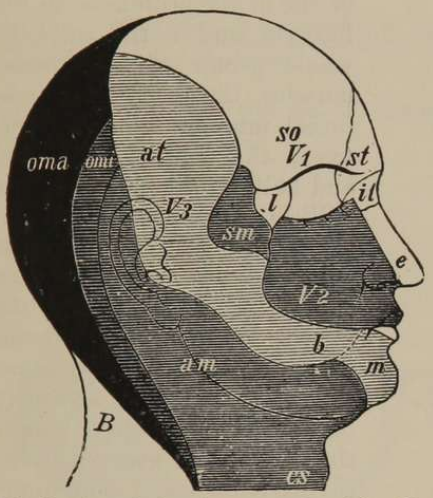
In determining the areas of anesthesia and paresthesia the surgeon should be careful not to rub the part nor adopt any other rude method of testing, for any displacement of the skin is perceived readily at a distance. The best methods are as follows: First, by a light pencil, or in some cases a feather or bristle or any other means of delicate touch, the area, for instance, of anesthesia is determined from point to point, and is mapped out. Sometimes for still more delicate determination the mere touching of the hairs that grow so plentifully over most of the body can be used. An additional means is the ability of the patient to recognize the points of a pair of compasses as two points or as one. The pair of compasses is fitted with a graduated scale indicating the distance between the two points, either in inches or centimeters, and is called an esthesiometer. The best are now provided with a small knobbed point and a sharp point to each arm of the compasses. An ordinary pair of compasses and a graduated ruler, however, will answer. In using them it is important that the test be made alternately on the two corresponding limbs under the same conditions and with the same number of repetitions, and that, for proper comparison, it be done in each limb either transversely or in its long axis, for the ability to distinguish the two points varies with the number of repetitions and with the placing of the points transversely or lengthwise. It is especially needful to see that the two points touch the skin simultaneously, for two successive touches would of course be appreciated as two points, even when if touched simultaneously they would be perceived as only one. All these examinations should be made with the patient blindfolded, so as to prevent the assistance of sight, and he should not be allowed to move the fingers, toes, or other parts in order to assist sensation by the muscular sense. It must be remembered also that normally many persons cannot distinguish well between adjacent toes, especially the third and fourth. Where sensation has been lost to ordinary touch it will still be retained to certain other stimuli, as, for example, electricity, and these also may be used as a means of diagnosis. The electric wire brush will evoke sensation in many cases where all other means fail. The sense of temperature should also be determined by dipping the hands or feet into water of a known temperature, or by applying mops dipped in the water, in many

cases using alternately hot and cold water. As a rule, it will be found that while sensation and motion may be equally lost at the time of injury, sensation will return, sometimes shortly, sometimes at a longer interval, before motion. Generally also the irritability of the muscles to the constant galvanic current is lost some time after their response to faradaic electricity, the return of electro-muscular contractility being in the reverse order. Voluntary control over the muscles is, as a rule, lost before response to electricity, and returns in reverse order.

DIAGNOSIS OF LESIONS OF SPECIAL NERVES.

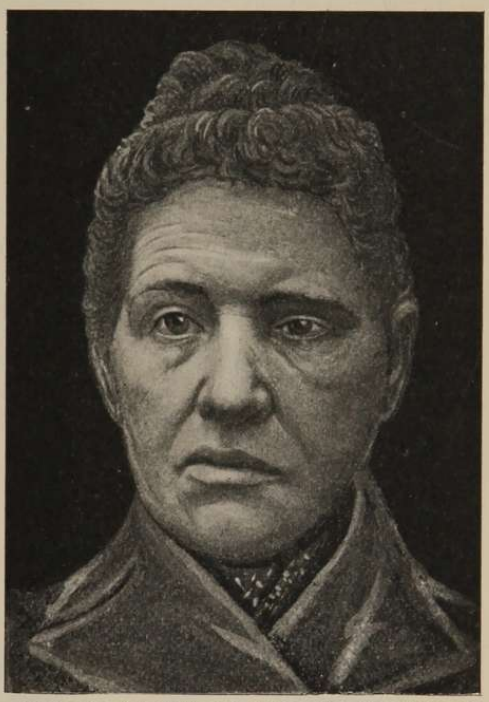
I. **Fifth or Trifacial Nerve.**—Figure 137 shows the cutaneous distribution of the three branches of the fifth nerve (V_1, V_2, and V_3) in different shadings. From a determination of

FIG. 137.



Distribution of the Cutaneous Sensitive Nerves upon the Head: *oma, omi*, the occipit. maj. and minor (from the N. cervical. II. and III.); *am*, N. auricular. magn. (from N. cervic. III.); *cs*, N. cervical. superfic. (from N. cervic. III.); V_1, first branch of the fifth (*so*, N. supraorbit.; *st*, N. supratrochl.; *it*, N. infratrochl.; *e*, N. ethmoid.; *l*, N. lachrymal.); V_2, second branch of the fifth (*sm*, N. subcutan. malæ seu zygomaticus); V_3, third branch of the fifth (*at*, N. auriculo-tempor.; *b*, N. buccinator; *m*, N. mental.); *B*, posterior branches of the cervical nerves (Seeligmüller).

FIG. 138.



Paralysis of Left Facial Nerve, the face being in repose (original).

the region of hyperesthesia or anesthesia the particular branch involved can be ascertained.

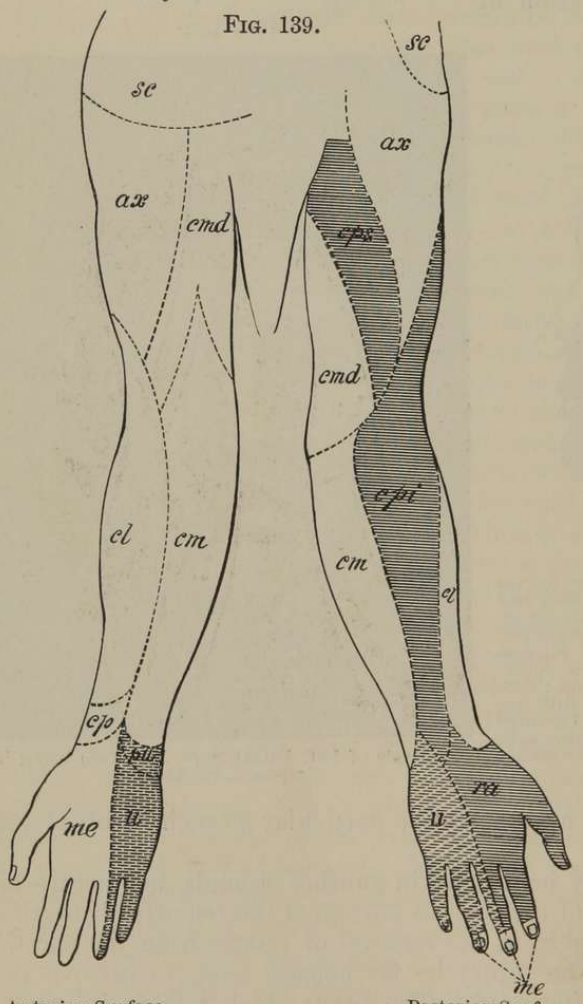
II. The **Facial Nerve** may be injured in gunshot wounds, in fracture of the middle fossa, or in necrosis of the petrous portion of the temporal bone, and may also be divided by the surgeon in the removal of tumors from the parotid and neighboring regions. If the injury be far enough back to involve the chorda tympani, taste will be impaired. The palsy which follows injury of the facial nerve is pathognomonic. The eyebrow cannot be raised or wrinkled horizontally, and the eyelids can be only partially closed. But the patient soon learns to roll the ball up under the upper lid in order to wet the cornea and preserve its translucency. The ala of the nose on the paralyzed side does not move in respiration nor by volition, and control of the angle of the mouth is lost, saliva and other liquids dribbling from it. The patient cannot pucker his mouth to whistle. The entire face on the side of the lesion has an expressionless stare. When the patient attempts to laugh or to close the eyes tightly, only

the unparalyzed side of the face is wrinkled, the other remains smooth. The facial being purely a motor nerve, no change of sensation occurs.

III. The **Pneumogastric and its Recurrent Laryngeal Branch.**—In a very few cases in tying the carotid or in the extirpation of tumors the pneumogastric has either been divided or ligated, and in the excision of goitre one of the chief dangers is the division of the recurrent laryngeal. Either lesion produces hoarseness and altered voice from paralysis of the vocal cord on that side, and if in the excision of goitre the nerves be cut bilaterally instant tracheotomy must be done to prevent suffocation. Except alteration of the voice, the effects of section of the pneumogastric or its ligation seem to be extraordinarily slight.

IV. **The Ulnar Nerve.**—This is cut most frequently just above the wrist. It may also be divided at the elbow or in the upper arm. The *motor* paralysis will affect the flexor carpi ulnaris, the inner half of the flexor profundus in the forearm, and in the hand the whole group of hypothenar muscles, the two ulnar lumbrical muscles, all the interossei, the adductor pollicis, and half of the flexor brevis pollicis. The appearance and action of the hand in ulnar paralysis are therefore very characteristic. Besides the wasting of the ulnar muscles in the forearm, the hypothenar eminence is wasted and may become even hollowed, and there is partial wasting of the thenar eminence. The interosseous spaces also are furrowed from the wasting of these muscles. If an object be placed in the palm and the patient be told to grasp it, he will first flex the last two phalanges of the fingers by the common flexors, and then by the further contraction of these muscles will roll the flexed fingers into the palm, but he will not be able to grasp an object by placing the tips of the fingers on the thenar and the hypothenar eminence by flexion at the knuckle, as can be done in the normal hand. Moreover, as the interosseous and lumbrical muscles extend the last two phalanges of the fingers, these joints of the fingers will remain constantly in semiflexion, while

Fig. 139.



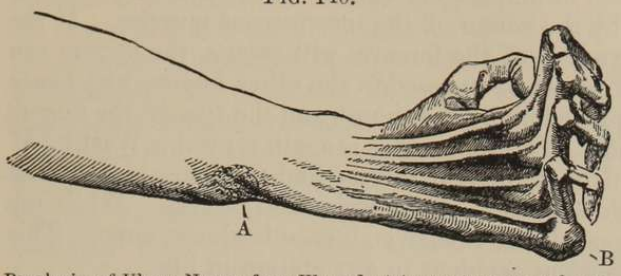
Anterior Surface. Posterior Surface.

Distribution of the cutaneous nerves to the shoulder, arm, and hand. The region of the N. radialis is represented by the unbroken hatched line, that of the N. ulnaris by the broken hatched lines. *a*, anterior, *b*, posterior surface; *sc*, Nn. supra-scapular. (plexus cervicalis); *ax*, chief branch of N. axillar.; *cps*, *cpi*, Nn. cutanei post. sup. and inf. (from N. radialis); *ra*, terminal branches of N. radialis: *cm*, *cl*, Nn. cutanei medius (also to the plexus) and lateralis (chiefly to the N. medianus); *cp*, N. cutan. palmar., N. rad.; *cmd*, N. cutan. medialis; *me*, N. medianus; *u*, N. ulnaris; *epu*, N. cutan. palm. ulnaris (Henle).

the first phalanges will be pulled backward in marked extension by the now unopposed common extensor.

As a result of this the "claw hand" is produced, and all the more delicate motions of the hand are lost. Fig. 140 shows an extremely bad case. The scar of the wound of the ulnar nerve is seen at A. A lesion of this nerve is therefore of very serious importance to any patient, whether he be laborer, artisan, or in the higher classes of life.

Fig. 140.

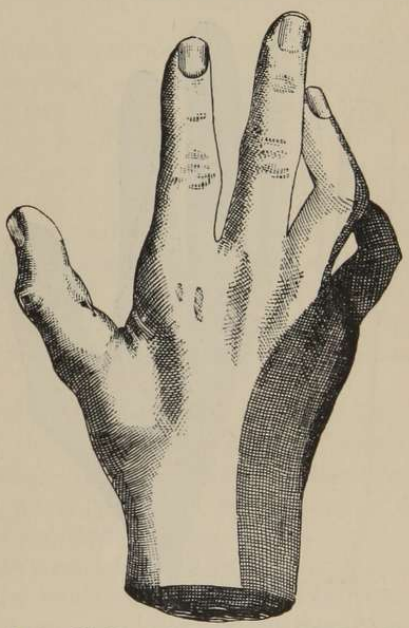


Paralysis of Ulnar Nerve from Wound at A; contracture of common extensor with posterior luxation of first phalanges; B, head of metacarpal bone (Duchenne).

Sensation.—As a rule, the ulnar nerve supplies the ulnar portion of the skin of the hand both front and back, the entire little finger, and the ulnar half of the ring finger; but at the tip of the finger the median nerve invades somewhat

Fig. 141.

Fig. 142.



Loss of Sensation on anterior and posterior surfaces of hand after division of the ulnar nerve (Bowlby).

the otherwise mathematical distribution of the ulnar. There are, however, in this region marked differences in different patients.

V. The **Median Nerve** also is most frequently divided just above the wrist, where it is comparatively superficial, the flexor tendons being often involved in the injury. It may be injured also higher up on the forearm or at any point in the arm.

Motion.—The motor symptoms will depend on the point where the nerve is injured or cut. If the median be divided above the elbow, all the flexors and pronators of the arm, with the exception of the flexor carpi ulnaris and the ulnar half of the flexor profundus, will be paralyzed. All the muscles of the thumb, except the adductor and half of the flexor brevis pollicis, will be

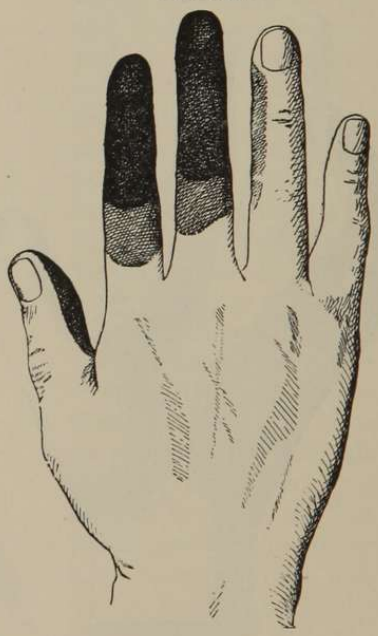
paralyzed. In both this and in ulnar paralysis flexion of the wrist is lost on the radial or ulnar side respectively, but remains on the opposite side of the forearm. The hand cannot be pronated except by its own weight. Flexion of the thumb is lost in the distal phalanx and weakened in the proximal, and, what is still more important, the thumb cannot be opposed to the other fingers. The last two phalanges of each of the fingers cannot be flexed, while flexion at the knuckles still remains by the action of the interosseous muscles. If the injury be at the wrist, the muscles of the forearm will escape, the fingers can be flexed, but the thumb still cannot be opposed to the other fingers, and hence small objects can neither be picked up by the thumb and the tips of the fingers nor be well grasped and retained. The appearance is again typical. Wasting of the forearm is more marked than in ulnar paralysis, and the hand is in partial flexion to the ulnar side, with extension of the wrist and fingers. While the hypothenar eminence is not wasted, the thenar eminence is almost gone. This too, it will be seen, is a very serious accident in any station in life.

Sensation.—On the palmar surface the area of anesthesia or paresthesia includes the radial half of the palm and the palmar surface of the thumb, index, and middle finger, and the radial side of the ring finger, including the major part

FIG. 143.

Section of Median Nerve: areas of anesthesia (heavy shading) and of dysesthesia (light shading) on palmar surface of hand (Bowlby).

FIG. 144.



Section of Median Nerve: regions of anesthesia and dysesthesia on dorsal surface of hand (Bowlby).

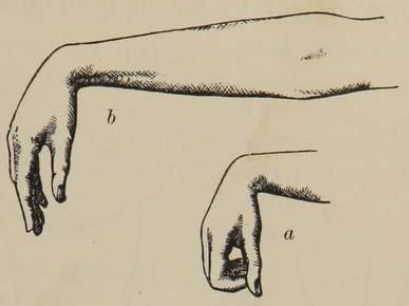
of its tip. Posteriorly, nearly the whole of the fore and middle fingers becomes anesthetic, and the radial side of the ring finger, but little or none of the dorsal surface of the hand.

VI. **Radial Nerve.**—This is divided occasionally as it passes over the front of the forearm to the back of the hand just above the wrist. No muscles are supplied by it. The region supplied by it with sensation, and therefore anesthetic after its section, is a portion of the skin over the metacarpal bones and first phalanges of the thumb and the forefinger.

VII. **The Musculo-spiral Nerve.**—This is most frequently injured by gunshot wounds or fracture of the humerus involving the musculo-spiral groove.

Motion.—If the nerve is paralyzed below the branch going to the supinator longus, this muscle escapes paralysis and its function as a flexor of the forearm becomes very marked. If the nerve is injured above the origin of this branch, the supinator longus is paralyzed, and flexion and supination are impaired, though not lost, for the biceps acts as a marked supinator as well as flexor, and is aided by the supinator brevis. Extension of the wrist and fingers is lost, and there is distinct wrist-drop, with inability to extend the fingers at the knuckle (Fig. 145). The last two phalanges, however, can still be extended by the interosseous and lumbrical muscles. Atrophy of the extensors is very marked.

FIG. 145.



Paralysis of Musculo-spiral Nerve after Fracture of the Humerus ("wrist-drop"); but when fingers have been flexed into palm, *a*, they can be extended *b*, at first interphalangeal joints by lumbricals and interossei, which are supplied by the ulnar and median nerves (Erichsen).

Sensation.—The loss of sensation will differ, depending on the level at which the nerve is injured.

Several of the above nerves may be injured at one time, or the brachial plexus itself may be ruptured in accidents and occasionally in surgical operations.

VIII. **The Great Sciatic Nerve.**—Since it is so well protected, the trunk of the sciatic is not often injured or cut by accident, except in gunshot wounds, but its external popliteal branch is sometimes divided in tenotomy of the biceps muscle or accidentally just below the head of the fibula.

Motion.—The importance of this branch lies in the fact that it supplies the anterior flexor muscles of the foot, and that its injury or division is followed by *foot-drop*, so that the foot drags in walking and the wearing away of the boot-sole under the great toe is very marked. If the main trunk of the sciatic is divided or injured, all the muscles below the knee are involved in the paralysis. The patient can walk, because, as a rule, the muscles of the thigh are not involved, but the leg is, as it were, flung forward from the hip at each step.

The loss of *sensation* (Fig. 146) is generally less extensive than the loss of motion, only the foot and the outer parts of the leg being entirely anesthetic.

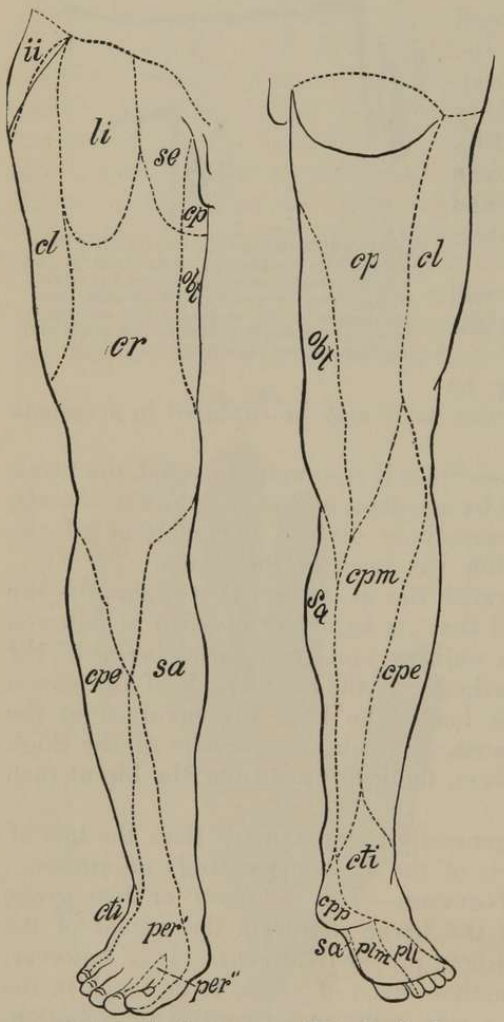
Prognosis after Injuries of Nerves.—This is more or less grave in accordance with the importance of the nerve involved, the extent of the injury, and the time that has elapsed without proper treatment. It is, however, possible, after a lapse of months or sometimes even of years, to do much in the way of restoration, sensation being, as a rule, more under control than motion. If the time has been long and the injury severe, good results can be attained only after treatment covering weeks or months, and in many cases can scarcely be hoped for. Hence the especial need for the early correct treatment of these injuries.

Treatment of Wounds of Nerves.—The fact that there is a lesion of a nerve will not modify the primary treatment of the wound unless the nerve be amenable to suture, as described below. This should always be done at the time of the accident. The wound should be treated in other respects precisely as any ordinary case. The treatment of the remote results due to nerve injury are, however, somewhat peculiar, and are now to be considered.

Treatment of the Remote Effects following Nerve Injury.—1. *Motion.*—Unquestionably the agent which gives us the best promise of relief from a destructive motor lesion is electricity. When a motor or a mixed nerve

has been divided, as has already been stated, the muscles which have been paralyzed very soon indicate degenerative changes affecting their nutrition and producing a permanent shortening. This degeneration can be prevented to a large extent by the daily or almost daily use of electricity, which will keep the muscles in their normal condition, ready to resume their natural function by volition on the rehabilitation of the nerve-trunk, which may then take the place of the electric stimulus. If the nerve responds to faradism, this is undoubtedly the best form to use. If, however, so much time has elapsed that the muscles do not respond to faradism, galvanism should be employed and the effect of faradism re-tested from time to time, and as soon as the muscles respond to faradism this should be used in preference. An important adjunct to this is systematic daily massage of the paralyzed limb, which should be persistently employed with the same object as the use of electricity. The hot and the cold douche should also be used, together with such general measures as will best keep up the general health. If muscular spasms occur, the injection of $\frac{1}{150}$ of a grain of atropine deep into the substance of the muscle is the best means of overcoming the spasm. If deformities have resulted, tenotomy is often indicated and will result beneficially. If the joints have become ankylosed or otherwise diseased, the adhesions must be broken up under anesthesia, very often repeatedly, and the joint stimulated to return to its normal condition by passive motion, friction, douches, massage, etc. These efforts must not be relaxed until the lapse of months or even of years has proved that the lesion is beyond relief.

FIG. 146.



Anterior Surface. Posterior Surface.

Distribution of the cutaneous nerves of the lower extremity. *ii*, N. ilio-inguinal. (plex. lumb.); *li*, N. lumbo-inguinal. (to the genito-crural, plex. lumbal.); *se*, N. spermat. ext. (to the genito-crural.); *cp*, N. cutan. post. (plex. ischiad.); *cl*, N. cutan. lateral. (plex. lumb.); *cr*, N. cruralis (plex. lumbal.); *obt*, N. obturator. (plex. lumb.); *sa*, N. saphen. (plex. lumbal.); *cpe*, N. commun. peron. (N. peron. tibial.); *cti*, N. commun. tibial.; *per'*, *per''*, N. peronæi ram. superfic. et prof.; *cpm*, N. cutan. post. med. (plex. ischiad.); *cpp*, N. cut. plant. propr. (N. tib.); *plm*, *pll*, N. plantar. medial. et lateral. (N. tib.) (Henle).

2. *Sensation.—Anesthesia.*—The best means of stimulating the skin, apart from the measures already indicated, massage, friction, douche, etc., is the electric brush. This is best applied with the faradaic current, the skin having first been dried with flour.

Pain.—The pain varies so much in degree that the treatment must be correspondingly varied. Sometimes the simple application of cold water is sufficient. Occasionally the injection of small amounts of morphine will answer

the purpose, and often rest will do much, but in cases of severe pain, especially that named by Mitchell "causalgia," all means employed will sometimes be futile. The patient who is a victim of such pain soon learns the value of cold water and keeps the part constantly wet, wearing a wet glove or pouring water into his boots. The most useful remedy in these cases is repeated blistering over the course of the nerve, and in many instances this will give even complete relief. Morphine should be given by the mouth or by injection, but care must be taken lest the morphine habit be formed. If the pain resists these remedies, especially when combined with those already mentioned, the nerve involved should be stretched, divided, or exsected. Sometimes even amputation is required.

SECTION VI.—OPERATIONS ON NERVES.

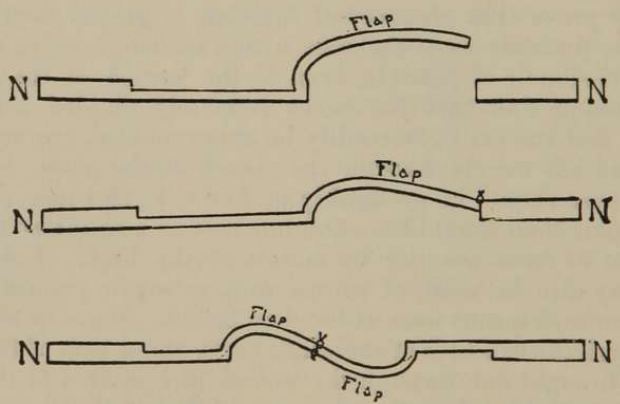
These are four in number: I. Nerve-Suture and Nerve-Grafting; II. Neurectasy, or Nerve-Stretching; III. Neurotomy, or Division of a Nerve; and IV. Neurectomy, or the Excision of a Part of a Nerve.

I. **Nerve-Suture and Nerve-Grafting.**—*Primary Suture.*—The old views of the dangers of sutures as applied to nerves are entirely exploded, and numerous cases in which suture of a nerve has been practised immediately after the injury prove that recovery of function is greatly facilitated by such suture. Hence, precisely as is the case with a tendon, a nerve should always be sutured immediately if possible, even if the section of the nerve is only partial. Supposing first that the nerve is merely divided, without loss of substance, and that the ends can readily be approximated, two or three sutures should be passed not merely through the sheath of the nerve, but through its substance. These should be preferably of fine silk, and inserted by sewing-needles. The part then should have absolute rest on a splint, so that the nerve-ends should not be torn asunder by motion of the limb. Catgut, kangaroo tendon, etc. may also be used, of course with antiseptic precautions. In one case in which no such means were at hand an ordinary hare-lip pin was inserted obliquely through the two ends of the ulnar nerve and a loop of fine silk thrown over its point, brought out through the wound, and secured to the head of the pin. At the end of three days the pin was withdrawn, thus loosening the silk, which was easily removed. The result was in every way satisfactory. If the ends are so far separated that they cannot be readily approximated, one or both ends of the nerve may be stretched until they can be placed in contact, and the same process then carried out. While failure has occurred in a good many cases, the results have been surprisingly successful in others. In a very few instances apparently primary union has taken place and sensation has been restored in two or three days, or even less; but more frequently one, two, or more weeks will elapse, and we should not despair of such a nerve until months or even years have passed. Bowlby has analyzed 81 cases of primary suture, of which 32 were entirely successful, 34 were partially so, and only 14 were failures, the result in one case not being recorded. It is especially important to remember that we should not be hasty in our conclusions as to results. The early results may be disappointing, but time must be allowed for union, degeneration, and regeneration of the nerve before we can expect return of function in most cases. Even the gravest of trophic changes should not make us despair of the ultimate result. Sensation will return, as a rule, before motion, and, in view of the time that elapses before the nerve will be able to carry the stimulus of volition to the muscles, the value of electricity in keeping the muscles in good condition must especially be borne in mind.

Secondary Suture.—Within the last few years, in a number of cases weeks, months, or even a number of years after the injury, when the muscles have been paralyzed for a long time and sensation has been altered or destroyed, the secondary suture of such divided nerves has been followed by success. This operation, like all others, must be strictly antiseptic. An Esmarch bandage should be applied, the nerve exposed, and the two ends loosened from their attachments. The proximal end will, as a rule, be bulbous and be found with ease. It is often more difficult to find the wasted distal end, and sometimes it is best to cut down on the nerve beyond the site of the injury at a point where the nerve lies in its normal relations, and then follow up the trunk till we come to the cut lower end. The whole of the bulbous extremity of the proximal end should be removed, but only a small portion, usually not over a quarter of an inch, of the distal end. The two ends should then be approximated by stretching, and the nerve sutured as before. Bowlby's table of 73 cases of secondary suture of the nerves gives successful results in 32, partially successful in 26, and failure in only 15.

Nerve-Grafting.—If, after stretching, the ends of the nerve cannot be approximated, two methods are open to us (Fig. 147): partially splitting the

Fig. 147.



Suture of a Nerve by Splitting the Ends (Beach).

nerve for a certain distance, turning over what may be called the flap of nerve, and uniting it to the other cut end; or flaps may be made from both ends (Beach). The results of this method of treatment have not, however, been very satisfactory. Possibly the transplantation or grafting of nerves will give better results. If a nerve can be removed from an amputated limb (the two operations of amputation and nerve-suture being simultaneous), a portion of human nerve can be transplanted. If it be impracticable to obtain a portion of human nerve, a suitable portion of a nerve from one of the lower animals can be removed, placed in its proper position, and sutured at both ends to the cut ends of the nerve. It is probably a matter of indifference whether this nerve be a motor, sensory, or mixed nerve, the nerve-tubules being simply subservient to the transmission of the nervous impulse in either direction. The suggestion of Von Bergmann that the entire limb shall be shortened by resection of a portion of the bone seems superfluous in view of the dangers of the operation as contrasted with those of the simple operation of nerve-grafting by transplantation.

II. **Neurectasy,** or **Nerve-Stretching,** was first introduced by Nussbaum in 1872. Vogt has shown by experiment that a nerve can be stretched

one-twentieth of its length, and that it yields most at its spinal extremity, the amount of elongation diminishing as we approach the periphery, where it becomes almost nothing. In order to guide us as to how much force we can apply, it is important to know what force will rupture the nerve. Marshall gives the following result of experiments on different nerves:

Cohesion of Human Nerves after Death—Breaking Strain in Pounds.

	Lbs.
Supraorbital	6
Infraorbital	12
Mental	5½
Brachial plexus	50–64
Ulnar	58
Musculo-spiral	61
Median	84
Crural	83
Internal popliteal	114
Great sciatic—Symington	86–176
" " Tillaux	118–127
" " Gillette	165
" " Trombetta	82–288
" " Ceccherelli	154–220

It must be remembered that the force necessary to produce rupture is probably somewhat greater in the living than in the dead subject. The nerves most commonly stretched are the facial, the spinal, and the sciatic, especially the latter. It should be noted that the facial nerve, which is not included in Marshall's table, will bear a strain of from seven to twelve pounds, and that therefore the head can be almost lifted from the table, and in some cases entirely so, without rupture of the nerve-trunk. The surgeon generally feels the rupture of some strands, which will warn him of the impending rupture of the entire trunk. The great sciatic nerve has ruptured in various subjects at a minimum of 82 pounds and a maximum of 288. It is therefore, as a rule, absolutely safe to lift the leg or even the pelvis by traction upon this trunk. Whether nerve-stretching produces any traction upon the cord has been much disputed. But Tarnowski has shown experimentally in rabbits that while slight traction on the sciatic nerve was followed by a passing hyperemia, when the traction was considerable hemorrhages in the gray matter and inflammatory exudations were caused, followed by sclerosis and atrophy of the nerve-cells; and marked effects have been noted after stretching of the brachial plexus. Moreover, inasmuch as there are on record at least eleven cases of death from lesion of the spinal cord after nerve-stretching, such deleterious influences can scarcely be denied.

The effects of nerve-stretching are more or less hemorrhage and destruction of the nerve-tubules, differing in amount with the force used, with later cell-proliferation in the neurilemma. This tearing of the nerve-tubules is followed by degeneration precisely as after section of the nerve, followed in turn, however, by a much greater regeneration. In the cord the changes are usually inflammatory, from a slight hyperemia up to a definite myelitis followed by atrophy. The direction of the stretching is not a matter of indifference, for, as shown by Tutschek, if a nerve be stretched by drawing it in a direction away from the cord, the sensory fibers are more dulled than the motor, but if the traction be toward the cord the motor filaments suffer more than the sensory. We should therefore stretch the nerve in different directions for the relief of pain and of spasm. If the stretching be very severe, it may be followed by trophic changes, just as after a lesion of the nerve produced in any other way. Various theories have been adduced as to the mode of action of neurectasy:

the probability is, however, that its benefit results from some obscure change in the nutrition of the nerve, in its separation from adhesions either to neighboring parts such as cicatrices, etc., or to its own sheath, and in many cases undoubtedly to absolute rupture.

Two methods may be adopted. *First, by operation.* The trunk of the nerve is exposed and loosened from the surrounding parts. It is then stretched either by hooking it up by the fingers, or in a small nerve such as the seventh nerve by a common pocket button-hook or similar instrument, or by Horsley's saddle-shaped hooks for the larger nerves. The *second or bloodless method* is applicable only to the great sciatic nerve. The patient is etherized, the leg kept extended at the knee, and the entire lower extremity, being then used as a straight, stiff lever, is carried into marked and forced flexion at the hip. The results of the last method seem to have been very good in a number of cases, but it must be borne in mind that in adults at least there must be considerable rupture of the bellies of the hamstring muscles, and there have been reported two cases of death after this method.

Conditions to which Neurectasy is Applicable.—The largest number of operations of this kind have been done for ataxia, and often with at least temporary benefit; but usually there has been only slight relief, and in many cases none. In spinal disorder of all kinds, such as paralysis, myelitis, paralysis agitans, athetosis, epilepsy, and tetanus, little good has been accomplished. In "tic convulsif," or spasm of the facial muscles, the facial nerve has been stretched in over twenty cases. In a very small number the relief has continued for months, and in Southam's case even for five years, but in most instances relapse has followed. The relief is so great, however, that the patient is generally willing to submit to repeated operations, and the operation is undoubtedly to be recommended. Neurectasy has also been used for wry neck, in a few cases with cure or benefit. Anesthetic leprosy has also been so treated with improvement. In all cases where nerve-stretching has failed to relieve it is possible to do a later neurotomy or neurectomy; hence very often neurectasy should precede these more severe operations.

III. and IV. **Neurotomy and Neurectomy.**—These two operations of simple section of the nerve and exsection of a portion of it may be considered together, as they differ only in the treatment of the nerve. As a rule, neurectomy is to be preferred to simple neurotomy. They are done occasionally for muscular spasm, but most frequently by far for neuralgia. Either may be done as a primary operation or secondary after neurectasy. Neurotomy can sometimes be done subcutaneously, as, for instance, in the supraorbital or the infraorbital nerve. When several nerves lie close to each other, as in the armpit, and there is doubt as to which is the nerve sought for, faradizing each exposed nerve in turn will differentiate them. Once the nerve is exposed it can be stretched, divided, or a portion of it exsected as may be desired. The following nerves are those most commonly operated on:

1. The **supraorbital nerve** emerges on the face through the supraorbital foramen or notch. If it is a notch, it can usually be felt, but if a foramen it can also be readily found, as it lies at the junction of the inner and middle thirds of the eyebrow. A simple curvilinear incision one inch in length, which if made in the eyebrow will be hidden by the hair, is sufficient to disclose the nerve.

2. **The Superior Maxillary Division of the Fifth Nerve.**—A line drawn from the supraorbital notch downward between the two lower bicuspid teeth intersects the infraorbital and mental foramina. The infraorbital nerve emerges at the former foramen. Simple section of this nerve, which was

formerly done for neuralgia, has been very properly abandoned. A curved incision an inch and a half long is made just below the lower border of the orbit. Where this incision intersects the line above mentioned the nerve will be found under the levator labii superioris, lying much deeper from the skin than would be supposed. The nerve having been found, a silk thread is passed under it by means of an aneurysm needle, and the thread is tied in order to identify and make traction on the nerve. The upper border of the incision is now raised by a spatula or retractor, and with a grooved director or other instrument the periosteum covering the floor of the orbit is lifted and held up by the spatula. Even if not at once seen, the canal for the nerve is readily found and broken in by pressing on the floor of the orbit with the grooved director. By a small sharply-curved hook the nerve is lifted from its bed and divided far back in the orbit by means of curved scissors. Traction on the anterior end will now pull out the entire nerve. Moderately sharp bleeding usually follows the division of the nerve in the orbit, but is readily arrested by packing with a little gauze. The bleeding of the external wound is controlled by hemostatic forceps.

3. **Removal of Meckel's Ganglion.**—Sometimes after removal of the superior maxillary division as above described, or better as a primary operation, Meckel's ganglion and the nerve are removed. This is done by Carnochan's method, or better by Chavasse's modification of it. It consists of a T incision below the eye, the horizontal part reaching from canthus to canthus, and the vertical one nearly to the mouth, but without entering this cavity. The infraorbital nerve is found, and as before is tied with a piece of silk. The anterior wall of the antrum is then perforated by a three-quarter-inch trephine or a chisel, including the infraorbital foramen. A half-inch trephine or a chisel is applied to the posterior wall of the antrum, care being taken merely to penetrate through the bone and not to wound the internal maxillary artery, which lies close behind it. The nerve is next divided on the cheek, and, after breaking through its groove in the floor of the orbit, the nerve is drawn down through the trephine opening. By this method the nerve is preserved and utilized as a guide to the ganglion. The nerve, being made tense, is now traced into the spheno-maxillary fossa and to the foramen rotundum, and is divided just below the foramen with long delicate curved scissors. To control the hemorrhage iodoform gauze and small sponges on sponge-holders are best, and it is almost essential that an electric light or forehead mirror be used to illuminate the deep parts of the wound. Abbe has recently recorded two cases in which he removed the nerve by a single horizontal incision one inch and a quarter in length, breaking down both the anterior and posterior walls of the antrum with a simple gouge. After removing the nerve he packed the wound lightly with strips of iodoform gauze, and did not suture it until he removed the gauze, forty-eight hours after the operation. Sensation being paralyzed, no pain is caused by the late sutures.

Instead of trephining through the antrum, Horsley, after exposing the nerve, lifts the contents of the orbit with the periosteum of its floor, lays open the canal by sharp-pointed bone forceps, and then follows the nerve to the foramen rotundum. Often the antrum will not be opened. Luecke resects the zygoma, turns the temporal muscle up, and so gains access to the ganglion.

4. **Inferior Dental Nerve.**—Several operations have been devised for this, but the best are as follows:

(1) *By External Incision.*—An incision two inches long is made along the lower border of the jaw, beginning slightly behind the angle. This is better than a vertical incision, which is almost certain to divide some branches of the

seventh nerve, and may paralyze the muscles of the mouth. The incision, being well under the border of the jaw, is entirely hidden in men by the beard and partly hidden in women by the jaw. The upper edge is displaced upward on the vertical ramus, and after scraping away the masseter muscle a half-inch trephine is applied an inch and a quarter above the angle. This exposes the nerve at its entrance into the inferior dental foramen. The nerve, having been brought to the surface by a small sharply-curved hook, is first stretched, and then as much of it as possible is exsected. If desired, the incision can be prolonged above and parallel to the edge of the jaw, and the canal for the nerve be laid open all the way to the mental foramen. Commonly rather copious hemorrhage is caused by the division of the inferior dental artery if this is involved in the cut. Packing will usually control it, but occasionally a ligature is necessary. By this same incision the nerve may be removed without trephining by separating the parts behind the jaw instead of in front of it, scraping the internal pterygoid muscle instead of the masseter loose from the jaw, and finding by the finger the sharp point of bone which marks the inferior dental foramen. The nerve can now be brought to the surface as before and be stretched and exsected.

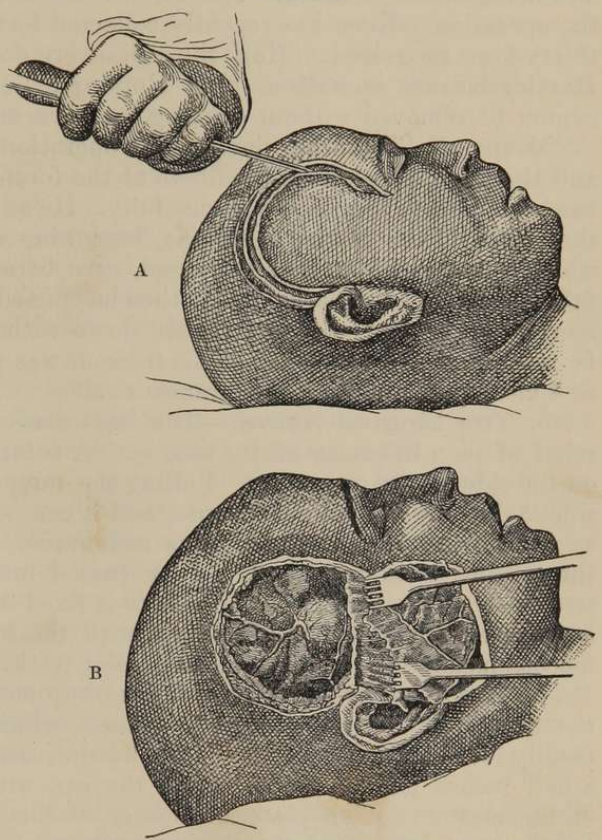
Horsley has recently proposed a new method by a vertical incision through only the skin and fat, beginning just above the zygoma, extending to the angle of the jaw, and then following its lower border as far as the facial artery. This flap is lifted without cutting the branches of the facial nerve. Between the upper branch of the nerve and Stenson's duct the masseteric fascia is divided, and the opening widened to three centimeters in diameter. The parotid is now retracted toward the ear and the posterior border of the jaw defined. Next the posterior two-thirds of the masseter are divided and the jaw cleaned, so that the sigmoid notch is well seen. By drilling several holes and by a small trephine the bone is removed, so that the sigmoid notch is prolonged downward twelve to fifteen millimeters to the border of the inferior dental foramen. Division of the periosteum on the inner surface of the jaw then discloses the inferior dental nerve. This can be followed to within a centimeter of the foramen ovale and exsected. The lingual nerve lies half an inch deeper and somewhat in front of the inferior dental, and may also be exsected. The bleeding is free, but controllable. The internal maxillary artery may have to be ligated and divided. An electric light is essential.

(2) The nerve can also be reached *through the mouth*, as follows: The mouth being held open as widely as possible by a gag on the opposite side, the mucous membrane is incised along the anterior border of the ramus of the lower jaw between the last molar teeth of the two jaws. The finger can now be inserted between the internal pterygoid muscle and the ramus of the jaw. The muscle being separated from the bone, the same sharp projection of bone at the opening of the inferior dental foramen before referred to is found and the nerve brought to the surface with a hook. The long internal lateral ligament of the jaw must not be mistaken for the nerve. Hemorrhage was very profuse in two instances on record, and gave considerable trouble.

5. **Removal of the Gasserian Ganglion.**—In not a few cases after the above operations, especially on the superior maxillary and inferior dental nerves, the neuralgia returns, and in order to remedy the pain Rose, Andrews, and others have removed the Gasserian ganglion itself. This ganglion lies, it will be remembered, on the anterior surface of the petrous bone underneath the dura, but above a layer of the periosteum which lies between the ganglion and the base of the skull. Mr. Rose's later method is as follows: The eyelids are first sewed together to protect the ball, the sutures being removed on the fourth

day. A curved incision is made from half an inch below the external angular process along the zygoma to its posterior extremity, then downward to the angle of the jaw, and finally along the lower border of the jaw to the facial artery. The flap is then dissected forward without wounding the facial nerve or Stenson's duct. The zygoma is first drilled and then divided, and turned downward with its attached masseter muscle. The coronoid process is similarly divided, and displaced upward with its attached temporal muscle, and later is removed. The internal maxillary artery is then ligated and divided. The external pterygoid muscle is separated from the great wing of the sphenoid and the external pterygoid plate. A long-handled half-inch trephine is next applied a little anterior and external to the foramen ovale, the edge of the trephine just impinging on the edge of the foramen. The trunk of the nerve is used as a guide to the ganglion, which is then removed by small, sharply-curved hooks, one of which has a cutting concave border. Hemorrhage gives considerable trouble. An electric forehead light is essential in working at such a depth. The results of the first case after twenty-two months were entirely favorable so far as the nerve was concerned, but the eye was destroyed and had to be removed—a calamity happily avoided by the improved technique of later cases, all of which, at least so far, have remained free from pain.

FIG. 148.



Intracranial Neurectomy of the Fifth Nerve (Hartley): A, manner of holding the chisel in cutting the groove through the bone; B, flap lifted and turned down, exposing the dura mater and middle meningeal artery.

Recently, the osteoplastic method of resection of Wagner-Wolff (p. 487) has been applied to this operation. In 1892, Hartley, and a few months later Krause, published independently identical methods of opening the skull by an osteoplastic resection. The usual horseshoe-shaped incision is made through the scalp directly down to the bone, but the flap is not lifted from the bone. The vertical and horizontal extent of the incision is usually about three inches. The base (Fig. 148) thus marked out is much smaller than the remainder of the flap, and terminates in front of the ear and behind the external angular process of the frontal bone. A groove is then cut in the bone with a chisel, and the inner table entirely divided by an osteotome, after which two or three periosteum elevators are inserted into the groove, and the flap, consisting of bone and scalp together, is lifted to such an extent as to

snap the bone on a line between the ends of the incision. The middle meningeal artery is unavoidably torn if it runs through a canal in the anterior inferior angle of the parietal bone, and even if not it is often torn by the small branches passing directly from it into the bone.

The dura is not opened. The temporo-sphenoidal lobe is then lifted from the middle fossa of the skull until the second and third divisions of the nerve are recognized. Just behind their junction lies the ganglion. The nerves are then cut as close as possible to their foramina of exit and the ganglion is broken up, or if possible is removed. In several cases the bleeding on lifting the temporo-sphenoidal lobe has been so profuse as to require packing by iodoform gauze. This has been removed after three days, and the ganglion and nerves then resected. An electric forehead light is almost essential in the operation. Keen has recently collected forty cases, of which six died and thirty-four recovered. Half the cases were done by Rose's and half by the Hartley-Krause operation. Mr. Horsley believes that the entire ganglion cannot be removed without opening the cavernous sinus.

Mixter of Boston has devised an operation for resecting both the second and the third divisions of the nerve at the foramina rotundum et ovale, which has been done several times successfully. He advises a curved incision through the origin of the temporal muscle, beginning and ending over the zygoma, which is sawed through at each end, care being taken not to go back of its tubercle, as the articulation would then be opened. The temporal and pterygoid muscles being separated and turned down with the zygoma, both nerves may be reached at the foramina. This incision was previously described by Salzer as a method of reaching the foramen ovale.

6. **The Lingual Nerve.**—This has occasionally been operated on for the relief of pain in cancer of the tongue. A suture is passed through the tongue on the side of the operation. Pulling the tongue forcibly toward the opposite side makes the lingual nerve tense, and it can be felt in the floor of the mouth as a firm band beneath the mucous membrane. An incision is made through the mucous membrane and a hook passed under the nerve, which is then stretched or exsected. If the tongue is fixed by the growth, the nerve may be exposed where it lies in contact with the lower jaw-bone just under the mucous membrane beneath the first molar teeth.

7. **The Seventh Nerve.**—One of two methods may be adopted to reach the nerve. First, the *method of Baum*, which is the best, as the nerve is readily found and the scar is hidden by the ear. A vertical incision two and a half inches long is made behind the ear, with a slight angle at the apex of the mastoid. The posterior border of the parotid is the first landmark. Displacing this forward, the shining aponeurosis of the sterno-cleido is the second. Clear the interspace between these two to a depth of one to one and a half inches, when the prevertebral muscles and their fascial covering are the next mark. The nerve lies in front of this fascia, crossing the deep and narrow space between the mastoid and the vertical ramus of the jaw. The electric light and the forehead mirror are very great helps. To find just where the nerve crosses this space, place a moist sponge electrode on the cheek; the nerve will be found by touching the tissues at successive points with a fine wire attached to the other cord of the battery. The current should be very weak.

In *Hüter's method* the vertical incision is made in front of the ear. One of the two main branches of the nerve will be exposed in the parotid gland, and is to be followed back to the main trunk. In this method the trunk of the nerve is apt to be reached in front of the point where it gives off its

branches to the occipito-frontal and the orbicularis, and these branches may escape being operated on.

8. **The Spinal Accessory Nerve.**—This has been operated on especially for wry neck. The nerve pierces the sterno-cleido-mastoid muscle, and then passes to the trapezius, supplying both of these muscles. It may be operated on before or after its passage through the sterno-cleido-mastoid: (A) If operated on before it enters this muscle, the incision is made along the anterior border of the muscle downward from the lobule of the ear for two or three inches. The muscle being exposed and turned outward, the nerve is discovered a little above the level of the hyoid bone where it enters the muscle. (B) To reach the nerve after it has emerged from the sterno-cleido-mastoid muscle the incision is made along the posterior border of the muscle two inches long, the center of the incision corresponding to the center of the muscle vertically. The nerve will be found a little above the center of the wound, and should be traced upward to its point of emergence from the muscle and exsected. The former operation is the better one.

9. **Division of the Nerves of the Posterior Cervical Muscles for Wry Neck.**—Keen has described an operation for the exsection of the posterior divisions of the first three cervical nerves, which may be done either independently of the operation on the spinal accessory or as an adjunct to it. Noble Smith and Powers have since done similar operations.

10. **Cervical Plexus.**—The branches of the plexus may be reached by means of an incision along the middle of the posterior border of the sterno-cleido-mastoid muscle.

11. **Brachial Plexus.**—The brachial plexus may be readily exposed just above the clavicle by the horizontal incision for the ligation of the subclavian artery. The plexus is reached immediately under the deep fascia. The nerve-trunks are easily recognized, and one or more of them may be operated on as is deemed best. Care is required not to mistake the lowest cord for the artery.

12. **Median Nerve.**—In the arm the median nerve is readily reached by the incision for ligation of the brachial artery, at the inner border of the biceps muscle at its middle. The nerve usually crosses in front of the artery from without inward. In the forearm the nerve can best be reached just above the wrist-joint by an incision two inches long at the inner side of the tendon of the palmaris longus. It lies immediately under the deep fascia. Its branches to the thumb and fingers are easily reached by an incision along the inferior border of the thenar eminence. It lies just under the edge of the palmar fascia.

13. **Ulnar Nerve.**—In the middle of the arm the ulnar nerve can be reached by an incision similar to that for finding the median nerve, but slightly farther back. Behind the elbow it can be exposed by an incision directly over it as it runs in the groove between the internal condyle and the olecranon. A little above the wrist it is exposed by an incision on the radial side of the tendon of the flexor carpi ulnaris. In the two positions first described the nerve lies immediately under the deep fascia. Just above the wrist it lies more deeply under a second layer of the deep fascia.

14. **Musculo-spiral Nerve.**—This can be readily found in the musculo-spiral groove by an incision corresponding to the groove between the biceps and supinator longus muscles. The deep fascia having been divided, the nerve is found in the interspace between these muscles, and can be felt as a cord rolling between the finger-tips.

15. **Radial Nerve.**—This branch of the musculo-spiral can also be easily found by a longitudinal incision on the outer border of the forearm, about three

inches above the wrist-joint, just where the nerve passes under the tendon of the supinator longus to the back of the hand.

16. **Great Sciatic Nerve.**—The patient should be placed upon his abdomen and an incision about four inches long should be made in the middle line of the leg, beginning just below the gluteo-femoral crease. As soon as the deep fascia is cut through, the belly of the biceps will be found, and on tearing through the connective tissue at its outer border the trunk of the great sciatic will be found with ease.

17. **Tibial Nerves.**—The anterior and posterior tibial nerves may be exposed by the same operations as for ligation of their respective arteries. The posterior tibial may also be exposed by a curved incision behind the internal malleolus and the heel. It lies just posterior to the artery.

CHAPTER VII.

SURGERY OF JOINTS.

SECTION I.—GENERAL CONSIDERATIONS.

LIKE the other structures of the body, the joints are subject to injury and disease. All the articulations have an anatomical construction which should be kept in mind because of its influence upon the nature and course of the pathological processes that are observed. The more or less expanded ends of the bones, in each of the larger joints, are covered with an incrusting cartilage. They are bound together by a capsular ligament, well developed in the ball-and-socket joints, imperfectly so in the hinge joints, with re-enforcing bands as may be required; such ligamentous structures being firmly attached to the bones and closely connected with the periosteum. The joint-cavity, except over the articulating cartilages, is lined by a synovial membrane, which is either a closed sac or communicates with adjacent bursæ. It is sufficiently lax to permit of the free movement of the bones upon each other, and consequently is more or less folded and fringed, and holds and covers larger or smaller masses of fat, intended to lessen shock. Outside the capsule and supported by connective tissue are the muscles moving the joint, their bellies, or more generally their tendons, often running in well-formed sheaths. These muscles are always innervated by branches of the same nerve that sends filaments to the joint structures proper, and from the same trunk come the fibers distributed to the fasciæ and the skin over the insertions of the muscles. The blood-vessels, each arising from the nearest large trunk, quickly break up into many small branches running among the fibers of the ligaments in the subsynovial connective tissue and in the synovial membrane; the incrusting cartilages being nourished by imbibition.

Inflammations of varying intensity are of frequent occurrence: they may be due to traumatism, to rheumatism or gout, to the presence and chemical products of micro-organisms, or to disturbances of innervation. They may be slight or severe, acute or chronic. They may terminate in resolution, in permanent new formations more or less deforming and disabling, or in destruction of the articulation. They may originate in the joint structures proper, especially in the synovial membrane, or they may extend from contiguous parts, the cancellous bone-ends, the overlying tendon-sheaths, or the periarticular

connective tissues. They may be largely confined to a single structure, the synovial membrane being the part ordinarily affected, or they may involve the whole of the joint.

The usual inflammatory changes in blood-supply, in cell-development, and in function are all present. Vascular fulness is observed chiefly in the acute affections and in the synovial membrane, which becomes reddened, it may be intensely so, especially in its fringes. Effusion of serum takes place in the membrane, in the connective tissue beneath it, in the interspaces of the ligaments, and particularly into the joint-cavity. The endothelial cells proliferate unduly and are thrown off, even to the extent at times of rendering the synovial fluid milky or purulent in appearance. Fibrinous exudations occur on the free surface and in the membrane and capsule. New cell-growth takes place in excessive amount in certain of the inflammations—*e. g.* the tubercular. Extravasations of blood may occur into or beneath the synovial membrane or into the cavity. The articular cartilage may undergo no material change, or may become softened and absorbed under pressure or by the action of the new-formed granulation-cells, or be separated in large flakes, or undergo atrophy, or become hypertrophied around its edge. The ligaments also may be essentially unaffected, or they may split up and degenerate in part or wholly, their place being taken by a lardaceous new formation. In all cases function is impaired, either as a whole with reference to movement or as respects the synovial membrane and its secretion of synovia, which latter may become very abundant and very watery, or very scant, not enough to lubricate the surfaces, which grate as they rub against each other.

SECTION II.—SYNOVITIS.

Except in acute attacks, mainly due to injury, an inflammation lighted up in the synovial membrane does not remain confined to it, but affects the other parts of the joint, and is an *arthritis* and not a *synovitis*, although not seldom even in very chronic cases the synovial affection is the chief one.

As the result of an aseptic wound, of a subcutaneous injury (contusion or sprain), of the irritation produced by a floating cartilage, or of exposure to cold and dampness, simple inflammation may attack the synovial membrane. The part becomes congested, chiefly around the edges of the cartilage and in the fringes, which because of their undue vascularity and the associated œdema are somewhat elongated. At times the whole membrane is highly injected and œdematous. The synovial secretion is more or less increased in amount according to the nature and intensity of the inflammation. In character it may remain normal or may become watery. Because of existing fibrinous exudations it may be flocculent.

The **symptoms** are unmistakable. The joint is painful, especially upon motion, often severely so, and particularly at night. It is swollen and tense, it may be fluctuating. At the knee the patella is floated up from the condyles, upon which it can readily be depressed, to rise again when pressure is taken off. By the muscular contraction of the flexors the joint is held in that position which permits of greatest distention and is therefore the most comfortable. The part is never in full extension, the production of which much increases the suffering. Each joint has its position of greatest ease, which is spontaneously and quickly assumed when inflammation occurs. The swelling is most marked in the spaces between the ligaments and where the capsule is not crossed by firm tendons. The local heat is decidedly raised, but the skin, while it is very sensitive to pressure, perhaps only at certain points, is neither

thickened nor reddened. Constitutional symptoms if present are only moderate in degree. After a few hours, or at most days, the intensity of the symptoms subsides, the pain lessens, the swelling diminishes as the effusion and extravasated blood are absorbed, the limb takes its natural position, and recovery quickly follows. If there has been much hemorrhage into the cavity, there may be afterward some restriction of motion in consequence of organization of a part of the clot and its adhesion to adjacent sides of the folded synovial membrane.

In the **treatment** the joint should be placed at rest. Cold may be locally applied by an ice-bag or a coil of rubber tubing (Leiter) or by continuous irrigation; or hot applications may be made, simple or medicated, the lead-and-opium lotion being perhaps the best; or equable pressure as firm as can be comfortably borne may be employed, the affected region being enveloped in a thick layer of cotton or wool, and a bandage, preferably of rubber, put on. The cotton or wool next the skin may be moistened with the hot lead-and-opium wash, and the advantages of both heat and pressure be secured; or the joint may be at once immobilized in plaster of Paris. Pressure will ordinarily prove most satisfactory. Unless the serous distention of the joint is extreme or there has been a large extravasation of blood into the cavity, the fluid will not need to be drawn off, but may be left to the action of the absorbents. If aspiration is done, every precaution must be taken to prevent sepsis.

Chronic Synovitis.—As already stated, a synovial inflammation, whatever its intensity, cannot long continue without extension of the morbid process to other structures of the joint and the development of an arthritis; yet not seldom the affection of the synovial membrane, so far as disturbance of its function is concerned, remains so prominent a clinical feature that the case may be very properly viewed as one of chronic synovitis. The active congestion that belongs to the acute stage, of which the chronic is usually the sequence, largely disappears, leaving the membrane but little changed in appearance from the normal. There is, however, an undue amount of fluid in the cavity, and the membrane itself is œdematous. Later, if the disease does not subside, the membrane and the articular structures become irregularly thickened by plastic exudation and the formation of fibrous tissue, with intervening patches where there have been degeneration and softening. The folds of the membrane are not seldom fastened together by adhesions resulting from the organization of blood-clots or from an exudation thrown out between them; and at times from the fringes and villi there are developed, it may be in great number, growths larger or smaller, often pedunculated, that push into the cavity. There is little or no change in the temperature of the part. Though the joint is weak, it is not specially painful except upon pressure, and may not be so even then. Movements, especially in extension, are restricted, and generally, as the effused fluid has become absorbed, are attended by some grating or creaking. It is the presence of an undue, often an excessive, amount of fluid in the joint that is alone to be here considered, all the other conditions being those of long-standing arthritis dependent upon diathetic, suppurative, or infective causes. The symptoms of such accumulation of fluid are well marked. The joint if a superficial one (and it is the knee that is by far the most frequently affected) is evidently distended, perhaps very much so. There is fluctuation upon palpation. The muscles in the vicinity are wasted, it may be considerably, making the articular enlargement the more prominent. With the hypodermatic needle fluid may be drawn off which will ordinarily be straw-colored or a little darker, somewhat viscid, occasionally flocculent, and at times more or less blood-stained.

The **treatment** varies with the amount of fluid present and according

to the type of the arthritis; for it must be remembered that superabundance of fluid in a joint is not in itself a disease, but a symptom of a traumatic, a rheumatic, a tubercular, or a deforming arthritis, or even of some local or general disturbance of the circulation. When the affection is not of long standing and the articular fulness is not very great, rest and pressure may be all that will be required to produce absorption, the joint being enveloped in cotton and bandaged (the elastic bandage being the best) or preferably immobilized with plaster of Paris. Baths, frictions, massage, electricity, blisters, mercurial ointment or plaster, each has often been found of service. Simple aspiration followed by immobilization may bring about recovery, or if, as is apt to be the case, reaccumulation of fluid takes place, it will be in much diminished quantity and will very likely be readily absorbed. When the affection is of long standing and the joint is much distended, with associated marked impairment of its usefulness, in the condition which may properly be called *hydrarthrosis* or *hydrops articuli*, when the methods of treatment already spoken of have been thoroughly tried and have proved useless, very excellent results may be secured by aspiration and injection of a 3 per cent. to 5 per cent. solution of carbolic acid. The parts having been thoroughly disinfected, the fluid is aspirated (every care being taken to have the needle aseptic), the cavity is irrigated with freshly boiled water until the fluid comes out perfectly clear, and then the 3 per cent. or, better, 5 per cent. carbolic solution is injected, after which the joint is immobilized. This method of treatment should not be adopted so long as there is any inflammation in the joint, and the operation must be done with the most scrupulous precautions as to asepsis.

SECTION III.—ARTHRITIS.

Inflammation of a joint as a whole may be either acute or chronic. It may be consequent upon the presence of pyogenic cocci, of infection by the bacilli of tuberculosis, or of the micro-organisms of any one of the acute infectious diseases, or of gonorrhea; upon rheumatism or gout or the rheumatoid condition, whatever may be its nature; upon syphilis; and upon lesions of the nervous system, especially tabes.

(A) **Tubercular Arthritis.**—The great majority of cases of chronic joint disease are tubercular, the bacilli being primarily deposited in the bone, the synovial membrane, or the capsule and periarticular structures; most frequently, especially in children, in the bone. In this osseous variety of joint tuberculosis the secondary infection of the soft parts takes place after destruction of the cartilage over a carious area or over a wedge-shaped tubercular infarct in the epiphysis, with resulting opening of the joint-cavity; or through a sinus extending to the synovial membrane outside the cartilage or reaching the capsule farther out; or, which is of comparatively rare occurrence, from the tubercular periarticular structures, the ligaments and the synovial membrane becoming infected by the extension of the morbid process. When the synovial membrane is affected, whether primarily or secondarily from a neighboring focus in the bone it matters not, the developed granulation-tissue is usually abundant and soon extends to and involves the capsule and the structures outside of it. The parts become thickened, œdematous, and of a gelatinous or lardaceous appearance, little or no fluid being present in the synovial sac. Occasionally the membrane is thickly studded with small tubercules, and is highly vascular; there is little new formation of tissue, but an abundant serous effusion into the joint takes place. In other cases the inflammation is a plastic one, the outgrowths being few and large or papillomatous and very numerous. In the ordinary

fungous variety (the "gelatiniform" or "gelatinoid degeneration" of many writers), as the result of the new growth and the œdematous infiltration, a marked change soon takes place in the size, shape, and appearance of the articulation. The natural elevations and depressions disappear, the softened ligaments offering little or no resistance to the pressure of the growing granulation-masses, with which before long they become incorporated.

The contour of the joint is globular or, more properly, spindle-shaped, because of the decided atrophy of the parts above and below and the swelling of the periarticular structures. The skin, as the result of obliteration of the vessels and œdematous infiltration, is white, thick, and firmly attached to the fascia beneath. A few large superficial veins can generally be seen. Palpation may and often does develop pseudo-fluctuation, because of the abundance of fluid in the tissues, and true fluctuation in the exceptional cases in which there is a large serous accumulation in the synovial sac or when the joint is distended with the so-called tubercular pus, which is not pus, but the milky fluid of the liquefying caseated masses. Pain is, as a rule, but slight in the strictly synovial variety; in the osteal form it is decided, and may be very severe. It is always to be elicited by pressure, although perhaps only over a limited space. When the originally synovial disease has extended to the adjacent epiphysis, pain will be present, even if previously absent. The heat of the part is always increased, but often the elevation of temperature is so slight as to be detected only by careful use of the thermometer.

Deformity is a constant accompaniment of the disease; its degree is greater or less according to the joint affected, the amount of disease present, and the treatment pursued. It is due to (1) the natural tendency of the parts to take the position of greatest ease; (2) the softening and destruction of the ligaments; (3) muscular contractions induced by reflex irritations. These causes often result in permanent vicious attitudes, assumed and maintained by the patient through a long period of time.

Caseation and liquefaction of the fungous masses take place here as elsewhere, giving, it may be, no evidence of their occurrence when the disease is of limited extent, but indicated generally by the formation of so-called abscesses and sinuses. The opening of these sinuses is almost certain to lead to pyogenic infection unless the latter is prevented by antiseptic treatment. When it occurs it results in a marked aggravation of the general and local morbid state. Very frequently in the history of a tuberculous joint, extending over months or years, a number of openings will successively arise, the sinuses which communicate with these limited degenerations of fungous masses, carious patches, or sequestra of small size alternately opening and closing.

The **diagnosis** of joint tuberculosis is easy, difficult, or impossible according to the extent, the character, the location, and the duration of the affection. If of the fungous variety in a superficial joint, advanced to the stage of decided deformity, still more to that of abscess and sinus, there can ordinarily be no mistaking the nature of the trouble. Syphilitic disease has points in common, but it is of comparatively infrequent occurrence, and generally there will be in the history of the individual or in the condition of other parts of the body evidences of a pre-existing specific infection. But if the disease is osteal, has advanced but little, has caused only a slight impairment of the articular motions, hardly, it may be, more than an unwillingness fully to use the joint, is attended with little pain and no appreciable swelling or atrophy, if the muscular rigidity is so little as to make it doubtful whether it exists, and if finally the joint is a deep one, the disease very likely will be overlooked. At best the diagnosis is but a probable one. In all such cases, even when there is only a well-grounded suspicion

of the existence of tubercular disease, the patient should be given the benefit of the doubt and treated for a time as though the disease was unquestionably present.

What is called "pannous synovitis" is rarely met with. In this form the tubercles are small and in great number, the vascularity of the membrane intense, new formation of very limited extent, and the ligaments and periarticular structures but slightly affected. The great serous accumulation in the synovial sac will almost certainly be regarded as non-tubercular in character until after aspiration and examination of the fluid.

The **prognosis** depends upon the extent of the disease, the general condition of the patient, and especially upon the treatment employed. In a few cases, doubtless, the tubercular area is so small, the extension of the morbid process so easily arrested, the new formation so slight, and the adhesions and bands developed in its cicatrization so limited, that after recovery has taken place there will be little, it may be practically no impairment of the motions of the joint. But in the great majority of cases this does not occur. The cartilages are more or less extensively destroyed, intra- and extra-synovial bands are formed, and the size of the joint-cavity is diminished. In proportion as there has been damage to the component structures of the articulation must the functional value of the joint be lessened, all the more when there has been displacement of one bone upon the other. The restriction of motion may be absolute. Ossification of the granulation-tissue uniting the surfaces of the epiphyses, which have been deprived of cartilage and eroded by caries, may have taken place (true bony ankylosis), progressing sometimes to the extent of complete fusion of the two bones; or the same result may have been secured without ossification, short, firm fibrous bands existing within the capsule, the action of which is further reinforced by ligamentous and periarticular contractions and adhesions (false, fibrous ankylosis). At times, though recovery has been in a great measure secured, a sinus or sinuses will long remain because of the presence of a limited amount of carious or necrosed bone or of the tuberculization of the sinus wall. Even where all morbid action seems to have been arrested, and the patient for months, it may be for years, has been free from all indications of disease, the joint may again become the seat of tubercular inflammation, either because of the setting free of primarily encapsulated organisms or because as a place of least resistance it most readily becomes the field of a new infection. During the necessarily long period that must elapse before recovery can take place there is an ever-existing danger of the development of visceral or general tuberculosis. Caseation, if extensive, is associated with constitutional disturbances of greater or less severity. When sinuses have opened, septic infection of the diseased parts is almost certain to occur unless prevented by antiseptic treatment, and the resulting suppuration exposes the patient to the added risks of exhaustion, amyloid disease, and septicemia.

The **treatment** is that of tubercular disease in general. The indications are to prevent, or, as far as possible, to limit, the multiplication of the bacilli and the extension of their action; to favor the condensation and cicatrization of the non-tubercular new-formed granulation-tissue; failing in this, to remove the infected part. For the fulfilment of the first, *rest* is of the utmost importance, since it lessens irritation and diminishes the blood-supply and the rapidity of its flow. It may be secured by splints and muslin or rubber bandages, but best by immobilization. The joint having been enveloped in a thick layer of cotton, the plaster-of-Paris bandage is to be firmly but not too tightly applied (that the beneficial effects of pressure may also be secured), not only over the joint, but also nearly to the levels of the joint above and that below, care

being taken that the joint is held in a position of ease during the setting. Such immobilization must be continued for weeks, often for months, new bandages being applied as the size of the joint diminishes. If this is employed at an early period and the affected limb is kept quiet, recovery may be expected in a large proportion of cases of joint tuberculosis. Instead of the plaster-of-Paris bandage, a fixation or a traction-and-fixation splint may be employed, and is by many regarded as preferable, but in general the plaster bandage will be found to secure more complete rest of the joint. Accumulations of fluid, either intra- or extra-articular, may very properly be removed by aspiration, provided a thoroughly aseptic needle is used, but in the ordinary cold abscesses consequent upon joint inflammation if the disease is thoroughly treated the abscesses may safely be left to take care of themselves. If they are tapped they should also be well irrigated, preferably with an oil or glycerin solution of iodoform (5 to 25 per cent. of the former; 5, or better 10, per cent. of the latter). For the relief of pain and localized tenderness ignipuncture or penetration into the bone with the thermo-cautery has been used with advantage.

When the case is one of tubercular dropsy, aspiration should always precede the application of the immobilizing dressing, or, better, aspiration followed by the iodoform injection.

Much attention has of late been given to the discovery and employment of agents that will condense and favor the cicatrization of the new tissue outside of the tubercular area and bring about the destruction or encapsulation of the bacilli. Chloride of zinc and iodoform are the remedies most in favor. They are injected into and around the tubercular masses, and their employment has certainly proved of service. In using the zinc solution only a few drops are thrown in—three to five drops ordinarily, at times as high as twenty. The tendency seems to be, of late, to increase both amount and strength. The 10 per cent. solution of iodoform in glycerin or oil has been much more largely used, and unquestionably it does both destroy the organisms and favor the condensation of the new tissue. It may be injected once a week or once a fortnight, and continued until the case is evidently well advanced toward recovery or until it becomes certain that no good is being accomplished. This can usually be determined in the course of a month. When used in the treatment of abscesses or of joints containing much fluid the injection should always be preceded by thorough irrigation with freshly-boiled water or a boric-acid solution (3 to 5 per cent.). Instead of either of the remedies mentioned the balsam of Peru may be used to advantage.

Of course, whatever local treatment is adopted, care must be taken to secure for the patient as far as possible those general hygienic conditions which are so strongly demanded by the subjects of tubercular disease, no matter where located; and the ordinary constitutional remedies should be employed.

When the extent of the disease and the local and general effects produced by it are such as to make it certain, or at least probable, that recovery cannot take place under the treatment indicated, or, if it may, that it will be only at great risk to life or after a long time, and then with a limb far from serviceable, conservative treatment must give place to operative. The tubercular tissue must be thoroughly removed, by erasion, by excision, or by amputation. These operations and the indications for the adoption of one rather than another are treated of elsewhere (see Operations on Joints), and need not be considered here.

TUBERCULAR DISEASE OF SPECIAL JOINTS.

Hip-joint Disease.—Hip-joint disease (*morbus coxarius, morbus coxæ*) is very much more common in children than in adults. In the former at least

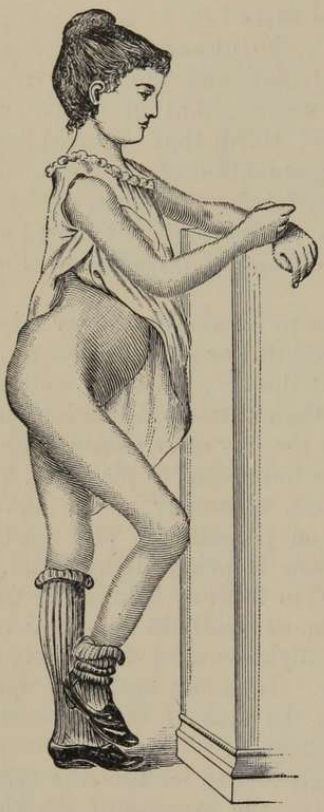
it is generally bony in origin, the tubercular deposit being in the majority of cases at first in the femoral epiphysis, a region naturally subject to the action of repeated shocks and slight traumatisms. In not a few patients the acetabulum is first affected, and primary infection of the soft structures of the articulation is probably by no means so infrequent, even in early life, as is often supposed. Whether in the beginning osteal or synovial, the disease naturally presents *three stages:* first, that of deposition of the bacilli and the early irritations and new formations consequent thereupon; second, that of fully-developed arthritis, with its effusions and fungous masses; third, that of breaking down of the infected tissues and greater or less disorganization of the joint, followed by repair, which is usually slowly effected and far from perfect, or by death. Each stage has its distinguishing **symptoms.** Because of the most apparent symptom, the second is often spoken of as the *stage of lengthening*, the third as that of *shortening.*

In the **first stage** the disease is very apt to be overlooked or misunderstood for a considerable time, because of the doubtful or slight character of the symptoms, though occasionally it is indicated at the very outset by well-marked signs. Slight lameness, generally little more than stiffness, is noticed at times —as a rule in the morning rather than later in the day after considerable exercise has been taken. The child is more or less indisposed to play, and quickly tires. Rigidity of the muscles about the joint, especially of the adductors, though not very decided, may be discovered on palpation. The muscles of the thigh are a little atrophied. If the disease is primarily synovial, slight fulness will perhaps be observed over the joint, in front or behind the trochanter, or be recognized on pressure. At times, almost wholly in the osteal variety, pain is complained of, about the hip, in the thigh, or most frequently at the knee, but usually the patient suffers but little. It is not until the epiphysis has become extensively diseased, especially on the side of the incrusting cartilage, that pain becomes a symptom of importance.

In the **second stage** the disease has progressed so far that the symptoms are decisive. The child limps, unquestionably; the atrophy of the thigh is positive, it may be great; the adductor rigidity is marked. If, as is probable, effusion has taken place into the joint, the fulness can be felt, if not seen, and the hip will be evidently broadened sidewise. The affected extremity is advanced and more or less abducted and everted, due to tilting of the pelvis, the weight of the body in standing and walking being thrown on the sound side (Figs. 149, 150). Occasionally, though rarely, the limb is adducted. The gluteo-femoral crease is more or less lowered and shortened, and the lines of the sulcus between the nates and, in girls, that of the vulva, are inclined. The limb is apparently lengthened, but only apparently. Pain will be present sooner or later. It will be located usually in the anterior and lower part of the thigh and the antero-internal surface of the knee in the course of the obturator nerve. It is often "starting" in character, and most severe at night or felt only at that time. But pain of itself is an unreliable symptom, and its absence should never be regarded when other indications of joint disease are present. The hip movements are restricted, chiefly, as a rule, in full extension and abduction. These symptoms are due to various causes: the muscular tension and distant pain, to reflex nervous irritation; the position of the limb, to involuntary muscular action, and, in a measure perhaps, to distention of the joint when effusion has taken place; the starting pains, to sudden forcing of the articular surfaces together. These pains occur chiefly at night, when the protecting muscles about the joint are less under control, and generally indicate more or less extensive destruction of the articular cartilage. The effusion within the joint is slight in the osteal

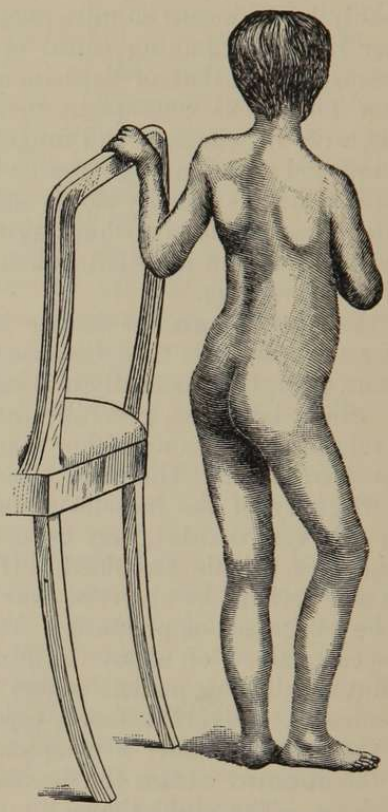
variety of the disease so long as it is simply osteal, but is usually considerable when the soft structures are affected, whether such affection be primary or sec-

Fig. 149.



Position in Coxalgia (Albert).

Fig. 150.



Position in Coxalgia (Albert).

ondary. Not seldom it becomes very great, and causes marked swelling in front of the trochanter major, and still more behind it. Because of the resulting intra-articular pressure the pain is likely to be severe, and the malposition of the extremity in flexion and abduction with seeming elongation to be much increased.

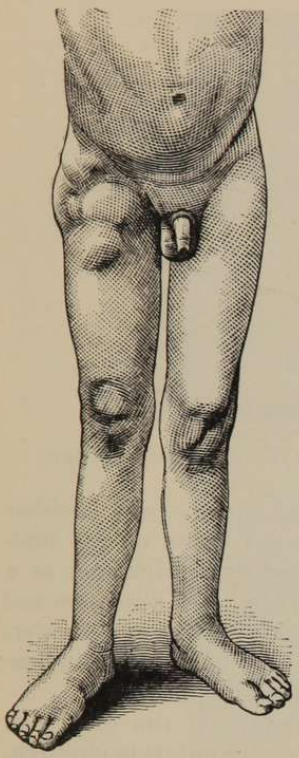
The constitutional symptoms are often severe.

Even when large in amount the effusion may spontaneously disappear to a greater or lesser extent, but not seldom the pressure upon the weakened diseased capsule is so great that rupture occurs, and the fluid is poured out into the periarticular tissues, which it tuberculizes. Abscesses and sinuses will probably follow (Fig. 151). Both local and constitutional symptoms are, as a rule, for a time much lessened in severity as soon as the tension is relieved. As the intra-articular fluid disappears, by absorption or after rupture, the joint surfaces come in contact. The irritated muscles act more directly upon the already damaged head and perhaps the acetabular rim, the bony parts are crowded together and more or less rapidly broken down and worn away, and progressively increasing flexion, abduction, and shortening result, sometimes very rapidly.

The so-called **third stage** is now thoroughly established. The femoral head is often much deformed, and is progressively pushed upward and outward as erosion of the acetabular rim takes place. Actual luxation rarely occurs, the head ordinarily remaining within the capsule, which attaches

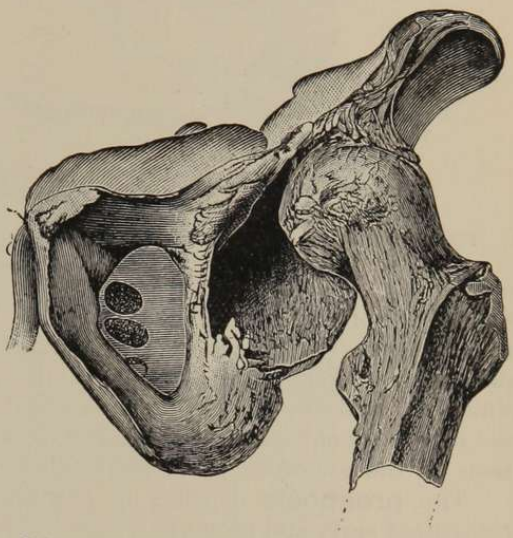
itself farther and farther out on the bone (Fig. 152). The flexion of the thigh upon the pelvis, which has been present in greater or lesser degree from the very commencement of the disease, is now decided and fixed. When the limb is brought down in extension so that the posterior surface of the thigh and that of the knee rests upon the bed or table, the lumbar spine is carried forward, and a marked lumbar curve is at once developed, which disappears as soon as the knee is raised. To determine this point, which is one of great

Fig. 151.



Common Site of Hip Abscess (Bradford and Lovett).

Fig. 152.



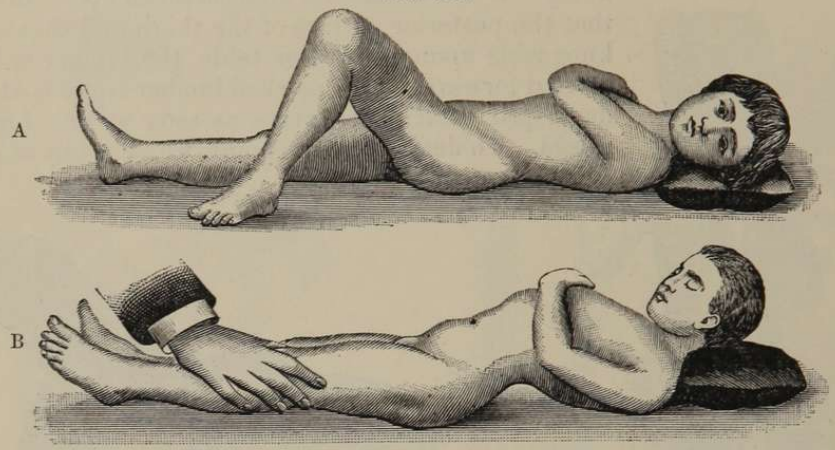
Intra-acetabular Luxation in Coxalgia (Tillmanns).

importance, the patient should be stripped and laid on the floor or a firm table. The *sound* leg can be flexed and extended at both the knee and the hip without any influence upon the lumbar spine (Fig. 153, A). But when the *diseased* leg is extended the lumbar curve becomes so marked that there is often space for the arm of the surgeon to be thrust under it (B). Flexion of this leg and hip is followed by the disappearance of the curve. The reason for this is that the femur and pelvis are held so rigidly together by the muscles that they move as if ankylosed, and the tilting of the pelvis in the extension of the thigh necessarily produces the lumbar curve. The adduction of the limb which in this stage succeeds to the abduction of the second stage is commonly not very great. As the result, however, of neglect of treatment it may reach an excessive degree, the thigh in such cases being usually very strongly flexed and carried across that of the sound side. The whole extremity, including the gluteal region, is greatly atrophied.

When the so-called abscess has opened or been opened, secondary septic infection is almost certain to take place unless prevented by antiseptic treatment. At times, though rarely, when there has been no perforation of the skin, the pyogenic cocci find access to the part by the blood-stream. Upon the occurrence of such mixed infection the parts suppurate, with more or less increase of local heat and tenderness and manifestation of the general symptoms of the "hectic" state. The later symptoms vary greatly according as the case progresses favorably or otherwise. When recovery takes place, the discharge,

if there has been any, lessens, the sinuses, or at least some of them, close, the patient is wholly or in a great measure free from pain, and the general health

FIG. 153.



Effects on the Lumbar Spine of Flexing and Extending the Diseased Leg in Hip Disease (Albert).

improves. Partial or complete ankylosis of the joint takes place, and is either fibrous or bony. In time the weight of the body can be borne on the limb with comfort, the inevitable shortening being made good by a thick sole or a raised shoe. When, on the other hand, the case does badly, new abscesses and sinuses form, the discharge increases, the deformity becomes greater and greater, the constitutional symptoms are graver, and there are very likely clear indications of the existence of visceral tuberculosis or of amyloid disease.

The **prognosis** depends largely upon the treatment. If the disease is recognized early and properly treated, recovery will generally follow in children, though it is a well-established fact that a majority of the patients are likely to die from some form of visceral tuberculosis before reaching full maturity. In adults the chances of recovery are decidedly less. The disease may be arrested at any point in its course, and the earlier this is effected the more nearly perfect will be the recovery. The three stages, it should be remembered, are not always regularly passed through; and if they are, the transition from one to the other may be either slow or very abrupt. From the nature of the cause the disease must be one of long duration, and at whatever point it is arrested, recovery will often be apparent rather than real, and will be followed by relapses, it may be, after many years. The future usefulness of the limb will be in proportion to the adhesions that have formed and the amount of damage done to the articulation. Even in the third stage, if favored by fair hygienic surroundings and a tolerably good state of health, under proper treatment, local and general, the patient, especially if a child, may be expected to recover, though only after months or even years, and with a hip ankylosed at a more or less vicious angle and a limb decidedly and, it may be, greatly shortened. The ankylosis may be fibrous or bony or mixed. In a comparatively small number of cases, after long-protracted disease, the fusion of the femur and the innominate bone is so complete that it is impossible even upon section to determine exactly the line of union. Fig. 154 shows a case of ankylosis of both hips at such an angle that the patient could not stand erect.

As respects **treatment**, the earlier it is instituted the sooner and more perfectly may the patient be expected to recover. The prime indication is to secure *rest*, as absolute as possible, of the diseased part. When the disease is

recognized early, in the great majority of cases prolonged recumbency, especially if combined with extension by weight and pulley, will arrest its progress. A

FIG. 154.

Double Ankylosis from Hip-joint Disease (original).

very simple yet efficient apparatus for securing the desired rest is the gas-pipe frame of Bradford (made of ¼ in. gas-pipe joined at the four corners by "shoulders"), which serves at once as a stretcher upon which the patient may be carried and a fixed frame to which a fixation or traction apparatus may be attached. Care must always be taken to make the extension in the line of the deformity; that is, in the line of the flexed and abducted or adducted thigh, which is to be lowered and the abduction or adduction corrected as the progress of the case may permit.

All the varieties of mechanical treatment that have been used—and they are many—have for their immediate object the securing of fixation or traction or a combination of the two. In the first class are to be placed the plaster-of-Paris dressing, the wire cuirass of Bonnet, the "plaster breeches" of Sayre, the leather splint of Vance, the long splint of Thomas, etc. Thomas's splint (Fig. 155), without doubt the most useful of the fixation appliances, is, in brief, a bar of malleable iron about ¾ in. wide, extending from the inferior angle of the scapula to the lower third of the leg, so shaped as to accommodate itself to the curve of the buttock, and held in position by three hoop-iron bands, the upper encircling three-fourths of the chest, the second two-thirds of the thigh on a level an inch or two below the perineum, and the third two-thirds of the calf. The apparatus is held in place by bandages and straps, and if the patient is going about, the sound foot is raised by a patten

to a height which prevents the toes of the foot of the diseased side touching the ground, and compels the use of two crutches in walking (Fig. 155).

Fig. 155.

Thomas's Splint.

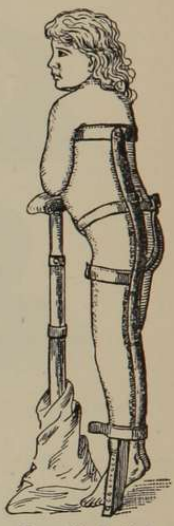
Fig. 156.

Phelps's Splint.

Fig. 157.

Taylor's Splint.

Fig. 158.



Lovett's Splint.

Recognizing the fact that fixation cannot be absolute, and that it does not overcome muscular contraction with the resulting injurious pressure between the head of the femur and the acetabulum, the great majority of American surgeons are employing some form or other of traction splint, a more or less extensive modification of the Davis splint of forty years ago, early improved upon by Sayre and Taylor. In these splints opportunity is afforded for altering their length at will by drawing away the sliding lower rod of the apparatus from the upper, or by acting upon the foot-piece through the aid of a windlass, the counter-force through the perineal bands preventing the body from following (Fig. 157). Pressure-symptoms are thus prevented or relieved and recovery correspondingly promoted. When by the use of one of these splints fixation is not sufficiently secured (which is comparatively seldom), a combined traction and fixation splint may be employed, many useful forms of which have been devised, among them those of Phelps and Lovett (Figs. 156, 158).

General treatment, if called for by an enfeebled and tubercular state, is indicated, but local medicinal treatment is of no value, except that which will secure the destruction of the bacilli and the condensation and cicatrization of the newly-formed granulation-masses, such as the injection into and around the joint of iodoform, chloride of zinc, or acid phosphate of lime. When the capsule is much distended or there is large extra-articular accumulation, aspiration of the fluid will give great relief. In a few cases the bone has been tunnelled through the trochanter and neck and a permanent drain established. When the so-called abscess is nearing the surface, whether it shall be opened or be left to itself to undergo absorption, as many times happens, or be spontaneously emptied, will depend upon whether or not it is causing much local distress. If it is, it should be aseptically opened and drained, the after-use of iodoform injections being of much service. If it is not, careful attention to the maintenance of quietude is all that will be necessary. If spontaneous opening is imminent, it is

better to anticipate it by incision, as the danger of infection by pyogenic organisms will be thus done away with or reduced to a minimum. In the more severe cases, when the tuberculosis of the bone and joint is extensive, excision or erasion may be done, either early by choice or late from necessity, that which is done early giving, of course, the best result. Though such operative interference, because of its aseptic or antiseptic character, is now not attended with much danger to life, and may be expected to lessen decidedly the period of treatment, yet it does not materially diminish the liability to the occurrence of other or general tubercular disease; recovery is almost always with considerable shortening, and the functional value of the extremity is often no better than that after spontaneous cure, and at times not so good. The resulting deformity can, if necessary, be well and easily corrected by osteotomy through the neck of the femur, or better below the lesser trochanter (Fig. 159).

Fig. 159.

Result after Double Subcutaneous Osteotomy of the Femur in the Case in Fig. 154 (original).

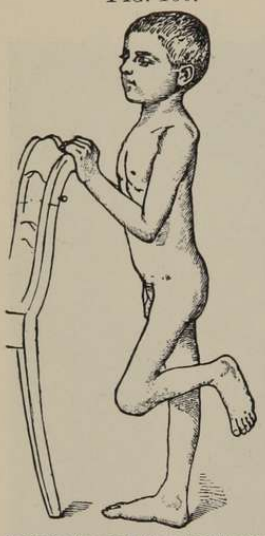
Fortunately, if the case is seen early and properly treated, the necessity of deciding the question whether or not operation shall be done will seldom arise, and excision is called for much less frequently now than it was a generation ago. When performed, a splint or some protecting apparatus should be worn for a long time afterward until the parts have become firm. Many if not most of the early relapses are due to neglect of such mechanical after-treatment.

Knee-joint Disease.—Of the larger joints, the knee, next to the hip, is the one most frequently affected with tubercular disease. In children the disease is as a rule primarily osteal, beginning in the femur oftener than in the tibia, very rarely in the patella. In adults, however, in more than half the cases it shows itself first in the soft parts. The arthritis is so generally and so typically fungous that the term "white swelling," used without qualification, is always understood to mean tubercular disease of the knee.

The **symptoms** in the osteal form are at first ill defined. There is usually slight lameness, with pain in the region of the affected epiphysis, more severe at night, but often only tenderness on pressure, generally over a limited space—by preference the internal condyle of the femur. Later there is expansion of the condyles. The tendons about the joint are somewhat tense, and there is some atrophy, especially of the parts just above the joint on the anterior surface of the thigh. Attempts fully to extend the leg are resisted and cause pain. As soon as synovial inflammation has been set up, the resulting effusion produces fulness of the joint, most noticeable on the sides of the patella and of its ligament. When this is infected by extension from the epiphysis or by primary location of the bacilli in the soft structures in the joint itself, the symptoms become more marked, and soon unmistakable. There are rigidity and atrophy of the part, and lameness, but in many cases this is accompanied with so little pain that the patient continues for a long time to run about. The leg is decidedly flexed, and the flexion steadily increases. But especially and characteristically there is swelling, the firm spindle-shaped enlargement of fun-

gous disease, in which the natural contour of the joint is lost and the skin over it is pale. Because of this swelling the disease is not likely to be mistaken for anything else, at least in children, though in adults osteo-sarcoma has not so very rarely been regarded as tubercular disease. This error of diagnosis should not occur, certainly if the case has been seen from an early day, since the malignant affection at first and often for a long time causes enlargement not of

FIG. 160.

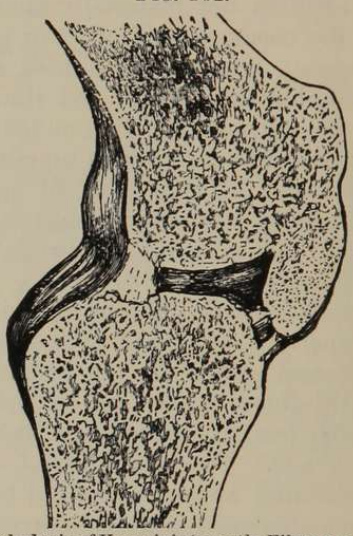


Ankylosis and Contractures in Tuberculosis of the Knee-joint (Tillmanns).

FIG. 161.

Subluxation in Knee-joint Disease (Schreiber).

FIG. 162.



Ankylosis of Knee-joint, partly Fibrous and partly Osseous: the tibia has undergone displacement backward (Marsh).

the joint, but of the parts just above or below it. Caseation and liquefaction of the tubercular tissue give rise to so-called abscesses, which in time undergo absorption, or, more often, open spontaneously or are opened by the surgeon. Through the resulting sinus diseased bone may frequently but not always be felt. Not seldom the leg is drawn back to and beyond a right angle (Fig. 160), and pathological luxation is often produced in badly-treated cases (Figs. 161, 162), after which, as a rule, the severity of the symptoms markedly diminishes. Such a luxation may occur also in spite of treatment.

According to its intensity, and still more to the thoroughness of early treatment, the disease terminates in one or other of three ways: (1) There may be recovery, with more or less deformity and impairment of function, secured after a few weeks or more often months, or, not uncommonly, only after years of discharge, with the elimination of dead tissues both hard and soft, and the destruction of the articulation. (2) Disorganization follows either slowly or rapidly, and if extensive and accompanied with grave constitutional symptoms may compel operation, followed by recovery, which may be speedy or slow, complete or partial. In the latter case sinuses remain, which will continue to discharge for a long time or even for the rest of life. (3) The patient dies from exhaustion, from tuberculosis of other parts, from amyloid disease, or from septic infection, whether an operation has or has not been done. When the case is recognized early and properly treated for a sufficient length of time, recovery with a useful limb may be expected.

The **treatment** is that of joint-tuberculosis in general. Rest must be secured by thorough immobilization—by plaster of Paris or by some form of splint securing fixation or both traction and fixation, as in Sayre's knee-splint. No physiological use of the joint should be permitted.

If the patient must walk, he should do so only with crutches, the sound foot having been sufficiently raised by a high shoe to prevent that of the diseased extremity from coming in contact with the ground. If abscesses form, they should be opened if the local and constitutional symptoms are decided. Iodoform and chloride-of-zinc injections are of great service, but are not required in the majority of cases coming under early observation.

If non-operative treatment fails, the tubercular tissue must be removed by erasion, excision, or amputation. No absolute rule can be established as to the time at which and the conditions for which operation should be done, but at the present day, as the mortality attending erasion or excision is but slight, operations are done earlier than before and in much less desperate conditions of the joint, and the results therefore are better. Though every case must be a law to itself, it may be said in a general way that operation is indicated, (1) when the disease has been of relatively rapid development; (2) when in spite of rest and the ordinary constitutional remedies, employed for a reasonable length of time, the tuberculization of tissue is extending and the tubercular masses are softening and breaking down, and the patient is steadily losing strength and weight; (3) when the disorganization of the joint is extensive, as indicated by grating on movement, by abnormal freedom of motion from destruction of the ligaments, by abscesses and sinuses, and by profuse suppuration. Whether erasion or excision is the better operation, especially when the patient is a child, has not as yet been determined. Theoretically erasion is preferable, since it takes away only diseased tissue, and by sparing the region of the epiphyseal line does not interfere with the after-growth of the femur in length. But it is by no means easy thus to get rid of all the infected tissue, and unless this is done recurrence will certainly take place. Even when the joint is excised tubercular foci (Pl. XI, Fig. 2) may not seldom be left in the bone outside the line of section.

Amputation is called for only in those cases of extensive disorganization in which there has long been marked enfeeblement of the general strength because of pain and suppuration, or when excision or erasion has failed to arrest the local extension of the tuberculosis. In the former, especially in adults, removal of the limb is more likely to save life and enable the patient afterward to earn a living, and the operation is really conservative. Not seldom it has happened that though by removal of the joint the limb has been saved, it has proved only an encumbrance.

Ankle-joint Disease.—Disease of the ankle-joint, if primarily of the articulation, is more frequently of synovial than of bony origin; if bony, the starting-point is more frequently in the astragalus than in the bones of the leg. Not very seldom it is in a malleolus, the outer rather than the inner. In many cases it is secondary to tuberculosis of the tarsus, and at times to disease of the sheaths of the tendons crossing the joint.

If synovial, the **symptoms** observed early are, interference with the free movement of the articulation and more or less well-marked fulness on the anterior surface outside the flexor tendons and on the sides of the tendo Achillis. If osseous, besides the intermitting inability or at least unwillingness fully to flex and extend the foot, there will be present for a time only the pain, spontaneous or elicited by pressure, which belongs to osteitis, following which expansion of the bone and intra-articular effusion will cause noticeable swelling. When the disease is well established the region of the joint has the globular contour with associated atrophy of adjacent parts that is so characteristic of fungous arthritis, and the foot is held in decided extension. The skin is pale, or deeply colored from congestion. Sinuses are developed comparatively late.

That the disease is not in the os calcis or in and about the middle tarsal articulation will be indicated by the locality of the swelling, below or in front of the ankle region.

The **prognosis** is that of tubercular arthritis in general, grave or not according to the age and constitutional state of the patient, and especially to the period of its recognition and the thoroughness of treatment.

Treatment.—As soon as the diagnosis is made, walking upon the foot should be stopped and the joint immobilized, care being taken in the application of the plaster-of-Paris bandage to place the foot at a right angle with the leg. The bandage must be renewed as often as the swelling subsides. After a time, if the disease still progresses, iodoform or zinc injections may be used with advantage. When the joint structures become disorganized, erasion or excision, typical or atypical, is indicated, and should be done without delay. Even when the tarsus has become extensively diseased and the tibia and fibula are infected beyond the epiphyseal line, removal of the tubercular tissue, both in the bone and in the soft parts, may be followed by recovery with a firm and useful limb. But such removal must be thorough, all diseased tissue being removed from the medullary cavity of the leg-bones, the tendon-sheaths, the meshes of the connective tissue outside the joint,—wherever it may be. If this cannot be accomplished, amputation should be done or the osteoplastic resection of Wladimiroff-Mikulicz. If the medullary canal is opened by amputation, all of the infected marrow must be thoroughly scraped out and the canal disinfected and drained.

Shoulder-joint Disease.—The shoulder is much less frequently the seat of tubercular disease than might be expected from its range of movement and its exposed position. Children are at times attacked, but disease of this articulation is rare in them as compared with disease of the hip, knee, or elbow. Young adults are the more common subjects, though it is at times met with, and as a rule in a very destructive form, in persons well advanced in life. Any of the varieties of the disease may be seen; and *caries sicca* more often attacks this joint than any other (Fig. 57, p. 267).

The **symptoms** vary according to the form, though impairment of function is common to all. In other than the dry variety the affected region is enlarged and of globular shape, firm to the touch when fungous masses are present, fluctuating if there is intra-articular fluid in excess or if a periarticular abscess has formed. Such an abscess may point in the axilla, or, following the course of the muscles, on the anterior surface of the arm, on the side of the chest, near the posterior axillary fold, or over the scapula. Pain to a considerable degree may be present, and is often very severe in the ordinary dry variety when suppuration occurs. In **caries sicca,** except in those rare cases in which abscess is developed at a late period, there is no abnormal fulness of the region; on the contrary, the parts are greatly atrophied. Because of the destruction of the head of the humerus, unattended by excessive new formation, a hollow is produced under the acromion process which may excite a suspicion of luxation, all the more because of the existing undue prominence of the coracoid process. Movement, especially in adduction, is resisted, and even under an anesthetic is found to be much limited.

The **diagnosis** in any of the varieties and at any stage is often difficult and uncertain, the affection being confounded with bursal disease, with chronic rheumatism, or with hysteria, especially the last two. The history of the case and examination of the aspirated fluid will probably indicate the non-existence of bursitis. Chronic mono-articular rheumatism is not likely to be present in a young adult, and it is at such period of life, as a rule, that *caries sicca*

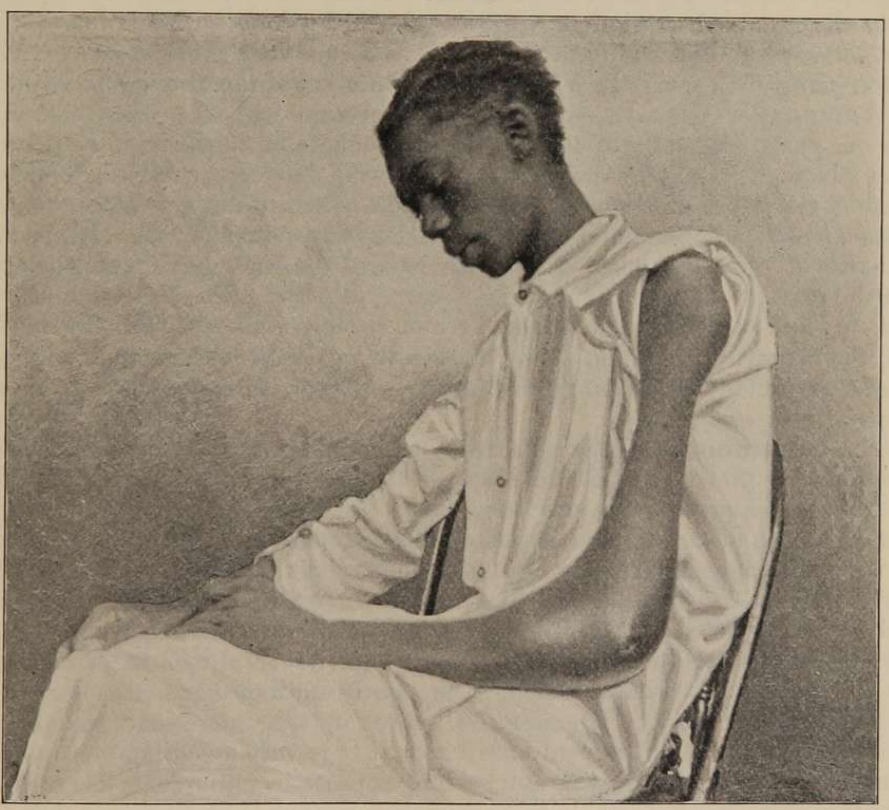
is found. In an hysterical joint there is no restriction of motion when the patient is anesthetized.

The **prognosis** is favorable in the majority of cases, particularly of the dry variety, especially if the parts are early put at rest and kept so.

Immobilization is essentially the only **treatment** required so long as abscesses do not form. When they have formed and the suppuration is free the head of the humerus will usually have to be excised. The final result of excision is ordinarily excellent, the new joint being firm and quite movable; sometimes it is very loose (flail-joint, dangle-joint), but even then it may prove serviceable.

ELBOW-JOINT DISEASE.—The elbow is tubercular much more often than either of the other large joints of the upper extremity. The disease shows itself usually in children, and is of synovial origin in the majority of cases. When osteal the primary focus is more likely to be in the epiphysis of the humerus than in that of the ulna or of the radius; in the latter it is rarely seen. Even when the joint disease is extensive the tubercular bone affection may be only on one side of the interarticular line, in which case the bone or bones on the other side will ordinarily be found decidedly rarefied.

FIG. 163.



Tubercular Disease of Elbow (original).

The **symptoms** here, as elsewhere, are not well marked in the beginning, especially in the osteal variety. Spontaneous pain may or may not be present, but pain can always be caused by pressure. There is some stiffness of the joint, and the forearm is somewhat flexed. As soon as effusion occurs into the joint or new formation to any decided degree takes place, fulness will be noticed on

the sides of the olecranon process and above it; not until much later on the anterior surface, because of the firm resistance of the overlying muscles and fasciæ. When the disease is well developed the region is markedly spindle-shaped, the arm and forearm much atrophied, the flexion permanent at an angle of about 140°, the hand pronated (Fig. 163). Increase of local heat may occasionally be recognized by touch. All movements are painful. If abscesses form they will probably open through the posterior surface of the joint.

Treatment.—As soon as the disease is detected the joint should be immobilized in flexion, the rectangular position being secured as soon as it can be tolerated—from the beginning, if it is not too painful. If abscesses form and open, the dressing must be so fenestrated as to permit of free discharge. Iodoform injections should be made through the sinuses into the abscess-sac or the opened joint-cavity; such injections or those of chloride-of-zinc solution may be made subcutaneously before sinuses have formed. After weeks or usually months of fixation of the joint, especially if it was commenced early, recovery may be expected; in the more fortunate cases it may be with quite complete preservation of the motions of the articulation, but much more often with ankylosis. It is because of the likelihood of the occurrence of a stiff joint that the parts should be fixed at a right angle, or even less—*i. e.* the angle at which the extremity will be most useful. When the joint has become extensively disorganized, erasion or excision should be done without delay. The result of such an operation at this joint is as a rule very satisfactory, excellent motion being often secured. Very rarely amputation of the arm will be required.

Wrist-joint Disease.—Except in connection with the same disease of adjacent parts, especially of the carpus, tuberculosis of the wrist-joint is rarely seen. Though it may be primary and synovial, it is commonly secondary to caries of the bones of the wrist, or, much less often, to fungous teno-synovitis. It attacks both children and adults, even persons beyond middle age. If primary, ordinarily it soon extends to the bones beyond the wrist, and even when first seen the case presents the symptoms of carpal disease. The joint motions are restricted and painful. The affected region is enlarged, especially on the dorsum, the forearm and hand being decidedly, often greatly, atrophied. The fingers are extended, seemingly lengthened. Disorganization takes place at a comparatively early period.

The **treatment,** as in like disease of other joints, is by immobilization and injection, by preference of the iodoform emulsion. Ignipuncture has been successfully employed by a few surgeons. If commenced early and steadily followed up, in a large proportion of cases treatment will effect a cure, though the wrist will almost certainly be a stiff one; but the time required is often very great, measured, it may be, by years. Because of this length of time and of the much-crippled or entirely useless hand that so often remains, it is as a rule wise to operate by erasion or excision if after several months of conservative treatment marked improvement in the local condition has not been secured.

Sacro-iliac Joint Disease.—Disease of the sacro-iliac articulation (sacro-coxalgia) is of infrequent occurrence. It is very much more common in young adults than in children, and seldom appears in individuals over thirty-five years of age. It is likely to be mistaken for hip-joint disease. As a rule it pursues an unfavorable course. Its pathological changes are essentially the same as those of tubercular disease of other joints. There are the usual effusions (which if intra-articular are necessarily limited) and exudations, abundant new formation of infected granulation-tissue, destruction of cartilage and bone, and the development of cold abscesses, internal or external. The fluid of such abscess, if internal, may pass down behind the rectum into the ischio-rectal

fossa or by perforation into the bowels, or, following the muscular planes, may reach the neighborhood of the sciatic notch, of Poupart's ligament, or the upper part of the thigh, or may pass along the sciatic nerve to the region behind the greater trochanter; if external, the abscess will probably be found over the joint near the edge of the ilium. If an abscess does not form, recovery may be expected, with an ankylosed joint; if an abscess does form, especially an internal one, the probabilities are very strong that the patient will die, though he may even yet recover after extensive bone destruction and later fusion of the sacrum and ilium. When the affection has occurred in early childhood it may be the cause of pelvic distortion, of much importance in the female.

The **symptoms** are ill or well defined according to the stage of the disease. At an early period there will be discovered scarcely more than a little stiffness, discomfort in standing or walking for any length of time, and pain, which is neither constant nor severe, in the region of the joint or sometimes in the thigh. Later, at a time when the case is most likely to come under observation, pain is decided when any motion is made, and may be present when the patient is lying down. This will certainly be the case sooner or later when an attempt is made to rest upon the affected side. Crowding of the ilia together will always cause suffering. The pain is not simply in the region of the joint, but as a rule radiates in various directions, according to the course of the nerves that pass in close proximity to the articulation, especially the sciatic, the anterior crural, the obturator, and the genito-crural. The thigh is more or less flexed upon the pelvis, with tension of the psoas, and the patient throws his weight upon the sound side. The affected limb seems elongated, or there may be quickly alternating apparent lengthening and shortening. The patient walks with a decided limp. The soft parts over the joint posteriorly may be swollen or flattened. Usually after a considerable time the pus will show itself beside the anus, in the outer part of the groin, behind the trochanter, or near the iliac crest posteriorly; and before very long, if not opened by the knife, it will be spontaneously evacuated. True suppuration is very apt now to occur because of an added infection by the pyogenic cocci, with corresponding increase in the gravity of the previously existing constitutional symptoms due to the tuberculosis.

The disease is likely to be mistaken for neuralgia of the joint, for lumbago, for vertebral or sacral caries, for sciatica, and especially for hip-joint disease. The location, limitation, duration, and character of the pain will serve to distinguish it from the various neuralgic and myalgic affections. There will be an absence of the ordinary local signs of spinal caries. If there is caries or necrosis of the sacrum or ilium away from the articulation, there will probably be a history of severe injury, with the after-symptoms of bone contusion or wound. From hip-joint disease the differential diagnosis may not be readily made. The attitude of the patient, the flexion and apparent elongation of the limb, the pain, which, if present, will be located in front of or behind the hip, or even at the knee,—are all much like what is observed in morbus coxarius. But careful examination will show that the motions of the hip are unrestricted; pressure over the joint and crowding the head of the femur against the acetabulum will cause no pain if the ilium alone is steadily fixed; there is no adductor rigidity; if the expanded wings of the ilia are pressed together severe pain is produced, as it is by any motion of the limb the action of which is continued upward through the pelvis; there is steady pain in the region of the sacro-iliac junction; the anterior superior iliac spine on the affected side is more prominent and upon a lower level than that of the sound side.

The **treatment** will vary according as there is or is not an abscess. In the latter case rest and counter-irritation are of extreme value. The first is secured by fixation of the whole pelvis and the limb of the affected side by apparatus or plaster of Paris; the last by the application of the actual cautery. If this treatment fails and abscesses have formed, they should be evacuated and injected with the iodoform-glycerin emulsion, or freely opened if possible, curetted, and kept thoroughly drained. When the pain in the joint is very severe and the formation of an abscess is strongly threatened, free opening of the joint should be made, if necessary with the trephine. Of course all these operations must be done aseptically and the wound and cavities protected from septic infection; and rest, as absolute as possible, should be maintained until healing is complete.

Besides the tubercular affection, this joint is the seat also of rheumatic, gonorrheal, and septic inflammations. The first two are comparatively mild, and are usually recovered from, occasionally without ankylosis. The septic arthritis, very generally of puerperal origin, is almost certain to destroy life in a short time, in spite of any treatment, local or constitutional, that can be adopted.

(B) SEPTIC ARTHRITIS.

Infection by the bacteria of suppuration, chiefly the staphylococcus aureus and the streptococcus pyogenes, produces an acute arthritis which, if not promptly and actively treated, and sometimes in spite of treatment, results in destruction of the part and not seldom in loss of life. The infection may be produced in one of several ways: (1) directly through an open wound made by a dirty instrument, or one in which there is lodgment of a foreign body carrying the pyogenic cocci, or through a later infection of an originally aseptic track; (2) by an opening of a joint-cavity in the progress of an osteo-myelitis or by the extension of suppurative disease of the articular or periarticular structures; (3) through the transmission to and deposition in the synovial membrane of the micro-organisms present in the blood of a pyemic patient. However produced, if the infecting organisms are many and the case is left to itself, a high grade of inflammation of the joint structures is rapidly developed, with an abundant formation of pus. Exudation occurs into the synovial membrane, the subsynovial connective tissue, and the capsule, all of which soon become disorganized. The articular cartilages break down, either quickly in masses of considerable size, or more slowly at many points, through erosion by granulations. The ligaments soften to such an extent, it may be, as to permit of undue motion of the bones upon each other or of their complete luxation. The periarticular structures are filled with newly-formed infected granulation-tissue, in the breaking down of which abscesses form extending in various directions above and below the joint, and soon an opening through the skin takes place.

The **symptoms** are such as might be expected from the intensity of the joint inflammation. The pain is very severe, generally worse at night; the swelling is great; the skin is red and hot; fluctuation is distinct; the parts above and below are œdematous. The joint is flexed to the angle at which intra-articular tension is least. Any attempt at motion much increases the suffering. The constitutional symptoms are always grave, and are proportionate to the extent and rapidity of development of the local disease. There is generally an initial chill, or at least well-marked chilliness. The temperature quickly runs up several degrees, remaining high, with no very great fluctuations, or showing a well-defined septic curve. The pulse, strong and full it may be at first, soon becomes rapid and weak. The "typhoid" state, more or less complete, quickly sets in. In the very acute cases death from septicemia may occur

within a few days. Ordinarily with the opening of the abscesses and the resulting relief of tension decided improvement, at least for a time, takes place in the symptoms, both local and general. In those cases in which the joint affection shows itself in the course of a pyemia the chief local symptom is swelling; the joint, or not infrequently several joints simultaneously affected, becoming greatly distended with pus in the course of a few hours, the synovial membrane and the articular structures in general showing upon examination little or no evidence of being inflamed.

In the **treatment,** as in that of similar disease of bone, safety lies only in prompt opening up of the suppurating area, followed by thorough disinfection and subsequent free drainage. In some of the milder cases aspiration of the joint with antiseptic irrigation will arrest the progress of the disease; but, as a rule, it is much better to incise the capsule and thus secure the complete evacuation of the pus. Most rigid antiseptic treatment should be pursued until the parts are entirely healed, and the joint must be thoroughly immobilized, care being taken to correct as far as possible any existing displacement. Recovery is generally by ankylosis, often bony and complete; but occasionally, because of early and thorough treatment, the articular motions are preserved.

The constitutional treatment is that of suppurative disease in general—careful feeding and stimulation, quinine, and, later, such tonics as may be required. If the suppuration continues in an exhausting degree despite the local treatment adopted, and the joint is extensively disorganized, operative interference is demanded. Erasion may be done, or, better, atypical resection. Often the joint and the neighboring structures are so widely destroyed and the general condition of the patient is so bad that only by amputation can it be hoped to save life. The pyemic joint is commonly but a symptom of a constitutional state that will cause death in a few hours, or at most in a few days, and the arthritis demands no treatment. When the affection is of but moderate intensity, the articular complication should be treated in the ordinary way.

(c) INFECTIVE ARTHRITIS.

Very similar to the suppurative arthritis just described is that met with in connection with an acute infectious disease, such as small-pox, measles, scarlet fever, typhoid fever, or erysipelas. It is due to one or, in many cases, to both of two causes—viz. the presence in the joint of the ordinary septic bacteria, or the pyogenic action of the specific micro-organism of the existing disease, that of erysipelas being very closely akin to, if not identical with, the streptococcus pyogenes. The symptoms, prognosis, and treatment are the same as those of the ordinary septic joint inflammation. In the typhoid arthritis of the hip, which joint is especially likely to be attacked, spontaneous dislocation occurs in a number of cases. It is often produced spontaneously, sometimes by movements of the patient or by careless handling of the limb at a time when the capsule is largely distended with fluid and the femoral head consequently is to some extent lifted out of the acetabulum, and when the ligaments and muscles are greatly weakened.

But the suppurative is not the only form of arthritis found associated with the diseases mentioned, nor even the most common. Not very rarely during the height of the affection, more often in the period of subsidence and convalescence, a joint or joints (polyarticular involvement being usually a result of scarlatina or small-pox) will be found swollen, hot, and painful, as if affected with rheumatism. Such inflammation may be attributed in part to the affection

of the nervous system belonging to the disease, and in part to the irritative action upon the synovial membrane of blood containing the specific organisms, but still more to their chemical products. Resolution ordinarily takes place in the course of a few days, and no treatment is required other than keeping the parts quiet, enveloping them in cotton secured with a bandage, or making hot applications, simple or medicated.

(d) Gonorrheal Arthritis (Gonorrheal Rheumatism, Post-Gonorrheal Arthritis).

Joint affections of several kinds are frequently found associated with gonorrhea. There may be often only a more or less severe intermittent arthralgia, which soon passes away; or there may be a chronic inflammation with abundant effusion into the joint-cavity (hydrarthrosis), chiefly that of the knee; or an acute sero-plastic arthritis; or a suppurative inflammation, which is comparatively rare.

For a long time the disease was called gonorrheal rheumatism, and even now it is generally so named. The joint affection, whether characterized by intra-articular effusion, by articular and periarticular exudations, or by the presence of pus, is not rheumatic, though a patient with gonorrhea may have rheumatism, and a rheumatic joint because of such antecedent disease may be more susceptible to the toxic action of the gonococcus or of the mixed gonorrheal and pyogenic infection. The more carefully the gonococcus of Neisser has been sought in the fluids and tissues of the affected joints, the more frequently it has been found, and in cases in which it cannot be detected there is good reason for believing that its ptomaïnes are the exciting cause of the metastatic arthritis. When joint disease of somewhat similar character is developed in non-gonorrheal urethral fever, as, *e. g.*, after the passage of a catheter or sound, it is possibly due to the taking up from the injured mucous membrane of the urethra of the common pyogenic cocci, or it may be due indirectly to their chemical products. The affection very rarely attacks women. It may appear at any period in the course of the urethritis, but occurs much more often in the third and fourth week than later, especially in its acute form. Any articulation may be its seat, though in nearly one-half of the cases it is the knee, and in about two-thirds the knee, the ankle, or the joints of the fingers or toes. Generally it is mono-articular; rarely more than two or three joints being attacked either at the same time or in succession.

The **symptoms** vary according to the form of the arthritis. In the chronic variety attended with abundant intra-articular effusion there is impairment of function, and, of course, marked swelling, but the joint is not painful or is but slightly so, except during the time of an acute exacerbation, which is occasionally observed. In the acute form the suffering is intense, persistent, worse at night, and much aggravated by movements, even slight ones. The parts are swollen and hot, the skin is red, and the joint is held in the position of greatest ease. Atrophy of the structures above and below is quickly produced. There are decided elevation of temperature and acceleration of pulse, and, because of the fever and suffering, rapid loss of strength and weight. When suppuration occurs, which is seldom, the local and general symptoms are intensified. The disease terminates in resolution, in ankylosis, or in destruction of the joint; most frequently by far in ankylosis (fibrous) either partial or complete, due to organization of the plastic exudations both articular and periarticular. The serous accumulation in the joint, in spite of any treatment, will often remain unchanged for many weeks, or it may be months.

In the **treatment** of gonorrheal as in that of other forms of arthritis rest is of prime importance. As long as there is any inflammation present the joint should be kept immobilized. Blisters, mercurial applications, fomentations, cauterizations, all of which have been employed again and again, can accomplish but a fraction of the good that results from the quietude and equable compression secured by the plaster-of-Paris bandage. But immobility of the joint must not be maintained for too long a time, lest ankylosis, to which, as has been stated, there is a strong natural tendency, be established; if on the other hand passive motion is too early resorted to, the inflammation will be lighted up again. The only safe rule to adopt is to keep the parts quiet until all inflammatory symptoms seem to have subsided, and then gently to move the joint. If the pain which follows disappears spontaneously within a few hours, twenty-four at the outside, no harm has been done, and the motions may be continued and increased. If the pain continues, the parts should be again immobilized for a time. An existing hydrarthrosis may be aspirated and carbolic-acid injections used. If suppuration occurs, aspiration and thorough antiseptic irrigation may be employed, and the joint then immobilized with a fair prospect of success. If such treatment is not quickly followed by marked amelioration of the symptoms, the cavity must be opened and drained as in suppurative arthritis due to other causes. Absorption of exudations and disappearance of adhesions, when not very close or strong, will be much favored by the employment of massage, baths, and douches continued for as long a time as may be necessary after the removal of the immobilizing dressings. If ankylosis has taken place, it must be broken up or the joint excised; such operation, however, will seldom be found necessary.

(E) RHEUMATIC ARTHRITIS.

Rheumatic articular affections are common, and are both acute and chronic. In the *acute* variety the joint inflammation is very rarely mono-articular, One or several joints may be attacked at first, and other joints are apt to be quickly affected, with at times rapid and complete subsidence of the inflammation in the articulations in which it was primarily located.

The **symptoms** are those of acute synovitis, pain, extreme sensitiveness to pressure, and heat and swelling due in part to effusion into the periarticular structures, but chiefly into the cavity. Suppuration never occurs unless there has been a mixed infection. As the arthritis is but a part of a general disease which is medical and not surgical, and ends with very few exceptions in resolution, leaving, at least after a single attack, no changes in the structures or the functional value of the articulation, it need not be here considered.

The *chronic* variety may be such from the start or may be the result of repeated acute attacks, each of moderate severity. The inflammation often causes no material alterations in the joint structures, the synovial membrane being only a little thickened and its vascularity diminished, with a diminution in the amount of synovial secretion and the production of a grating or creaking on motion as a consequence. On the other hand, there is occasionally an excess of fluid in the joint. At times the arthritis is decidedly plastic, the membrane, the capsule, and the periarticular structures being much thickened, with the formation of bands and adhesions restricting motion even to a considerable degree. The cartilages are usually unaffected, but may be irregularly thickened and thinned.

Treatment consists in the prevention of acute or more often subacute exacerbations which serve to increase the weakness and stiffness of the affected joint, and in the securing of absorption of the exudations and resulting adhe-

sions to such an extent as may be possible. The first is to be accomplished by avoidance of the exciting causes, cold and dampness, and by the proper protection of the joint by warm woollen clothing; the second by the employment of hot baths, frictions, and massage and due use of the joint, together with the internal administration of the ordinary anti-rheumatic remedies—the salicylates, the iodide of potassium, the salts of lithium, etc. Partial ankylosis should be broken up under ether, and followed by massage, the douche, and active and passive motion.

(F) GOUTY ARTHRITIS.

Whatever may be the essential nature of gout, its most constant manifestation is in the joints, in the smaller much more often than in the larger—*e. g.* those of the fingers, and especially the metatarso-phalangeal articulation of the great toe. Deposits of the urates, chiefly sodium urate, occur in the connective tissue of the joint; they produce destruction of the cartilages, unless it be true, as has been maintained by some, that the deposit can take place only in cartilage that is in a state of necrosis. As a result of the irritation consequent upon the presence of the abnormal salts, there is overgrowth of the connective tissue, with later contraction of the new-formed fibrous tissue, followed by alterations in the shape of the joint and impairment of its motions. Repeated attacks of acute inflammation occur, of greater or lesser intensity according to circumstances. Frequently the urates form masses of considerable size in the affected joint (*chalk-stones*, *tophi*), which may long remain without exciting any particular disturbance, may give rise to the formation of an abscess, or may often cause ulceration of the skin and exposure of the chalk-stone. As is the case in rheumatism, the joint affections of gout are but symptoms of a diathetic state, the consideration of which belongs to the physician rather than to the surgeon, except so far as they may produce disabling contractions and deformities.

(G) OSTEO-ARTHRITIS (CHRONIC RHEUMATOID ARTHRITIS, RHEUMATIC GOUT, ARTHRITIS DEFORMANS).

For many years a disease in certain respects much resembling rheumatism, in others resembling gout, has been recognized. As a rule having few exceptions, it is very chronic; goes steadily on from bad to worse; often produces extreme deformities; and disables its subjects, even to the extent of altogether preventing motion in the affected joints. Of the many names that have been given to it, that of osteo-arthritis is to be preferred. It is occasionally acute, when the patient is generally a young woman, though this form of the affection may be met with in children. The disease is ordinarily seen in middle or advanced life, even up to extreme old age. Women are more often attacked than men. Of the smaller joints those of the hands and feet, of the larger the hip and knee, are the ones usually diseased; as a rule, two or three of the larger joints are affected at a time; when mono-articular it is most frequently located in the hip or knee.

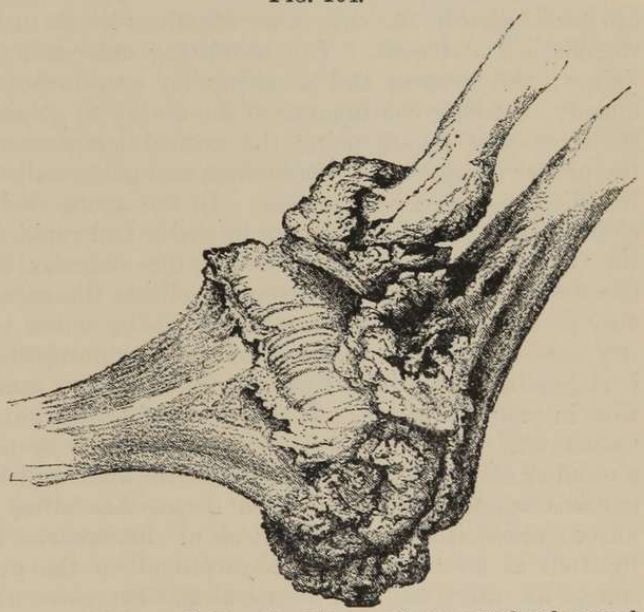
Its assumed causes are many. As predisposants there are heredity, a rheumatic or gouty family or personal history, long-continued hard work, mental worry, an occupation or residence favoring exposure. The exciting cause has been found in cold, in dampness, in injury, in the wretchedness of poverty, and in a trophic neurosis of undetermined origin, at times doubtless septic. It is one of the earlier degenerative affections, and anything that will impair the general strength may be a cause, especially anything weakening the nervous system. The poor are very subject to it, but perhaps no more so proportionately than the well-to-do, the privations of the one class being offset by the

nervous strains of the other. A curious illustration of the possible causative effect of dampness and want of sunlight may be afforded by the fact that the disease has been found in five out of sixteen skeletons of gorillas examined in various European museums, the native home of the gorilla being in the depths of the African forests; although more probably in this case the true cause is to be found in the abnormal and depressing effects of captivity.

The advocates of the neural theory of causation believe that "the articular lesions are peripheral manifestations of a degenerative change in the center for joints situated in the medulla oblongata."

The articular cartilages are first affected. There occurs a fibrillary degeneration of the intercellular substance, with abundant new growth of the cartilage-cells, and soon a breaking down and disappearance of both, leaving the surface eroded and velvety, or, less often, smooth and thinned. By pressure of the adjoining bone marked central thinning is produced, the extent and precise location of which are determined by the pressure. Later there is complete disappearance of the cartilage and exposure of the underlying bone. This in its turn wastes away, with resulting changes in its shape. Not seldom the external layer becomes sclerosed, even of ivory-like hardness, and by pressure is worn down uniformly or in grooves. While the central part of the articulating surface is wearing away, the peripheral is increasing in thickness, and grows out into lips hanging over the edge, which later partly or wholly ossify (Fig. 164). The synovial fringes enlarge, new ones form, and outgrowths are developed. The original cartilage-cells of the membrane proliferate greatly. Adhesions of adjacent sides of the fringes take place. Many of the outgrowths become pedunculated, and some of them may be detached, constituting one variety of "floating cartilage." The capsule and ligaments, at first only congested and œdematous, after a time as a rule undergo fibrous degeneration, with later the formation of adhesions and contractions. They seldom ossify. Occasionally, instead of becoming harder and firmer, they soften and permit undue movement of the joint surfaces, even to the extent of the production of luxation. The irritated periosteum over the end of the affected bone throws out new bone, the osteophytes at times being numerous and of considerable length. The interior of the joint is generally dry, but occasionally contains fluid in large quantity (hydrarthrosis). Hernia of the synovial membrane may be produced, or a communication established with a neighboring bursa. Muscular atrophy occurs early. The tendons passing over the joint may harden and contract, may ossify,

FIG. 164.



Advanced Osteo-arthritis of the Elbow, with eburnated and grooved articular surfaces and enormous lips of bone (Moullin).

may become detached from the bone, or may soften and disappear. At the shoulder the long head of the biceps is commonly destroyed.

As the result of changes in the shape of the articulating surfaces, of new growths upon their edges, and of degeneration of the synovial membrane, the ligaments, the muscles, and the tendons, deformity and restriction of movement soon follow and become greater and greater. In the hand, where the disease so commonly manifests itself, pronation occurs, with the fingers strongly inclined to the ulnar side and held in flexion or extension. On the sides of the finger-joints, especially the distal ones, there may generally be found small, hard, pea-like nodules (the nodosities of Heberden). In certain very mild cases the knobbed condition of the fingers may be almost the only observed indication of the existence of the disease. Several of the vertebræ or all of them may be tied together by a bridge of bone, often said to be produced by an ossification of the anterior common ligament, but really by a new formation in place of the ligament, which has undergone absorption. In a few cases almost every joint in the body has been found firmly fixed, the patient being incapable of movement. While all these changes are going on in the joint there are very slight or even no constitutional disturbances present. Suppuration does not take place either in or about the joint, except in rare cases.

The **symptoms** of the chronic variety, when the disease is well developed, are unmistakable, the only other affections likely to be thought of being chronic rheumatism and gout. The coexisting enlargement and distortion of several joints; the grating and creaking on movement; the slow progress of the malady; the long continuance of the ability to go about and attend to business; the absence of severe pain; the normal temperature and pulse; the want of the proper symptoms of rheumatism and gout,—all these taken together render the diagnosis easy and certain. In the acute variety, occurring generally in children and young adults, the intensity and rapid development of the disease, the symmetrical joint involvements, the articular enlargements, and the early manifestation of muscular atrophy indicate the nature of the affection. When only a single joint is affected—and this is, as has been stated, far more often the hip—the diagnosis for a time may be uncertain. Like the other varieties, it is generally seen in old persons (*malum coxæ senile*), but is occasionally met with in young subjects. It frequently follows contusion, as from a fall on the trochanter. Nothing specially abnormal may be noticed for a time, but after a number of weeks or even months the limb will be shortened and the joint motions much restricted. Such a case has often been mistaken for an old unrecognized fracture of the neck of the femur. Long ago it was described by Bell as an "interstitial absorption" of the neck, but in such cases not simply an interstitial but a general and extensive absorption of both head and neck has taken place, with the formation of new bone along the neck in substitution of that taken away. The destructive and formative changes about the joint are in no material respect different from those observed in the ordinary polyarticular variety.

Of late Spender has called attention to certain symptoms that are developed early, before any distinct evidence is afforded of articular changes. These are (1) rapidity of the heart's action and increased arterial tension, due to disturbance of the inhibitory action of the pneumogastric; (2) the appearance of bronzed and discolored patches upon the skin; (3) clamminess of and atrophic changes in the skin because of vaso-motor disturbances; (4) pain in the muscles of the ball of the thumb or along the inner side of the wrist. The importance of these symptoms, if they prove to be constant ones, is very great, as only at an early stage is the disease curable. When joint changes to any considerable

extent have taken place, the damage is irreparable, and, probably, further progress of the malady cannot be arrested.

The **treatment** must be by the removal as far as possible of all depressing causes, the improvement of the general nutrition, and the administration of drugs and the employment of measures that will promote absorption. Cod-liver oil is of much value, as is arsenic in the early stages; later on arsenic has proved to be decidedly injurious. The iodides, especially that of iron, are beneficial, as are electricity, baths, douches, and massage. Various thermal and sulphur springs have enjoyed considerable reputation as affording relief. Blisters and other strong counter-irritants, especially the actual cautery, have been employed, but it is very doubtful if they ever do much good. If hydrarthrosis is present, compression or better aspiration and carbolic injections should be employed. Here is the one great exception to the rule of securing rest to a diseased joint. Immobilization is *not* indicated, but active and passive movements should be employed as long and as freely as possible.

(H) NEUROPATHIC ARTHRITIS, OR TABETIC ARTHROPATHY (CHARCOT'S DISEASE).

Since it was first described by Charcot in 1868 a peculiar osteo-arthritis in patients affected with locomotor ataxia has been frequently observed. The joint changes are in the main those of osteo-arthritis in general, but there are certain differences of importance. The disease is much more acute, and affects chiefly the large joints, particularly the knee. There is little or no pain, and constitutional disturbances are absent. Without any injury having been received, the joint suddenly swells, and soon a large intra-articular effusion occurs, which after a time disappears through absorption or organization. Extensive and at times very rapid ulceration and wearing down of cartilage and bone take place. New formations are as a rule very limited, though an hypertrophying variety is sometimes met with. The lesion often extends some distance up the shaft, and pieces of bone are separated as though there had been a comminuted fracture. Marked grating and crackling even on slight movement are perceived early. The ligaments quickly break down, with resulting great mobility, it may be in every direction. Dislocation, or characteristic deformity without complete luxation, occurs. Great atrophy of the affected limb is soon observed. All these changes may take place while the patient is confined to bed, proving conclusively that the rapidity and extent of the lesions are not due to over-use of an osteo-arthritic joint the sensibility of which has been greatly diminished or practically altogether lost because of the existing tabes. Ordinary osteo-arthritis may occur in a tabetic patient, but it does not run the acute course that is so characteristic of tabetic arthropathy proper. That the disease does not depend upon degeneration of the peripheral nerves is shown by the absence in a considerable proportion of cases of any marked changes in such nerves. Everything seems to indicate that the disease is a peculiar one, depending upon changes that have taken place in the spinal cord, perhaps in the anterior horns.

The **treatment** is practically confined to protection of the affected joints from injury, and to limitation of the abnormal movement by position or by apparatus. If dislocation of a joint in the lower extremity has occurred, it will probably be necessary for the patient to keep his bed. In a few cases excision has been done, but the results have not been satisfactory.

(I) HYSTERICAL JOINTS.

More than half a century ago Brodie directed attention to cases of seeming

articular disease in which no joint lesion was present, and which were only manifestations of hysteria. Since then such cases have been found to be of frequent occurrence. In the great majority of instances the patients are women, especially young women. Generally they are well educated, in easy circumstances, and highly impressionable, often the subjects of some ovarian or uterine disturbance. The knee and hip are the joints commonly affected; the trouble may come on suddenly and without known cause or after a slight injury, or follow a mild arthritis which has quickly disappeared. The patient imagines that she has serious disease which causes great local distress and decidedly or entirely prevents passive motion except at the cost of much suffering. Active motion may seem as impossible as though the muscles were paralyzed, or, as is usually the case, may be executed without special difficulty, but in a rather feeble way. The parts are generally normal in size and appearance except as affected by a slight amount of atrophy from disuse, or are at times somewhat swollen and a little reddened, commonly because of the applications that have been made. There is great hyperesthesia of the skin, the least touch causing pain, much more than that produced by firm pressure. There may be an apparent rigidity of the muscles about the articulation, but this at once and completely disappears when the patient is anesthetized. The joint may from the first be held fixed in extension or flexion, but will rarely be found at that angle of flexion which secures the greatest ease and which is characteristic of a true arthritis. Very often the position of the limb varies from time to time, the change, it may be, occurring suddenly.

The local temperature is normal, or even subnormal, because of the sluggish circulation, though transient and variable increase of heat may be noticed that may even appear quite regularly at certain hours of the day. It is of the highest importance that the true nature of the affection should be determined at an early period. These cases are often misunderstood, and the patient is treated for actual articular disease, traumatic, rheumatic, or even tubercular, and in consequence becomes a permanent cripple.

The **diagnosis** is to be established by observing, first, the marked disproportion existing between the subjective and the objective symptoms, a disproportion so characteristic of all manifestations of hysteria; second, the intense hyperesthesia; third, the absence of any evidence of degeneration of the tissues; fourth, the complete relief of symptoms when the attention of the patient is directed from herself and her malady; and fifth, the entirely normal outline of the joint and complete freedom of its motions during the anesthetic sleep. It should not be forgotten that in any case of suddenly appearing disease of the knee or hip in a young woman, especially if she is of a neurotic temperament, the antecedent probabilities are all in favor of the hysterical nature of the affection. But before concluding that it is of such nature care must be taken to make sure that there are not in and about the joint evidences of an organic lesion. The extreme difficulty at times of learning the real character of the disease and the deceptive character of this neuro-mimesis or nerve-mimicry are shown by the fact that in some cases surgeons have commenced an excision or amputation only to find upon exposure of the joint structures that there was nothing the matter with them.

The **treatment** is constitutional, supporting, and tonic, and directed to any existing visceral disease. Moral treatment is especially needed. Unless the confidence of the patient is gained and she realizes the truth of the statement made to her that she has no joint disease, she will not get well. Of local treatment the less the better. Electricity, frictions, baths, massage, all are very apt to keep the attention of the patient fixed upon her affection. The

joint should never be immobilized, and no brace of any kind should be applied, as fixation of the articulation will almost certainly cause the formation of disabling adhesions. Hypnotic suggestion has been found curative in certain cases.

SECTION IV.—NEURALGIA OF JOINTS.

Neuralgic pain in a joint may be due to constitutional or to local causes—*i. e.* to disease of the brain or spinal cord; to neurasthenia; to malaria; to syphilis; to nerve injury; to pressure upon the main trunk high up or upon branches near the articulation by a tumor or an inflammatory new growth; to affection of organs more or less remote, as in the hip in cases of uterine or ovarian disease. Like similar pain elsewhere, it is intermittent and variable in intensity, and is unassociated with any apparent permanent change in the articular or periarticular structures. It is to be treated in the ordinary way, by improvement of the hygienic surroundings, by regulated exercise, and by the therapeutic or operative removal of the existing cause. In a few cases it has been asserted that there has been a neuralgia, generally located in the knee, so intense and so persistent that it could be relieved by nothing short of nerve-stretching, neurectomy, or amputation. It may well be questioned if some or even all of these cases were not really hysterical affections instead of arthralgias. Occasionally peripheral neuritis consequent upon traumatism, the pressure of a tumor, or disease of bone has given rise to arthritis that has ended in ankylosis and deformity.

SECTION V.—WOUNDS AND INJURIES OF JOINTS.

Wounds of joints are of two classes, *non-penetrating* and *penetrating*. The former are of little importance as long as they do not suppurate, but when they suppurate there is danger of extension of the inflammation to the joint. If attended with loss of substance, the resulting cicatricial contractions may more or less interfere with articular movements. However slight such a wound may be, it is wise to stop all motion of the joint, to clean and close the opening, and to apply an antiseptic compress. In a few days complete repair may be expected.

Penetrating wounds, on the other hand, are always serious accidents. If they are properly treated recovery follows in a large proportion of cases; if improperly treated or neglected they are almost certain to result in local destruction, not seldom in loss of life. Aside from compound dislocations and complicated fractures, which are considered elsewhere, they are generally produced by gunshot, by stabs, or accidentally by tools of trade. In a few cases in originally non-penetrating injuries communication with the joint is established later, often through a bursa.

The **symptoms** vary according to the nature of the vulnerating body, the joint opened, and the extent of the injury, though there will be always observed a discharge of synovia more or less mixed with blood, and in a short time swelling of the parts from hemorrhage and intra-articular effusion. The discharge of synovia in small quantity, however, is not pathognomonic, since it may come from an unconnected bursa; but if synovial fluid to any considerable amount is poured out, penetration of the joint should be accepted as a fact. In large wounds the articulating surfaces can be seen or felt. Pain and bleeding are always present in greater or less degree, but are not indications of penetration, as they are equally associated with wounds that do not open the cavity. If protected from septic infection, the opening in the capsule readily closes, the effused serum and extravasated blood are absorbed, the synovitis quickly subsides, and recovery takes place with little or no impairment of the functional value of the part, though some weakness and a slight

restriction of motion are apt to continue for a time. When such a wound is made by an unclean instrument, or if at any time before healing it becomes septic, the symptoms are very different and the prognosis is grave. By the end of about the third or fourth day after the receipt of the injury, or at such period as infection of a primarily aseptic wound may occur, the symptoms of suppurative synovitis, already described, become manifest. If promptly and vigorously treated, the joint may and generally will be saved, though probably in a decidedly damaged condition. It is not in the fact that the wound involves an articulation, but in the risk of its becoming septic, that the great danger lies. Here, as elsewhere, every effort must be directed toward preventing this occurrence.

By far the most dangerous of the joint wounds are those produced by **gunshot.** In military surgery until recently, whether the articulation was extensively crushed by the passage into or through it of a large ball or piece of shell or opened by fissuring of the extremity of the wounded bone, unless amputation or excision was primarily performed a suppurative arthritis was developed within forty-eight or seventy-two hours, and quickly proved fatal, or was recovered from only after weeks or months, and that with a greatly damaged limb. When only the joint was injured there might be produced an articular empyema, or the pus, travelling along the connective-tissue planes or the tendon-sheaths, widely infected the soft parts. How far under the peculiar circumstances attending the receipt and early treatment of joint wounds in war it may be possible by "first aid" and after antiseptic treatment to prevent such wounds from becoming septic is a question as yet unsettled, though the limited experience of a few surgeons in late wars renders it highly probable that very much may be accomplished.

But in civil life, in which the wounds are commonly produced by pistol-balls, it has been clearly shown that under proper treatment the joint injury in the great proportion of cases may be conducted to a safe termination, even to the extent of preservation in large measure of the articular movements.

Treatment.—Such a wound should never be examined with dirty fingers or a dirty probe. The track of the ball and the probable extent of the damage done should be determined only with an aseptic instrument or a thoroughly cleaned finger. As a rule having very few exceptions, a piece of cloth carried in with the ball can be detected only by the finger, and the presence of such a foreign body is almost absolutely certain to infect the wound. The opening and the track being enlarged if necessary, all foreign bodies and all completely detached pieces of bone should be removed and the wound carefully disinfected as after compound fractures. A drainage-tube should then be introduced, through and through drainage being secured if required. Antiseptic dressings should then be applied and the joint immobilized. When the bone injury has been so extensive as to necessitate operation, atypical rather than typical resection should be done.

As in the larger wounds in war, so in the smaller ones in civil life, the fate of the part if not of the wounded man himself is in the hands of him who first sees him; in other words, if septic infection is prevented a good recovery may be expected. If the wound becomes septic the cavity and the suppurating tracks about must be opened up and thoroughly cleaned, sequestra removed as they become separated, and proper general treatment pursued. Ankylosis of the joint, frequently complete, is the ordinary termination if part and life are saved.

Sprains.—By far the most common joint injury is sprain. This is produced by a sudden wrench or twist of the articulation, and is experienced most frequently in the ankle and wrist, in the former because of a misstep or a fall

upon the foot, in the latter because of a fall upon the hand. Its degree may vary from that which is so slight that its effects quickly subside to that which is associated with luxation or fracture or both. The line of displacement may pass through any section of the investing capsule, according to the mode of production of the injury, but it most often is through that part in which motion is physiologically least; hence in the hinge-joints it is lateral. By the abnormal movement the synovial membrane is unfolded on one side and compressed on the other, and when the normal limit of such change is reached the membrane is torn and crushed. The ligaments, though their fibers cannot stretch, do elongate somewhat as a change is produced in their structural reticulations (as illustrated in the Indian puzzle), but the limit is quickly reached, and further extension produces laceration. The degree of tearing varies according to the severity of the wrench, from that of only a few fibers to that of the entire ligament, to its detachment from the bone, to the production of fracture or dislocation, and to rupture of distant muscles. Laceration of the vessels and slight or extensive hemorrhage into the joint-cavity, the meshes of the articular structures, and the connective tissue outside necessarily occur. Intra-articular extravasation to any considerable amount is indicative of severe injury and adds greatly to the gravity of the case. The accident is most common in young and middle-aged adults, is most likely to affect a joint that has previously been sprained, and is much more easily produced in a deformed limb or one in which the muscles are feebly developed and the ligaments relaxed; hence its frequency in the weak-ankled.

The **symptoms** are well marked, the only question, as a rule, being whether or not the case is a simple sprain or whether there is an existing luxation or, more often, fracture. Pain is instantly produced, and is always severe. Not very rarely the patient faints. After the first sharp attack there occurs a period of comparative ease, followed, either quickly or more commonly after the lapse of some hours, by a return of suffering, due to tension and inflammation. Before long the parts become swollen. If there is much hemorrhage into the joint-cavity, the fulness may be observed within a very short time, but ordinarily only after a few hours; it is then due in part to extravasation, but chiefly to effusion into the cavity of the joint and the periarticular structures. The swelling is especially noticeable in those parts of the articulation in which there is least pressure exerted by tendons and ligaments. Movement of the joint is arrested either wholly or in large measure. If the ankle or the knee is affected the patient cannot walk at all, or can walk only with a limp. After a time, usually several days, subcutaneous extravasations are seen, with resulting color-changes in the skin. If in a hinge-joint a lateral ligament has been completely torn across, the gap may commonly be felt, and an abnormal movement of the joint can always be effected. Laceration of a muscle can be detected by touch, as also can a fracture with or without separation of the fragments, as in the lower end of the radius or through a malleolus. In the ankle, as pointed out by Callender, "sprain fracture" may occur. This is a fracture of a part of the articular surface. Its existence cannot be discovered by touch. This accident explains many of the cases of ankylosis of the ankle following what is apparently a mere sprain.

The **prognosis** varies with the joint affected, the extent of damage done, and especially the promptness and efficiency of treatment. When there has been a large hemorrhage into the cavity, blood-clots often remain for a considerable time; occasionally their organization and fusion with the adjacent synovial membrane result in adhesions which decidedly restrict the after movements of the joint.

The **treatment** has for its object, as far as possible, the prevention or the limitation of the inflammation in and about the joint. In the milder cases rest, with cold or, much better, hot applications, may be all that will be required. Compression is of decided service, a layer of cotton or wool being wrapped around the joint and held in place by a moderately tight bandage of flannel or rubber. After the active inflammation has subsided, massage is of great value, and its early employment is advised by many surgeons. Free active and passive motion of the joint from the first, as has been strongly advised by some, is painful, and cannot be otherwise than injurious when the sprain is a severe one. By far the best treatment, as a rule, is immobilization of the joint by the application of a plaster-of-Paris bandage. If applied soon after the accident has occurred, it will very much lessen congestion, hemorrhage, and effusion, and diminish the time of confinement. If there has been a large amount of blood poured out into the joint, it should be withdrawn through an aseptic aspirator needle before the dressing is applied. One great advantage of this method of treatment is that it will permit of the patient's going about and attending to business if necessary—on crutches if the sprain is of the knee or the ankle, with the arm in a sling if the affected joint is of the upper extremity. Immobilization applied at once and maintained for a number of weeks, especially if the patient is kept quiet and the limb elevated, will in great measure prevent the occurrence of the weak, swollen, painful, and crippled condition of the joint that so often follows a severe sprain treated in other ways. Even if there has been a fracture or a dislocation, this method of treatment is the best that can be employed.

Ankylosis.—As the result of cicatricial contractions of new-formed granulation-tissue in and about a joint, its motions are restricted, and the articulation is said to be ankylosed. Limitations of movement due to loss of substance in the skin and underlying soft parts consequent upon severe injuries, or due to contractions of muscles and tendons, are not, properly speaking, cases of ankylosis, though they are at times associated with the ankylosing effects of articular and periarticular inflammation, and, it may be in marked degree, increase the disability due to such inflammation.

That ankylosis may be produced, there must have been (1) a blood-clot adherent to the folds of the synovial membrane which later has become fused with them; or (2) the organization of an exudate within the joint commonly attached to eroded parts of the articular cartilage, though at times deposited only in an interosseous ligament; or (3) similar change in an exudate in the subsynovial and interligamentous connective tissue; or (4) degeneration of ligaments, with after-contraction of the substitution granulation-tissue and the formation of adhesions to the adjacent parts; or (5), what most often occurs, a combination more or less extensive of two or more of these conditions. Until a few years ago it was believed that simple disuse of a joint would be followed by ankylosis, but this is now known to be an error, at least as to the larger joints. Without inflammation of some form or other, ankylosis cannot take place. The restricting band or bands may be of limited extent outside the cavity and of considerable length within, or they may be very extensive in and about the capsule and very short between the ends of the bones. The inflammation may terminate, as it commonly does, in the formation of fibrous tissue, or may go on to ossification, partial or complete. When the latter change has taken place within the joint-cavity, where osseous union is generally found, there must have been a prior opening up of the cancellous tissue of both the articulating bones. If the bone deposit is external, it may occupy the place of a degenerated ligament and adjacent connective tissue, having started from the periosteum and passed over the

joint as a natural splint altogether preventing any movement; or it may be in patches, larger or smaller, in the parts outside the synovial membrane.

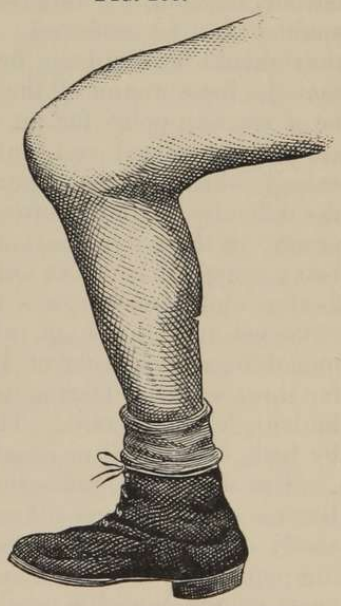
According to the degree of organization of the new-formed tissue, ankylosis is *fibrous* or *bony;* as respects the extent of restriction of movement, it is *partial* or *complete.*

Except when, as after certain fractures and in cases of osteo-arthritis, the ankylosis is due to displaced fragments and stalactitic outgrowths, or when there has been but a limited bone deposit in the periarticular structures, bony ankylosis is a complete one. It is not, however, by any means always associated with entire obliteration of the joint-cavity, for, as has already been stated, there may be only an outside bridge; and when the union is an internal one very often there will remain for years or through a long life a small synovial cavity. The fusion of the articulating bones is seldom so complete that the line of junction is not recognizable on section, but occasionally it is impossible to find where one bone ends and the other begins, even the medullary cavities being so directly continuous as to constitute but a single one.

Bony ankylosis is commonly a termination of septic (often an osteo-myelitic) or tubercular inflammation, while fibrous ankylosis, which may be met with after any form of joint inflammation, is very generally due to a traumatic, a gonorrheal, or a rheumatic arthritis.

In the fibrous variety the adhesions may be so extensive and short as practically to prevent all motion at the joint, or so lax as to interfere but little with the ordinary movements; or, as is more commonly the case, they may be sufficient decidedly to limit the use of the limb. In the cases in which this variety most strongly resembles the bony, even when motion at the articulation cannot be recognized, its fibrous nature is proved by the pain attending manipulations and the manifestation within a few hours of the symptoms of irritation or inflammation, especially a local rise of temperature.

Fig. 165.



Angular Ankylosis of the Knee (Bradford and Lovett).

The *ill effects* of an ankylosis are proportionate to the resulting interference with the physiological use of the joint; they depend, therefore, not only on restriction of motion, but also, and to a greater extent, on the angle of fixation. A knee completely ankylosed in the straight position is much better than one held in permanent flexion or one which is movable and yet cannot be fully extended (Fig. 165). An ankylosis of the elbow that prevents the forearm from being flexed at a right angle with the arm is much more crippling than one in which extension cannot be carried beyond a right angle. At the shoulder, ankle, and hip loss of motion is often compensated in a great measure by the free movement of the scapula, at the knee, and at the sacro-iliac junction respectively. When ankylosis occurs in a young child more or less interference with the after-growth of the bone may be expected.

The **treatment** will depend upon the variety, the angle, and the joint affected. When the nature and extent of an articular inflammation make it probable that ankylosis will occur, such inflammation should be limited as

much as possible, especially by rest: care, however, must be taken not unduly to prolong immobilization, particularly in cases of rheumatic origin, in which after a time regular passive motion should be made. In certain fractures, notably those about the elbow, it has been advised by many practically to disregard the fracture after a few days, and by passive motion prevent the joint from becoming stiff; but it is better to treat the fracture in the ordinary way, remembering that immobilization most thoroughly limits inflammation, and that the adhesions are due to inflammation. Both at the elbow and at the knee (after fracture of the patella) a resulting fibrous ankylosis, if forcibly broken up, will commonly be quickly reproduced, but with active use of the joint will generally spontaneously disappear in the course of a few months or at most in a year or two. When the ankylosis is bony and the position a good one, no treatment should be pursued, unless it be at the elbow, where by excision, partial or complete, a serviceable movable joint may often be secured. When the angle is a vicious one, excision should be done or the malposition corrected by osteotomy; at the hip the latter is much the preferable operation. Forcible breaking down of bony adhesions should never be done; destructive inflammation of the part is very likely to follow, the original disease having been almost certainly septic or tubercular; and if it does not, the surfaces will unite again by bone.

By massage, by frictions, by baths, by regulated movements, by the use of electricity, especially by massage and movements, much may be accomplished in the removal of periarticular exudations and adhesions.

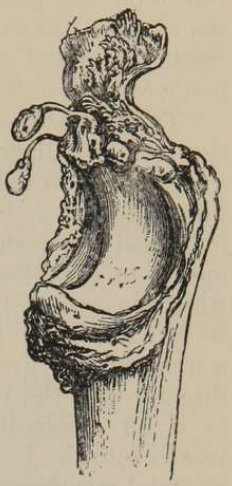
But in the majority of cases a fibrous ankylosis will require for its removal either a forcible rapid breaking up of the adhesions and straightening of the limb or a slowly-effected correction of the deformity by continuous or intermittent traction, by weight-extension, or by apparatus. As a rule, the former method is to be preferred. If the tendons about the joint are contractured, they should be divided a few days before the straightening is to be done, so that the little wound of the skin may be entirely healed, as otherwise it may be a starting-point for an extensive laceration. Very generally the tendons are only contracted, and that more apparently than really, and will yield readily enough when the limb is extended. When it is the knee that is the seat of the difficulty, as is so often the case, the patient may be upon his back or prone; in the latter position leverage can more readily be exerted. The limb being grasped above the ankle and above the knee, firm, steady movements in flexion and extension are to be made until the leg can be fully and easily extended upon the thigh, when the whole limb is to be enveloped in cotton and immobilized by plaster of Paris, the dressing being kept on for two or better for three weeks. During the straightening the rupture of the adhesions can be both felt and heard. The operation is usually free from danger and followed by little or no local or constitutional disturbance.

But accidents, and serious ones, may occur. The main vessels may have become shortened and adherent, and may be ruptured when the limb is straightened; or there may be laceration of one of the popliteal nerves, with resulting paralysis; or the skin and adherent fascia may be extensively torn; or long-encapsulated pyogenic cocci may be set free and develop extensive suppuration in the leg or thigh. No one of these accidents is to be expected; any one of them may happen. Because of the danger of setting free the infecting organisms and producing destructive inflammation of the joint and structures outside, forcible breaking up of ankylosis following either septic or tubercular disease should not be done. By the employment of weight-extension or by an apparatus permitting of a gradual widening of the abnormal angle the deformity can usually be corrected after a time.

SECTION VI.—LOOSE BODIES IN JOINTS.

Loose bodies sometimes occur in the larger joints, in nine cases out of ten in the knee. They consist of fibrous, bony, or cartilaginous tissue or a mixture of them. So commonly are they cartilaginous that they are often called by the general name of "floating cartilages." They are sometimes free in the cavity of the joint, or less frequently attached by a long or a short pedicle (Fig. 166). Occasionally they are multiple, but more commonly there are only one, two, or three. In size they vary from that of a pea or bean up to that of the last joint of the thumb. When multiple they are usually very small. They are developed in several ways, originating (1) from villous outgrowths from the synovial membrane, which are more and more crowded off from the surface, the contained cartilage-cells growing, and after a time often ossifying in the center; (2) from detached osteophytes of osteo-arthritis; (3) from outgrowths from the articular cartilage; (4) from detached pieces of cartilage, with or without a bony substratum, which have been separated either by sudden violence or slowly by "quiet necrosis;" (5) from blood-clots, either in the cavity itself or much more probably in the synovial villi; (6) from fibrin poured out in an acute inflammation, or, much more often, in a rheumatic subject, over a limited space under the synovial membrane, which it pushes inward until pedunculation and later separation of the nodule take place; (7) from overgrowth of the cartilage-cells normally contained in the synovial membrane; (8) from detached tuberculized fringes or small parts of the infected membrane. The first is by far the most common origin, the others being rare, most of them (3, 5, 6, 7) very rare. By many it has been denied that the floating cartilage ever is a piece chipped off the articulating end of the bone, but sufficiently numerous specimens prove that this accident occasionally occurs.

Fig. 166.



Nodules of Fibro-cartilage attached by Elongated Pedicle (Marsh).

However produced, they usually undoubtedly follow traumatism, which is often slight, or else are associated with a rheumatic or osteo-arthritic diathesis. They are found in adults under middle age as a rule, and in men far oftener than in women. When very small and numerous they are not usually attended by other symptoms than those of chronic arthritis. When there are but one or two, and these of considerable size, they demand treatment because of the pain and disability produced by them. Occasionally by pressure they produce absorption and erosion of the bony surface with which they are in contact.

Symptoms.—Sooner or later the presence of such a body is followed by a slight weakness and fulness of the joint, the patient at times feeling the nodule at various parts of the joint, oftenest in the neighborhood of the patella. Occasionally the cartilage will be caught somewhere between the femur and the tibia. Instantly pain is experienced, so intense, it may be, as to cause nausea and fainting. Motion of the joint is arrested, and the patient perhaps falls. The inability to flex or extend the joint continues until the loose body is dislodged by various movements. Moderate or often considerable effusion into the joint-cavity soon occurs, but is quickly absorbed, the joint then resuming its previous condition. Similar attacks follow one another with increasing frequency, and after each the recovery is progressively less complete, until finally the effusion becomes permanent, and the joint is markedly weakened.

The **diagnosis** is, as a rule, easy. A small body which slips away from under the finger can be detected first in one and then in another part of the joint.

When it cannot be felt its presence can only be inferred from the sudden attacks of disability. The only affection with which it can be confounded is the so-called "internal derangement of the knee-joint," which is caused by the slipping or dislocation of one of the semilunar cartilages. This also causes a sudden, intensely painful arrest of motion at the knee, followed by acute synovitis; but the joint is more likely to be held in the locked condition, and after the effusion has subsided an irregularity can usually be detected just above the border of one of the tuberosities of the tibia. This is the edge of the semilunar cartilage, dislocated forward or backward.

Treatment.—When such a sudden attack of pain and disability occurs, the loose cartilage must be displaced by forced flexion and extension at the knee, under an anesthetic if necessary, after which the joint should be immobilized for a number of days. The only radical treatment is removal of the loose body by opening the joint. Modern antiseptic methods have made the operation a perfectly safe one, in marked contrast to the very serious results which formerly followed the opening of this joint. The loose body is first to be fixed, if possible, either by the fingers or by a steel pin thrust into it, often a procedure of great difficulty owing to its density. An incision is then made directly into the joint, as near the cartilage as possible. This is pressed out, or if any difficulty is experienced the finger or a blunt hook or forceps is passed into the joint and the cartilage seized. The edges of the wound in the synovial membrane are to be united by buried catgut sutures, and the cutaneous wound is closed and dressed as usual. The leg should be immobilized either by a plaster-of-Paris dressing or a splint.

SECTION VII.—DISPLACED SEMILUNAR CARTILAGE.

This has long been termed "internal derangement of the knee-joint," but is now known to be due to the slipping or displacement of one of the semilunar cartilages, most frequently the internal. It may occur in health, the coronary ligament being torn away; but it is commonly associated with chronic synovitis or osteo-arthritis, in which diseases the attachments of the cartilages are relaxed and more easily torn. The cartilage may be merely slipped between the ends of the bones, or it may be rolled upon itself and entirely detached from the tibia. Having once occurred, the accident is liable to be frequently repeated.

The **symptoms** are sudden and severe pain, with inability to stand or walk, the leg being partially flexed and the joint locked. Swelling follows quickly, but subsides after displacement of the cartilage. When the luxation has occurred frequently, however, the effusion is more permanent and the limb weak.

Treatment.—At the time of the accident replacement of the cartilage is effected by flexion and extension with rotation of the knee, if necessary under an anesthetic. Sometimes the patient will execute this maneuver himself better than the surgeon. Occasionally replacement is impossible. When the cartilage has been replaced the joint quickly resumes its normal condition, an elastic knee-cap being often employed to steady and assist it. If the disability is very great or reduction impossible, the joint should be opened and the cartilage seized and brought back to its normal position, where it should be fixed by sutures carried through the periosteum of the tuberosity. It has been removed with excellent functional results. Absolute asepsis is required.

CHAPTER VIII.

DISLOCATIONS.

DEFINITIONS.—A dislocation is a permanent, abnormal, total, or partial displacement from each other of the articular portions of the bones entering into the formation of a joint.

A *temporary* displacement, followed immediately by a return to place, constitutes a **sprain.**

When the opposing articular surfaces are completely separated or touch each other only by their edges, the dislocation is complete; lesser forms of displacement are termed *partial* or *incomplete*, or **subluxations.** In the ball-and-socket joints the dislocation is said to be complete when the center of the globular head rests outside the rim of the concave socket.

A coexisting wound of the soft parts that establishes communication between the outside air and the cavity of the joint makes the dislocation **compound;** and the coexistence of other important lesions that seriously affect the treatment and prognosis makes it *complicated.*

When the corresponding joints of a bone symmetrically placed on both sides of the median line of the body, as the lower jaw or a vertebra, are dislocated, the dislocation is said to be *bilateral.* It is total when both ends of a bone, as the clavicle, are dislocated, or when a small bone having several joints, as a carpal or a tarsal bone, is widely displaced. Dislocations are *double* when symmetrical on both sides of the body, as of both shoulders. Dislocations are said to be *multiple* when two or more bones are simultaneously dislocated, as two or more fingers, a shoulder, and a hip. Both these last two terms are sometimes used in the sense of total.

Ordinarily a dislocation is *traumatic*, and occurs abruptly in a normal joint as the result of external violence or of the sudden contraction of the patient's muscles upon the bones forming the joint, but occasionally it takes place gradually (or suddenly) without recognizable violence in joints that have been so altered by disease as to facilitate the displacement; such dislocations are commonly known as *spontaneous* or *pathological.* *Congenital* dislocations are those that occur during intra-uterine life, and are usually the result of defective development.

NOMENCLATURE.—As a general rule, the *distal* member of the joint is the one said to be dislocated; thus we speak of a dislocation of the humerus, and not of the scapula, when the scapulo-humeral joint is dislocated; an almost universal exception to this rule is the term dislocation of the outer end of the clavicle, used instead of dislocation of the acromion or of the scapula. Sometimes the name of the joint or of the region is used, as dislocation of the shoulder, hip, elbow. Terms indicating direction correspond to the change in the position of the distal segment of the joint, as backward dislocation of the elbow, meaning that the upper ends of the radius and ulna are displaced backward. Special names indicative of the new relations of the displaced bones are applied to some of the commoner varieties, as subcoracoid dislocation of the shoulder, iliac or dorsal dislocation of the hip.

STATISTICS.—Dislocations are less frequent than fractures in the proportion of 1 to 10; those of the shoulder are the most frequent, those of the elbow

next. The proportions vary in different statistics, but in general terms it may be said that *dislocations of the shoulder constitute from one-half to two-thirds of all dislocations.*

Age.—Dislocations may occur at any age from the very moment of birth; the absolute frequency is greater between the ages of twenty and thirty; the relative frequency, computed according to the number of people living at the different ages, is greatest in the three decades between forty and seventy. Below the age of twenty years dislocations of the shoulder are rare, those of the elbow frequent; above that age those of the elbow are rare, those of the shoulder frequent. It has been pointed out that dislocations of the elbow are produced in childhood by the same violence—*i. e.* falls upon the outstretched hand—that produces fracture of the humerus in adults, and dislocations of the shoulder in adults by that which produces fractures of the clavicle in children —*i. e.* falls upon the shoulder.

ETIOLOGY AND MECHANISM.

The causes are (*a*) *predisposing*, and (*b*) *immediate* or *determining*.

(*a*) **Predisposing Causes.**—*Normal* predisposing causes are found in the conformation of certain joints which diminishes the area of contact of the opposing articular surfaces in certain positions or establishes conditions of leverage favorable for the rupture of opposing ligaments, as in hyper-extension of the elbow; or which avoids the opposition of ligaments, as in the movement forward of the condyles of the lower jaw; and also in the greater exposure of certain joints to external violence. Normal freedom of motion is more of a protection against dislocation than a predisposing cause thereto, because the necessary rupturing strain is not ordinarily put upon the opposing ligaments before the limit of motion has been reached. A predisposing cause at the elbow is found in the outward deviation of the forearm from the long axis of the arm. *Pathological* predisposing causes are distention of the joint by an effusion, destruction or softening of the ligaments by violence or disease, and the fracture of bony processes or of one of a pair of parallel bones.

(*b*) **Immediate** or **Determining Causes.**—These are external violence and muscular action. *External violence* may be exerted directly upon the end of the bone that is displaced, as in a dislocation of the head of the humerus by a fall or a blow upon the prominent part of the shoulder; or indirectly through and parallel to the shaft of the bone; or in a more complex manner by moving the limb beyond the normal limit of the range of motion, so as to rupture the ligaments, and then forcing the liberated bone out of its place.

Muscular action dislocates by communicating a momentum to the limb which acts in the same manner as external violence when the limit of the range of motion is reached, or by acting directly upon the end of the bone to draw it out of its socket. Thus a woman dislocated her shoulder by raising her arm quickly to strike a blow, a man dislocated both shoulders by drawing himself upward by his hands, another by raising his arm to paint a ceiling, others during epileptic convulsions; dislocation of the lower jaw may be produced by yawning. Some individuals can voluntarily dislocate certain joints by the contraction of certain muscles or groups of muscles; in others a liability to dislocation of some one joint by slight causes exists (recurrent or habitual dislocation) as the result of a primary traumatic dislocation, or of the paralysis of certain muscles, or of other pathological conditions.

PATHOLOGY OF RECENT DISLOCATIONS.

Except in very rare instances, one or more of the ligaments of a joint and its capsule are torn during a dislocation; in the ball-and-socket joints the rent in the capsule is on the side toward which the round head of the distal bone is displaced; in other joints the ligaments on either side or on both sides may be torn, the position and extent of the injury varying with the mode of production and the range of displacement. There is reason to think that both the capsule and the ligaments escape rupture in the simpler dislocations of the lower jaw, and a few cases have been reported in which those of the shoulder have similarly escaped. In joints relaxed by paralysis of the corresponding muscles or by an effusion within the capsule, dislocation habitually occurs without laceration.

Attached muscles that are put upon the stretch may be ruptured or torn from their attachments, perhaps bringing with them in the latter case the scale or apophysis of bone to which they are attached. Opposing prominences of bone or portions of a prominent articular edge or rim may be broken off, as the coronoid process of the ulna or the edge of the head of the radius in a backward dislocation of the elbow, or the rim of the glenoid or cotyloid cavity. One articular surface may be deeply indented by impact against the edge of the other surface.

Associated injuries of adjoining parts may exist as **complications.** The shaft of the dislocated bone or of a parallel bone may be broken; the dislocated end may be split; the neighboring blood-vessels or nerves may be ruptured or bruised; adjoining organs may be lacerated or compressed; the soft parts and the integument may be torn. Fracture of the shaft or of the neck of the dislocated bone may constitute a serious, perhaps an insurmountable, obstacle to reduction, because of the difficulty of communicating the necessary movements to the dislocated end; the commonest example is fracture of the surgical neck of the humerus in combination with dislocation of the shoulder. Fracture of the articular end of the dislocated bone is rare, although there is reason to think that limited bruising of the head of the humerus by impact against the edge of the glenoid fossa is not very uncommon. Partial fracture of the rim of the socket of an enarthrodial joint or avulsion of an apophysis is common, and does not ordinarily constitute an important complication. Rupture of neighboring blood-vessels is most frequent at the shoulder, where it usually consists in rupture or avulsion of the subscapular or circumflex artery. Of injuries of nerves the most common is that of the posterior circumflex at the shoulder. At the knee and the elbow the main arterial, venous, and nerve trunks are occasionally torn. Injuries of adjoining viscera are rare. In backward dislocation of the sternal end of the clavicle the trachea or œsophagus is sometimes pressed upon; and in one reported case the dislocated humerus was forced through the wall of the chest, the bone retaining its new position and the patient surviving many years.

In uncomplicated cases **reduction** is habitually **followed by repair** of the torn capsule and ligaments, but complete restitution to the normal condition may be prevented by faulty repair of some of the lesions, by periarticular thickening, by subperiosteal formation of bone in the young, or by more or less persistent sensitiveness of the joint. Thus at the shoulder the ruptured tendon of the supraspinatus and the upper part of the capsule may fail to reunite, and the patient be thereby exposed to frequent recurrence of the dislocation, or the fracture and retraction of the greater tuberosity may annul or weaken the power of active external rotation, or injury to the circumflex nerve may result in more or less prolonged paralysis and wasting of the deltoid. At the

elbow the stripping up of the periosteum from the posterior aspect of the external condyle may lead to such thickening of the bone as will limit extension.

In dislocations that remain unreduced the displaced and lacerated connective tissue becomes thickened and condensed about the head of the bone, sometimes uniting directly with it, sometimes forming a new capsule about it which is more or less broadly continuous with the old one; the torn ligaments and muscles contract new adhesions which serve to fix the bone in its new position and limit its motion. The untorn portion of the capsule is drawn across the other articular surface (*e. g.* the glenoid fossa), and, if the contact is close, unites permanently with it; if the contact is not close, the cavity of the socket fills up with fibrous tissue of new formation. The dislocated head comes to rest against an adjoining surface of bone, and under the influence of its pressure the bone and the periosteum are stimulated to the production of new bone about the point of contact, and thus is formed a bony rim, a veritable new socket, possibly covered with fibro-cartilage (Fig. 167). The ossifying process may extend to the adjoining soft parts and produce large and irregular masses of bone continuous with one and possibly with both of the members of the joint. A very important feature is the occasional binding fast of neighboring large vessels or nerves to the dislocated bone. The result of all these changes is that the dislocated bone becomes permanently fixed in its new position, and its return to its former one can be effected only with lacerations similar to, and usually much more extensive and serious than, those which accompanied its first displacement; furthermore, the socket from which it was displaced has been shut off by the adherent capsule or filled up with new tissue.

Fig. 167.

Old Supracotyloid Dislocation of the Femur, with very complete new acetabulum (Krönlein).

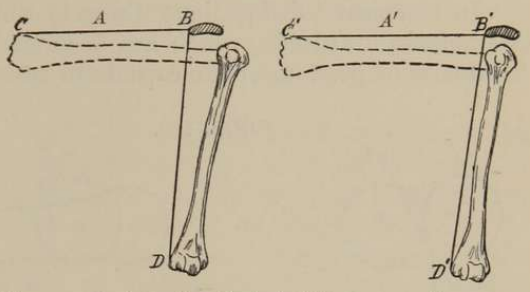
SYMPTOMS.

Deformity, including in this term changes in contour and attitude, is always present, and is frequently so marked as to be almost diagnostic on inspection alone. The one demonstrative sign of dislocation is the recognized *presence of the head of the bone in an abnormal positon;* and this sign should always be sought for in preference to others that are less demonstrative, but perhaps more easily recognized. It is obtained by palpation of the region, by systematic exploration of the bony prominences, and by the identification of abnormal prominences or of those abnormally situated, by means of gentle movements communicated to the limb. Thus in the common anterior dislocation of the shoulder the finger recognizes the absence of the normal bony resistance offered by the head of the humerus below the acromion in front, and finds a new one below or to the inner side of the coracoid process, which shares in rotatory

movements communicated to the arm; and the surgeon also notes that the axis of the limb if prolonged upward passes through this prominence.

Measurements.—Many confusing statements concerning shortening or elongation of the limb in different dislocations have been made. Error may arise through failure to place the compared limbs in symmetrical positions, contradiction through the choice of different lines of measurement. It may be positively stated that, with one or two extremely rare exceptions, such as dislocation forward of both bones of the forearm, *shortening* can always be found if the measurement is made on the proper side and with the limb in a suitable attitude. The proper side is the one away from which the head of the bone has been dislocated; the suitable attitude is the one in which the limb is inclined toward this side. Thus, at the shoulder the measurement should be made from the tip of the acromion to the external condyle of the humerus, and the arm should be in abduction. Fig. 168 illustrates the sources of error and contradiction. *A* represents an anterior dislocation of the right shoulder seen from in front; *A'*, the same shoulder with the bones in place. Measured in abduction, *B C* is shorter than *B' C'* or *B D* or *B' D'*; measured with the arm alongside the chest, *B D* is as long as, perhaps longer than, *B' D'*.

FIG. 168.



Diagrams to show the effect of attitude upon the measured length of the arm (*A*) in dislocation of the right shoulder, and (*A'*) when the bones are in normal position; *B*, *B'*, the acromion (original).

In typical dislocations, those in which certain ligaments and portions of the capsule remain untorn, the *attitude* of the limb is characteristic, because of the limitation of movement imposed by the untorn bands: thus in the common anterior dislocation of the shoulder the elbow is held away from the side; in the common dorsal dislocation of the hip the thigh is flexed and adducted.

As the consequence of this opposition of the untorn ligaments, the *normal range of motion* is restricted in certain directions while it is unaffected in others. In the hinge joints the normal range of motion is restricted and abnormal lateral mobility exists. The statement is frequently made that mobility is increased in fracture and diminished in dislocation. In that form the statement is entirely misleading: ordinarily the mobility that is found in fracture is wholly abnormal and exists between two parts of the same bone; the mobility whose absence or restriction is noted in dislocation is mobility between two separate bones. Normal mobility may be restricted, both in fractures and in dislocations, by the opposition of the muscles aroused by fear of pain. In dislocation of the elbow backward abnormal lateral mobility exists, just as it does in fracture of the lower end of the humerus.

The production of the dislocation is usually accompanied by severe *pain*, which may persist for some time or may promptly give place to a feeling of soreness, with pain when the member is moved or the region handled. Persistence of severe pain appears to indicate that some of the soft parts are not torn, but are kept forcibly stretched.

Treatment.—As a rule, a recent dislocation should be *reduced* at the earliest practicable moment. The conditions which may make delay advisable are great inflammatory reaction and swelling and great shock, due usually to

associated injuries, which may contraindicate the infliction of pain or the use of anesthetics.

The choice of a suitable **method of reduction** depends upon the recognition of the obstacles to reduction. In most cases these are of two kinds: the contraction of the muscles, excited by pain or the fear of pain, and the resistance offered by untorn ligaments or portions of the capsule to movements of the limb in certain directions. Other obstacles are the interposition of a portion of the capsule, common in certain dislocations (*e. g.* the metacarpo-phalangeal), but rare in others, and unusual relations to certain adjoining muscles created by a wide movement of the dislocated bone.

In "typical" dislocations, those in which the limb assumes and retains a characteristic attitude, which has been shown to be due to the action of untorn ligaments or portions of the capsule in resisting movement in certain directions, it is essential that the limb should be placed in a position and moved only in a direction in which the opposition of these untorn structures will not be encountered. Fig. 169 shows diagrammatically the position (*A*) in which the ligament (*L*) opposes and that (*B*) in which it permits the movement of the limb in the direction indicated by the arrow, and by which the head would be restored to its socket (*S*). In "atypical" dislocations the laceration of the ligaments and capsule is so extensive that they offer little or no opposition to movement in any direction. In the typical forms, therefore, certain well-defined manipulations are needed whether anesthesia is or is not employed to remove the opposition of the muscles; in the atypical forms reduction is usually very easy by moderate traction and coaptation, without special attention to the attitude of the limb during the manipulation.

Fig. 169.

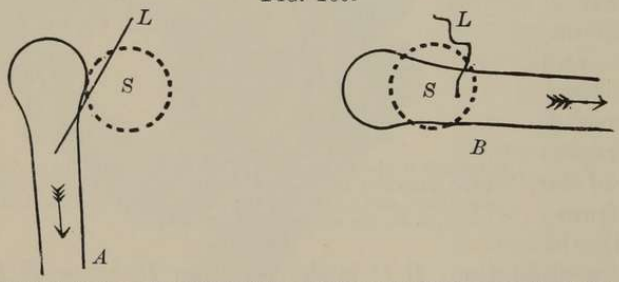


Diagram to show the effect of the position of a limb upon the tension of a ligament (original).

Reduction by manipulation is a term applied to a succession of gentle movements communicated to the dislocated limb by which the sides of the rent in the capsule are separated from each other and the head of the bone is rolled back into place by the aid of the untorn ligaments. The method is applicable only to typical dislocations, and the best-known examples are Kocher's method for the reduction of anterior dislocations of the shoulder, and Bigelow's for that of dorsal dislocations of the hip, the details and mechanism of which will be described in the appropriate places.

The opposition of the muscles, by which is meant a persistent contraction of those attached to the dislocated bone which prevents its movement toward its socket, may be annulled by **anesthesia**, or overcome by forcible or persistent traction, or avoided by momentarily distracting the patient's attention. The use of anesthetics has made the reduction of most dislocations very easy. It should be pushed to the point of complete muscular relaxation: this is sometimes obtained during the short period of primary anesthesia which usually precedes by some minutes the condition of complete anesthesia, and in the simpler cases reduction may be then obtained; but if the manipulations are likely to be at all prolonged, or if the patient is feeble or diseased or suffering

from shock, it is safer to wait for complete general anesthesia. The proportion of cases in which death has followed the use of an anesthetic in the reduction of dislocations is exceptionally large, and seems probably to be due to its timid and insufficient use; the anesthesia not being complete, the reduction causes dangerous shock by pain. Such, at least, appears to be the explanation of the disproportionate fatality of minor but painful operations under an anesthetic. Ether is safer than chloroform for the purpose.

The use of **pulleys,** which formerly was general, is now rare in the reduction of recent dislocations, having been replaced by anesthetics or by the prolonged application of moderate traction, the muscles yielding gradually to fatigue. This gradual traction can be made by a weight and pulley or by india-rubber, or, in some cases, by the weight of the dependent limb in a suitable position. Even without anesthesia, if the attention of the patient be diverted the muscles will sometimes be seen to relax, and then by a sudden sharp blow the bone may be replaced.

In cases in which reduction is prevented by the **interposition of the capsule,** as at the metacarpo-phalangeal joint, or of a muscle or tendon, as occasionally at other joints, an open arthrotomy may be necessary. Under the protection of antiseptics this operation is reasonably safe, but the risk appears to be least, in the case of the larger joints, if it is done while the injury is fresh, on the first or second day, or, failing this, if it is postponed to a much later period, after the reaction has subsided and the extravasated blood has been reabsorbed, about the third or fourth week.

In **old dislocations** the manipulations used in recent ones will sometimes succeed after the adhesions that bind the dislocated bone in its new position have been ruptured by forcible movements of the limb, but usually strong traction is also required to draw the bone to its place. Interference in such cases is unavoidably blind and uncertain; more extensive lacerations are necessary to free the bone than those occasioned by the original dislocation, and the changed relations of important vessels and nerves are such, and their fixation by cicatricial tissue is so firm, that serious injury may be done. It seems much safer, therefore, in many cases to resort to a cutting operation if the attempt is to be made to restore the bone to its place. Furthermore, the structural changes, are occasionally so great that even if the dislocation is reduced the condition of the joint will fall far short of the normal, and the limb, in such cases, will be no more useful than while the dislocation existed. Hence in some instances it is as well to let the dislocated bone remain unreduced.

The **accidents** that may follow attempts at reduction are numerous and varied. The skin may be torn by excessive and improperly applied traction, the bone may be broken, vessels and nerves may be ruptured, suppuration may be excited, and death may follow through the agency of the anesthetic or the shock of the manipulations.

Fracture of the bone may occur, and may involve the shaft, the neck, or the bony prominences, the fracture of the olecranon in old backward dislocations of the elbow being the commonest example of the latter. It has been noted that the bones of a dislocated limb sometimes show exceptional fragility, apparently the result of interstitial changes provoked by disuse or altered conditions of nutrition consequent upon the primary injury.

Injuries of vessels are most frequent and important in the common forms of anterior dislocation of the shoulder, and of these the commonest appears to be the rupture of the subscapular or circumflex artery or its avulsion from the axillary. The axillary artery itself has been torn completely across, or its inner and middle coats ruptured; the axillary vein has rarely been injured.

Rupture of an artery at the shoulder is followed by rapid extravasation of blood in the axilla; pulsation at the wrist may persist. The condition is a grave one: of 47 cases 31 ended fatally (Stimson). Methods of treatment that have proved successful are digital pressure, ligature of the subclavian, and disarticulation at the shoulder. Double ligature at the point of injury has been uniformly fatal.

Injuries to main nerves are more rare: the roots of the brachial plexus have been torn out in reducing a dislocation of the shoulder; in some cases paralysis of the limb has followed reduction.

Syncope and sudden death have also followed reduction in a very few cases: in some of them it was probably due to rupture of a vessel or of large nerves; in one case fat embolism of the lungs was found.

After-treatment.—After reduction of a dislocation no other treatment is usually required than immobilization of the limb for a few days in a suitable position, and the subsequent avoidance for a few weeks of attitudes which would favor recurrence. In dislocations of some joints (clavicle), and in certain forms of dislocations of others, the tendency to recurrence is so great that special measures are requisite to prevent it. Passive motion if made at all should be kept within a painless range.

The condition of **habitual dislocation** can hardly be relieved except by operation.

CONGENITAL DISLOCATIONS.

Under this term are included certain dislocations which do not appear or are not recognizable until after the lapse of some months or years, but the causes of which—faulty development of the joint, paralysis, etc.—are supposed to have existed at birth. From it are excluded those traumatic dislocations which are produced *in utero* or during delivery.

Congenital dislocations of the hip (Fig. 170) are by far the most frequent, about 90 per cent. of all; they are much more common in females than in males, the proportion, according to different statistics, varying from 60 to 90 per cent. One or both joints may be involved. The typical congenital dislocation of the hip is due to a defective development of the acetabulum as carried on by the Y cartilage, which permits the head of the femur to pass, under the influence of the weight of the body or of the contraction of the muscles, upon the dorsum of the ilium. Exceptional cases in which it passes upon the pubes or into the obturator foramen have occurred, but they are very rare. Usually the head of the femur is smaller than normal and the neck short. As the child begins to walk, the changes increase, the displacement is finally arrested, and compensatory changes in the attitude of the pelvis and spine appear, the upper part of the pelvis being tilted forward, and the lumbar spine showing a marked curvature forward. If only one hip is involved, the child limps in walking; if both are involved, there is no limp, but the attitude of the body and the gait are peculiar. The tilting of the pelvis disappears when the child is recumbent or when the thighs are flexed; the shortening of the thighs can sometimes be overcome by traction.

Of the reduction of such a dislocation, in the usual sense of the term, there can of course be no question, for the normal structure of the joint does not exist, and the most that can be attained is to diminish the deformity and functional disability. Much has been gained in some cases by traction continued for many months, by which the head of the femur has been drawn nearer the acetabulum and fixed there by condensation of the tissues about it, and perhaps by the growth of a new bony rim or socket on the ilium. Palliative

measures have also been usefully employed in the form of firm corsets of felt or leather which kept the pelvis from tilting. In some unilateral cases the affected limb has been kept fixed in abduction, so as to make it relatively longer in walking. Operative measures, usually the creation of a socket by chiseling, have of late been resorted to with a fair measure of success. For a description and discussion of the various methods and their results the reader is referred to papers by Bradford and Myers in the *Annals of Surgery*, August, 1894, and by Kirmisson in *Revue d'Orthopédie*, 1894, No. 3. The conclusions reached by Bradford are: (1) That the methods of treatment by traction or by mechanical means, with or without tenotomy, do not effect a cure; (2) that correction by forcible reduction without incision can be applicable in but few cases and is not reliable; (3) that operative reduction offers the best prospect of a cure. The method at present, however, involves risks and is not certain in its results, but it is to be expected that further experience will give greater precision and more certain results. The shortened condition of the Y-ligament forms an important obstacle to complete reduction, and these fibres should be thoroughly divided; this can be better done by incising them from in front than from behind.

FIG. 170.

Double Congenital Dislocation of the Hip (Stimson).

Among the rarer forms of dislocation of the hip found at birth or appearing shortly thereafter are those due to dropsy of the joint *in utero*, and those succeeding paralysis of one of the groups of muscles. In such cases a reduction may perhaps be effected, and the surgeon's efforts must then be directed to preventing its recurrence. Congenital dislocations at the *shoulder* appear also to be due to defective development of the glenoid fossa.

Among congenital dislocations of the *knee*, the most frequent is that in which the leg is in extreme hyperextension, the foot sometimes resting against the abdomen. They have usually been easily corrected.

SPONTANEOUS DISLOCATIONS.

Under this term are included those in which the dislocation occurs, usually without external violence, as the result of predisposing changes in the articular surfaces or in the ligaments or of the unopposed action of certain muscles, others being paralyzed. Those due to destruction of the bones are incidents of the diseases that produce the destruction, and will not be considered here. Those due to dropsical distention of the joint are of more importance, for they are capable of reduction and may easily escape notice at first. They occur in the course of the eruptive fevers, less frequently in that of the continued fevers (Keen) or of articular rheumatism, and are most common at the hip. The effusion in the joint makes the occurrence easy; the habitual attitude in bed, the patient's position, resting on his side with the thighs flexed and the upper one adducted, is also favorable, and the contraction of the muscles usually does the rest.

Paralytic or "*myopathic*" dislocations are most common at the shoulder.

The weight of the limb being unopposed by the scapular muscles, the head of the humerus sinks and is easily displaced forward or backward.

SPECIAL DISLOCATIONS.

DISLOCATIONS OF THE LOWER JAW.

These constitute about 4 per cent. of all dislocations, are more frequent in women than in men, and may be unilateral or bilateral. The displacement is forward, the condyle resting in front of the eminentia articularis at the root of the zygoma. This forward displacement is an exaggeration of the normal forward movement of the condyle in opening the mouth. The interarticular fibro-cartilage may accompany the condyle or may remain behind, its anterior attachment to the condyle being torn.

Dislocations *backward* are very exceptional, a few cases having been reported in which, by a blow upon the chin, one or both condyles have been driven backward, breaking through the anterior wall of the external auditory meatus. By a similar blow very rarely the condyle has been driven into the cranial cavity. In what follows only the forward dislocations are considered.

The usual cause of *forward* dislocation is the wide opening of the mouth, either voluntarily in laughing, yawning, or introducing some large object, or in manipulations about the mouth, as by a dentist. Fixation is due to the passage of the condyle in front of the line of the lateral ligaments, the attachments of which to the jaw are exceptionally low. The internal pterygoid and masseter aid in the fixation, partly by maintaining the elevation of the angle of the jaw and partly by opposing the backward movement that would aid reduction. The engagement of the coronoid process of the inferior maxilla in front of the malar bone, which has been alleged to be a cause of the fixation, rarely occurs, if ever.

The **symptoms** are inability to close the mouth, some projection of the lower jaw, and the presence of the condyle in advance of its normal position. In unilateral dislocation the chin is deviated to the opposite side and the interference with function is less.

Theoretically, the dislocation should be most easily **reduced** by opening the mouth more widely to relax the lateral ligaments, and then pressing the jaw backward; but the involuntary contraction of the muscles, unless the patient is anesthetized, will be a serious obstacle. A fairly successful method is by forcible pressure with the thumbs downward and backward upon the lower molar teeth. In bilateral dislocation it is sometimes easier to make reduction on each side separately.

The liability to frequent recurrence which sometimes ensues has been combated by opening the joint and suturing the meniscus to the periosteum at the margin of the articulation. The injection of tincture of iodine into the joint has also been proposed.

DISLOCATIONS OF THE STERNUM.

Dislocation of one of the normal segments of the sternum from another is a rare injury, and one not always to be distinguished clinically from a fracture. We describe dislocation of the body from the manubrium, and of the ensiform process from the body.

Dislocation of the Body from the Manubrium.—The lower border of the manubrium is on a line joining the sternal ends of the second costal cartilages, which articulate with both segments. Dislocations forward and

backward have been observed, the former being the more common. Forward dislocation has been caused by direct violence (a blow upon the sternum), by indirect violence (compression of the sides of the chest), by muscular action (the effort made in exercising on parallel bars), and possibly by forced dorsal flexion of the trunk. It may be complete or incomplete. In the complete form the lower fragment may override the upper one as much as an inch, the anterior fibro-periosteal envelope being torn and the posterior one being stripped from the second segment. The costal cartilages retain their attachments to the manubrium. Backward dislocations appear to have been caused only by direct violence received upon the second segment. Either form is frequently associated with dislocation or fracture of the ribs or of the costal cartilages.

The general **symptoms**, interference with respiration and circulation, may be very severe. The **diagnosis** is made by recognition of the change in the anterior aspect of the sternum and of the relations of the line of separation to the second costal cartilages. In forward dislocation the shallow depressions at the upper corners of the body for articulation with the second costal cartilages may be recognized. The well-known gravity of the injury appears to depend mainly on associated lesions.

Reduction is made by forcible dorsal flexion of the trunk and direct pressure on the projecting fragment. In one or two instances it has been aided by the coughing of the patient or by his making a deep inspiration. In some cases in which the dislocation has remained unreduced it has caused no disability.

Dislocations of the Ensiform Process are very rare; the apex may be directed either forward or backward. The most prominent symptom in some cases has been persistent vomiting, relieved by drawing the apex of the process forward with the fingers or with a sharp hook introduced through the skin.

DISLOCATIONS OF THE RIBS AND COSTAL CARTILAGES.

Dislocation of the Head of the Rib.—Nine cases, several of them verified by autopsy, have been reported, the head of the rib having been thrown forward by a blow upon the rib from behind. In one the head had been forced through the pleura into the lung.

Chondro-costal Separation.—A half-dozen examples of this injury are on record; the causes have been external violence and prolonged or violent coughing. The **treatment** is the same as that of fracture of the rib or cartilage.

Chondro-sternal and Chondro-chondral Dislocations.—A few cases of dislocation of the costal cartilages from the sternum or from each other have been reported, besides those associated with fracture or dislocation of the sternum. The causes have been external violence received upon the chest and muscular action exerted through the pectoralis major. Both forward and backward displacements have been observed; the former were easily reduced by pressure, but readily recurred.

DISLOCATIONS OF THE CLAVICLE.

The clavicle may be dislocated at either end or at both ends simultaneously.

Sternal End.—The joint possesses an intra-articular fibro-cartilage which has its strongest attachment above to the upper edge of the end of the clavicle, and below to the cartilage of the first rib. The clavicle may be dislocated forward, backward, or upward, in this order of frequency.

Dislocation forward appears to be most frequently caused by forcible movement of the shoulder downward and backward, in which the center of the clavicle comes to rest upon the first rib, and the inner end is thus thrown forward as the outer one is lowered and carried backward. In cases of habitual dislocation the bone slips out of place when the arm is raised beside the head or when the shoulder is thrown back as in putting on a coat. In a case reported by Stimson the liability to displacement was gradually developed in a youth of nineteen years, so that it occurred whenever the elbow was raised to the height of the shoulder, the bone returning to its place as the arm was lowered. The dislocation may be complete or incomplete: in the former the end of the bone rests upon the front of the sternum to the inner side of or below its normal position. Occasionally a piece is broken from the end of the clavicle or the edge of the articular surface of the sternum.

The **symptoms** consist in the marked projection and abnormal position of the end of the clavicle, with local pain, sinking of the shoulder downward and inward, and inability to use the arm.

Reduction is effected by drawing the shoulder backward and by suitable pressure on the end of the clavicle; and recurrence is prevented by immobilization of the shoulder. This is the difficult part of the treatment, and many plans have been tried, such as a figure-of-8 bandage about the two shoulders, the turns crossing on the back; prolonged rest in bed upon the back to avoid the influence of the weight of the arm in reproducing the displacement; moulded caps of leather or gutta-percha fitted to the end of the clavicle and held in place by straps about the chest; and direct pressure by a hernial truss the pad of which rests upon the end of the clavicle while the spring passes to the back under the axilla of the uninjured side.

The liability to recurrence may be extremely troublesome. In Stimson's case it was overcome by three injections of a dram of alcohol into the periarticular tissues at intervals of a fortnight, the arm being meanwhile confined to the side of the body. The same condition subsequently developed in the other clavicle of the same patient, and was cured by a single injection.

Dislocation backward may be caused by direct violence received upon the front of the inner end of the bone or by the forcing of the shoulder forward and inward; it may be complete or incomplete, and in the former case the displacement is also inward or inward and downward, so that the bone presses upon the trachea and œsophagus and causes dyspnea or dysphagia.

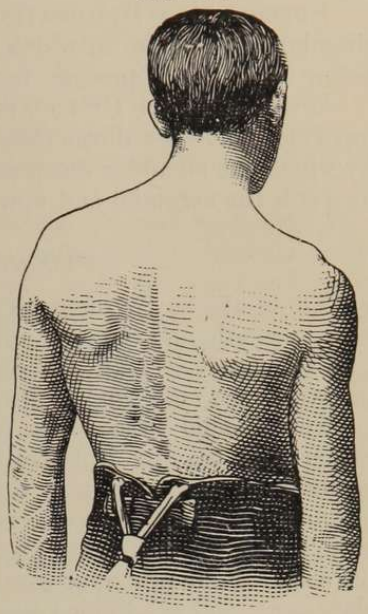
Symptoms.—The dislocation is to be recognized by the absence of the end of the bone from its normal position and its presence in its new position, which may be determined by palpation or by attention to the direction of the accessible portion of the bone. The shoulder hangs somewhat forward and inward.

Reduction is effected by drawing the shoulder outward and backward, and recurrence is prevented by maintenance of the shoulder in this position. In a number of cases in which the dislocation remained unreduced it was borne without inconvenience, but in one in which the displacement was subsequently increased by progressive distortion of the spine the interference with deglutition was such that it became necessary to excise the end of the bone.

Dislocation upward has been caused by the forcible depression of the shoulder: in a case reported by Stokes it was gradually produced on both sides, apparently by the action of the sterno-cleido-mastoids "in forced inspiratory efforts produced by great dyspnea due to ascites." The end of the bone is displaced inward as well as upward, passing behind the sternal head of the sterno-cleido-mastoid, and resting in the episternal notch. **Reduction** is made by drawing the shoulder outward and by direct pressure on the end of

the bone. Malgaigne's hooks, devised for the treatment of fracture of the patella, have been used to prevent recurrence, one being fixed in the clavicle, the other in the front of the sternum.

Fig. 171.



Upward Dislocation of Acromial End of Right Clavicle (original).

Acromial End.—The common dislocation is upward or upward and outward, so that the end of the clavicle overlaps the acromion (Fig. 171). Fracture of the edge of the articular surface of either bone may accompany the dislocation. The cause is usually a blow or fall upon the shoulder.

In the great majority of cases the end of the clavicle simply rises more or less above the level of the acromion without overriding it, and can be easily pressed down into place if the arm is at the same time pressed upward; but the displacement recurs as soon as the pressure is removed. The manipulation may be accompanied by crepitus if there has been fracture of the edge of the articulation, but the injury can be readily distinguished from a fracture of the outer part of the clavicle by attention to the relations of the projecting bone to the acromion and by comparative measurements of its length. If it overrides the acromion, the overriding can be overcome by drawing the shoulder outward.

Retention of the bone in place after reduction has presented so many difficulties that some have taught that it is not worth while to attempt it, especially since the persistence of the dislocation ordinarily causes no loss of function; but the method recommended by Stimson is so simple and efficient that it should always be tried (Fig. 172). A long strip of adhesive plaster three inches wide is placed with its center under the point of the flexed elbow and its ends carried up in front of and behind the arm, crossed over the end of the clavicle, and secured to the front and back of the chest respectively while the bone is held in place by pressure upon the clavicle and elbow. Recurrence can be readily detected through the plaster by the finger or the eye. For additional security the forearm should be supported in a sling and the arm bound to the chest.

Fig. 172.

Adhesive Plaster Dressing for Upward Dislocation of Acromial End of Clavicle (original).

Subacromial Dislocation.—A few cases have been reported in which the end of the clavicle was displaced downward and engaged under the acromion, the causes being respectively direct violence upon the upper surface of the outer end of the clav-

icle, a fall upon the shoulder, and muscular action while the arm was raised. Reduction was easily made by drawing the shoulder outward, and a tendency to recurrence was observed in only one case.

Subcoracoid Dislocation.—Two surgeons have reported cases of this singular dislocation, in which the clavicle is displaced forward and downward below the coracoid process, but the reports are viewed with some suspicion.

Simultaneous Dislocation of both Ends of the Clavicle has been reported in about a dozen cases, the cause usually having been extreme violence by which the shoulder was pressed inward; in all the sternal end was dislocated forward, the acromial end upward.

DISLOCATIONS OF THE SHOULDER.

These are as frequent as all other dislocations taken together; they are rare in youth and old age, and much more frequent in men than in women. The frequency is readily accounted for by the formation of the joint and by its exposure to external violence.

The glenoid fossa looks forward as well as outward, and the head of the humerus in leaving it laterally passes forward and inward or backward and outward; it may also pass downward or, in very rare cases, upward. The secondary displacements succeeding to these primary ones are numerous and varied, and are commonly produced by subsequent changes in the attitude of the arm. Four principal groups may be made according to the primary displacement, and subdivided according to the points at which the head of the bone comes to rest or according to other clinical features, as follows:

Anterior	Subcoracoid; very common. Intracoracoid; exceptional. Subclavicular.
Downward	Subglenoid; uncommon. Erecta; very rare. Subtricipital. (?)
Posterior	Subacromial; rare. Subspinous; very rare.
Upward	Supraglenoid; very rare.

In the anterior dislocations the displacement is also more or less downward (also of course inward), and in the downward ones it is usually also forward and inward, and consequently the two merge into each other without a sharp line of division; as the term is used here, the anterior include in the subcoracoid subdivision many of those known in the older terminology as subglenoid. The latter term is correspondingly restricted to include only those in which the head of the humerus lies very low.

ANTERIOR DISLOCATIONS.

These present two varieties, the *subcoracoid* and the *intracoracoid*, according to the distance to which the head of the humerus is displaced inward; an extreme form of the latter is sometimes called the *subclavicular*.

Subcoracoid.—In this, the commonest form, the head of the humerus lies beneath the coracoid process, in contact with it or at a variable distance, a finger-breadth at the most, below it. The extent of displacement inward also varies, from just sufficient to keep the head balanced on the anterior edge of the glen-

oid fossa to that in which three-fourths of the diameter of the head lies to the inner side of the coracoid process; greater displacements inward are termed *intracoracoid.*

The injury may be **caused** by direct violence, as a blow or fall upon the shoulder; indirect violence, as a fall upon the hand or the elbow; forcible abduction or outward rotation of the limb; or muscular action. Muscular action can produce a dislocation either by directly pulling the head out of its socket, as in convulsions, or, much more frequently, by imparting a sudden movement to the limb which creates conditions of leverage and impulsion similar to those of indirect violence.

The capsule is torn at its inner and lower portion, the rent extending for a greater or lesser distance along the margin of the glenoid fossa. Exceptionally, there may be no rent in the capsule. In "typical" cases the outer and upper portion of the capsule remains untorn and aids in determining the attitude of the limb and the limitation of its movements. The subscapularis muscle may be pushed inward or torn for a variable distance upward from its lower margin. The interposition of its untorn portion between the head of the humerus and the coracoid process accounts for the interval between these bones observed in some cases. The supraspinatus may be ruptured or torn from the humerus; also, but less frequently, the infraspinatus, and rarely the teres minor. Avulsion of a portion of the greater tuberosity may take the place of this rupture. The head of the humerus may rest against the edge of the glenoid fossa or farther inward against the side of the neck of the scapula; its articular surface is occasionally bruised by impact against the edge of the fossa. The tendon of the long head of the biceps is occasionally torn from its attachment, and when the greater tuberosity has been broken off it may slip to the outer side of the head.

Symptoms.—The elbow hangs a little away from the side, the outer aspect of the deltoid is flattened, and the anterior and outer fulness of the shoulder is lost (Fig. 173). Viewing the arm from in front, the axis of the humerus is seen to pass to the inner side of the glenoid fossa, and the anterior fold of the axilla is lowered. On palpation the normal bony resistance below the front and outer side of the acromion is absent, and an abnormal one is found below the coracoid process which shares in slight rotatory movements communicated to the arm. In the higher forms the head can be felt only indistinctly, if at all, in the axilla. Voluntary movements are usually lost; passively, the arm can be easily abducted, but cannot be so far adducted as to bring the hand upon the opposite shoulder and the elbow to the front of the chest. Measurement from the acromion to the elbow while the arm is abducted shows the distance to be less than on the opposite side with the arm in the same position.

FIG. 173.

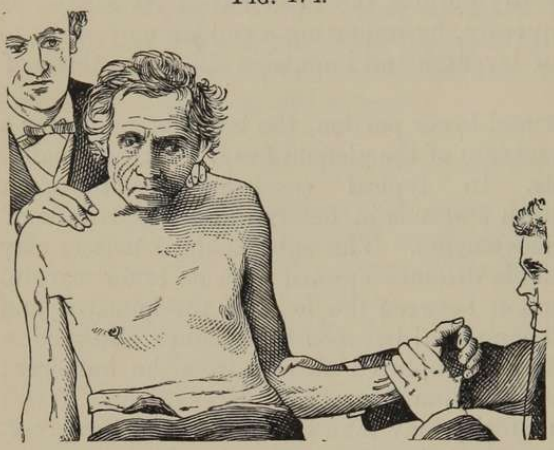
Subcoracoid Dislocation of the Left Shoulder (original).

In making a **diagnosis** every effort should be used to determine the position of the head of the bone and its continuity with the shaft. In very fat patients this may be difficult or even impossible without the aid of an

anesthetic. Where there is associated fracture of the anatomical neck, a rare complication, the only means of diagnosis if the patient is fat may be the shortening of the abducted limb.

In *intracoracoid* dislocation the head of the humerus is displaced farther inward, either by the prolonged action of the dislocating violence or, more commonly, by a greater primary displacement downward by which the subscapularis is widely torn, and then on lowering the elbow the head of the humerus passes upward and inward. The rent in the capsule is correspondingly greater. In a case reported by Stimson the head of the humerus had passed below and to the inner side of the untorn subscapularis, the tendon of which thus formed an insuperable obstacle to reduction and made arthrotomy necessary.

Fig. 174.



Kocher's Method of Reduction by Manipulation. First movement, outward rotation (Ceppi).

The **symptoms** are similar to those of the subcoracoid form; the elbow is more widely abducted, the deltoid more flattened, the head of the humerus easily recognizable in the subclavicular fossa. Occasionally the arm is fixed in complete horizontal abduction.

Treatment.—Reduction is usually easy, but occasionally, as in the case just mentioned, may be impossible except by operation.

Fig. 175.

Kocher's Method of Reduction. Second movement, elevation of elbow (Ceppi).

Fig. 176.

Kocher's Method of Reduction. Third movement, inward rotation and lowering of elbow (Ceppi).

Kocher's method is very successful in the higher forms of subcoracoid dislocation, but frequently fails in the lower and in the intracoracoid. It may be employed with or without the aid of anesthesia. The elbow is flexed at a right angle and pressed closely against the side; then the forearm is turned as far as

possible away from the trunk (external rotation of the arm) (Fig. 174). Unless the head of the humerus rolls outward in front of and below the acromion during this movement, the attempt will fail. Then, while the external rotation is maintained, the elbow is carried well forward and upward (Fig. 175), the arm rotated inward, and the elbow lowered (Fig. 176). Sometimes it is useful to have an assistant press the head outward with his fingers or by a band in the axilla during the later steps.

Traction outward is also a very useful method, although it involves a certain degree of risk to the axillary vessels, especially in the aged. The patient is laid on his back on the floor, and the surgeon, seated beside him, placing one foot against his chest, seizes the arm at the elbow, and draws it steadily outward in full abduction. If this does not bring the bone into place, an assistant may press its head upward with his fingers, his thumbs resting on the acromion. Or, the patient lying on the bed, the surgeon makes traction on the arm for a few moments, and then, while maintaining the traction with one hand, swings the arm toward the side over his closed fist in the axilla. This is similar in action to the old method of the unbooted heel in the axilla, but is less dangerous.

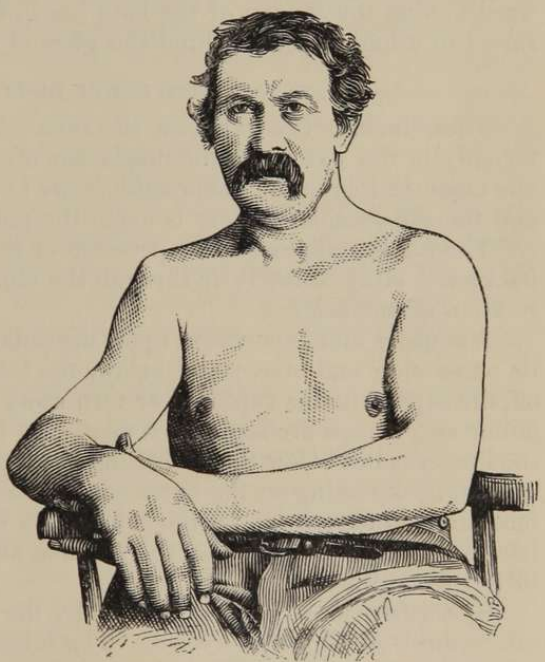
Occasionally reduction can be made by *taking the patient unawares.* He is made to stand up, and the surgeon, standing beside him, holds his wrist, with the elbow flexed at a right angle, and gently moves the arm and engages him in conversation. Little by little the deltoid is seen to relax, and then a smart blow downward upon the fold of the elbow with quick external rotation of the arm will effect reduction in a considerable proportion of cases (Cole).

In intracoracoid dislocations traction outward should be used.

In older cases forcible rotation is needed to break up adhesions, after which Kocher's method may succeed or forcible traction may be required.

The cases in which complete reduction is prevented by the interposition of a portion of the capsule or of a tendon are very rare.

FIG. 177.



Subglenoid Dislocation (Stimson).

DOWNWARD DISLOCATIONS.

This class includes those rare ones in which the head of the humerus rests below the glenoid fossa on the tendon of the long head of the triceps, and those more common ones in which it lies somewhat higher and to the inner side under the lower and anterior edge of the glenoid fossa. The name by which they are commonly known is *subglenoid.* The class also includes a rare form, the *luxatio erecta*, and a doubtful one, the *subtricipital.*

The **cause** is forcible abduction of the arm, by which the capsule is torn

at its lower part, followed by rotation or impulsion which engages the head beyond the edge of the fossa. The lower part of the tendon of the subscapularis may be torn, and the greater tuberosity appears habitually to be in part broken off by the traction of its attached muscles.

The **symptoms** are similar to those of subcoracoid dislocation, but more marked. The elbow is abducted, the shoulder flattened, the acromion prominent, and the head of the humerus can be readily felt in the axilla (Fig. 177).

Treatment.—Theoretically, the best method of reduction would be to raise the elbow as far as possible and then to make traction, but as this involves some risk to the axillary vessels it is better to use an anesthetic and reduce by traction in moderate abduction, with direct pressure upward and outward upon the head of the humerus.

Luxatio Erecta.—In this rare form the arm is held vertically, the forearm resting on the top of the head and held there by the patient to escape the pain caused by lowering it. In the half-dozen cases reported the cause appears to have been forcible elevation of the arm. Reduction was easily made by traction upward without changing the attitude of the limb until after the head had been drawn into its socket.

Subtricipital Dislocation.—Of this only a single case has been reported. The head of the humerus was thought to have passed, after dislocation downward, backward behind the tendon of the long head of the triceps, and then to have been raised to a higher level behind the glenoid fossa by the lowering of the elbow.

POSTERIOR DISLOCATIONS.

These include two varieties, the *subacromial* and the *subspinous*, which differ only in the extent of the displacement. Some English writers make only one class and give the name *subspinous* to all. The dislocation is infrequent, and the subacromial variety is much the more frequent of the two.

The **cause** appears to be pressure of the head of the humerus outward and backward, either directly or through the elbow, aided by adduction and internal rotation of the arm.

Autopsies and experiment upon the cadaver show that the capsule is torn on its outer side and above and below, the lesser tuberosity is sometimes broken off, the supraspinatus ruptured or torn away with its facet of insertion, the teres minor and triceps are sometimes torn. In the subacromial variety the head of the humerus lies below the projecting outer portion of the acromion, with its anatomical neck resting on the outer edge of the glenoid fossa and its articular surface directed outward. In the subspinous variety the head is displaced farther backward below the spine of the scapula, and perhaps separated from it by the interposed infraspinatus.

Symptoms.—The arm hangs by the side in inward rotation, with the elbow directed slightly forward. The fulness of the shoulder is lost in front and increased behind. The absence of the head of the humerus in front and its presence behind can be recognized by palpation; the coracoid and the anterior part of the acromion are abnormally prominent. Voluntary movement is lost, passive motion restricted and painful.

Treatment.—Reduction appears to be easy in both recent and old cases by traction forward upon the arm or by direct pressure forward upon the head of the humerus, but recurrence is frequent, presumably because of the loss of the support of the subscapularis. When the dislocation has remained unreduced the disability has been greater than is usual in anterior dislocations.

UPWARD DISLOCATIONS.

The possibility of the occurrence of this very rare form has been proved by a few clinical cases and two autopsies. Among the causes were a fall upon the elbow, a blow downward upon the acromion while the arm was raised, and an epileptic convulsion. In one case certainly, and possibly in two others, the coracoid process was broken.

The head of the humerus lies in the interval between the acromion and the coracoid, closely in front of the clavicle and usually above its level. The arm hangs by the side, the elbow directed somewhat backward. Active and passive movements are greatly restricted (Fig. 178).

Reduction was effected in three cases by traction, and by elevation of the elbow in one, but the dislocation at once recurred in the latter. In three old cases reduction failed.

FIG. 178.

Supracoracoid Dislocation (Albert).

COMPLICATIONS OF DISLOCATION OF THE SHOULDER.

Compound dislocations are very rare, and are usually caused by extreme violence, which is associated with extensive laceration of the soft parts in the neighborhood of the dislocation, and inflicts other, and perhaps fatal, injuries at the same time. The wound in the skin is commonly in the axilla. The gravity of the condition arises either from associated injury done to the arteries of the axilla or from the extent of the laceration of the soft parts and the probability of suppuration. Infection is likely to take place before treatment can be begun, the extravasated blood favors its rapid spread, and the extent and irregularity of the laceration make subsequent cleansing almost impossible. Nevertheless, some very satisfactory recoveries have been reported. The **treatment** calls for the thorough antiseptic cleansing of the parts, the reduction of the dislocation, renewed cleansing, and thorough drainage of the cavity of the joint. Probably in most cases it would be best not to close the wound in the skin, but instead to pack rather deeply with the iodoform gauze for a few days. Excision of the head of the humerus may be advisable to favor drainage and oppose ankylosis.

Fractures.—These may involve any of the prominences of the humerus or scapula or the anatomical or the surgical neck of the humerus. The upper part of the greater tuberosity is sometimes, perhaps frequently, torn off by traction through its attached muscles in anterior dislocation; the periosteal attachments may persist and the displacement consequently be slight, or the piece may be entirely detached, and may even lodge in the glenoid fossa and constitute a serious obstacle to reduction. The fracture may be recognized by localized pain and crepitus and by loss or diminution of voluntary outward rotation.

The *lesser tuberosity* has been found broken off only in backward dislocation by traction through the attached subscapularis. The acromion has been broken by a blow upon it from above, which, continuing, has then dislocated the humerus downward and forward.

The *coracoid process* has been rarely broken; once certainly in connection with supracoracoid dislocation. The *glenoid fossa* is probably often broken at its edge, and the fragment may be large enough to interfere seriously with the maintenance of the humerus in its socket.

Fracture of the Anatomical or of the Surgical Neck of the Humerus.—The former is a much rarer complication than the latter: it appears to be caused after the head has left its socket by impact against the anterior edge of the glenoid fossa, which acts like a wedge along the anatomical neck and splits off the head.

It is difficult of recognition. The diagnostic points are the recognition of the head in its abnormal position beneath the coracoid process and its failure to move with the shaft, the normal or nearly normal position of the greater tuberosity, the direction of the axis of the humerus toward the glenoid fossa, and the absence of the limitation of passive movements peculiar to dislocations. Possibly crepitus may be obtained.

In fracture of the surgical neck the recognition of the dislocation is easier, because the greater tuberosity remains out of place together with the head; there is the same absence of characteristic limitation of motion and the same normal direction of the axis of the humerus; the tuberosity fails to move with the shaft, and crepitus is almost certainly to be felt.

The small almost hemispherical head may sometimes, after fracture of the anatomical neck, be pressed back into place with the fingers, and may even resume its proper relations to the shaft and reunite with it. In dislocation with fracture of the surgical neck the dislocation may sometimes be reduced under an anesthetic by direct pressure upon the head and traction on the arm. McBurney effected reduction in one case by cutting down through the deltoid upon the lower end of the upper fragment, drilling a hole in it, and inserting into this hole a strong right-angled hook, by means of which he made forcible traction and rotation upon the fragment. This failing, the choice lies between attempting reduction after the fracture has been united or establishing a false joint at the seat of fracture.

Injuries to the Blood-vessels and Nerves.—The axillary artery or one of its branches, especially the circumflex and subscapular, may be ruptured in a dislocation, but of the reported cases of such injury the majority appear to have been caused by attempts to reduce. The accident is to be recognized by the rapid extravasation of blood into the axilla and down the arm and over the chest. The radial pulse may persist, for the injury is more frequently of an arterial branch than of the artery itself. The pressure of the extravasated blood seriously interferes with the circulation, and operative interference may be required because of the persistent hemorrhage or because of the imminence of gangrene. The various methods of treatment have been pressure, ligature of the subclavian or of the axillary artery, and disarticulation at the shoulder. The resultant rate of mortality is high.

The posterior branch of the circumflex nerve appears very frequently to be bruised or stretched, with consequent temporary, or possibly permanent, loss of sensibility in the skin covering the deltoid, and of voluntary control of the deltoid muscle. It is well, before attempting reduction, to test the sensibility of the skin in the indicated region, in order that the loss of power in the deltoid when subsequently recognized shall not be wrongly attributed to the means employed in reduction.

The **after-treatment** rarely calls for more than immobilization of the joint for a fortnight and the avoidance of abduction for a week or two longer.

The **prognosis** is good in respect both of reduction and of complete restoration of function. The cases in which an uncomplicated dislocation cannot be reduced are extremely rare. The subsequent usefulness of the limb may, however, be impaired by persistent stiffness and tenderness, especially in the old and rheumatic, by paralysis of the deltoid, or by a liability to recurrence.

When the dislocation remains unreduced the arm is ordinarily fairly useful, the lost mobility of the joint being compensated for in part by increased mobility of the scapula, but occasionally it happens that the pressure of the displaced head causes so much pain or the immobility is so marked that an operation is called for to relieve it.

Treatment of Old Unreduced Dislocations.—If the dislocation cannot be reduced by the usual methods after freely breaking the adhesions by forcible rotation and traction, the surgeon has his choice between reduction by open arthrotomy and excision of the head of the humerus. The former has furnished a few good results, but it has more often proved impossible to make reduction or the usefulness of the limb has not been increased. The method of open arthrotomy is by an anterior incision. Excision of the head, through an anterior incision or through one in the axilla, relieves pressure and gives a movable joint; but, as the division of the bone is made below the tuberosities, active rotation is lost. Subcutaneous division and also open division of the periarticular tissues have been employed a few times successfully, as has also intentional fracture of the surgical neck to improve the position or to create a false joint.

Habitual dislocation, that is, the liability to recurrence of the dislocation on certain movements of the arm, has been successfully relieved in two cases by Ricard by an operation which consisted in exposing the front of the joint by an incision along the line between the deltoid and pectoralis magnus, and a second one running from the upper end of the first outward along the margin of the acromion; through this the anterior portion of the deltoid is detached and turned back. Then without opening the joint the lengthened and thinned portion of the capsule on the inner side is pinched up in a transverse fold, which is made permanent by two or three vertical silk sutures which include part of the tendon of the subscapularis below and the unchanged thick upper portion of the capsule above.

DISLOCATIONS OF THE ELBOW.

These are second in order of frequency, and are much more common in persons under twenty-five years of age than in others. They present a great variety of forms, for the radius and ulna may be displaced together backward, forward, inward, or outward, or the two bones may be displaced each in a different direction, or either may be dislocated alone, the other remaining in place. The following table is taken from Stimson:

- **Dislocations of the forearm (both bones) on the arm.**
  1. Dislocations backward:
     - Backward and outward.
     - Backward and inward.
  2. Lateral dislocations:
     - Incomplete { inward. / outward.
     - Complete outward.
  3. Forward dislocations:
     - Incomplete, or first degree.
     - Complete, or second degree.
     - With fracture of the olecranon.
  4. Divergent dislocations:
     - Antero-posterior.
     - Transverse.
- **Dislocations of the ulna alone . . . .**
  1, 2. Backward and upward. { 1. Incomplete, or first degree. / 2. Complete, or second degree.
  3. Backward and outward, behind the radius.
- **Dislocations of the radius alone . . . .**
  1. Backward.
  2. Outward.
  3. Forward.
  4. By elongation, or the subluxation of children.
  5. Associated with fracture of the ulna.
- **Congenital and pathological dislocations.**

Dislocation of both Bones Backward.—This is the most common of the dislocations at the elbow: two varieties, showing additional displacement inward or outward, are noted, but the variation from the displacement directly backward has no practical importance (Fig. 179).

The **cause** is usually a fall upon the outstretched hand, and the mechanism in such cases is either hyper-extension of the elbow, with the formation of an angle opening backward, or an increase of the normal outward deviation of the forearm, followed by a twist which brings the coronoid process below and then behind the humerus. The theory of dislocation by hyper-extension finds some additional support in the apparent relation between the frequency of the injury in children and the fact that in most young people the limb can be easily extended beyond the straight line. In either case, as experiment shows, the internal lateral ligament is torn, and the external one is either ruptured or torn away from the bone, perhaps retaining its connection with the periosteum, which is stripped off the back of the external condyle as the head of the radius passes backward. The capsule is torn in front, the internal epicondyle (epitrochlea) is sometimes broken off, apparently by traction exerted through the flexor muscles attached to it, and sometimes instead of this the muscular attachments are ruptured. The coronoid process is occasionally broken, as may also be a portion of the head of the radius, the cause in each case being pressure against the condyle; both fractures are rare complications, and probably occur only in cases in which the dislocation is caused by great violence while the joint is in partial flexion.

Fig. 179.

Dislocation of the Elbow Backward (Stimson).

Symptoms.—The elbow is partly flexed; the region is swollen; if the thumb and middle finger are placed on the internal and external epicondyles, and the forefinger on the olecranon, the displacement of the latter is readily recognized, and then if the head of the radius is sought for it will be found behind the external condyle as a bony prominence which rotates when the hand is pronated and supinated. Passive flexion and extension are possible within a narrow range, and in full extension abnormal lateral mobility can be recognized. If the swelling is not too great, the tendon of the triceps can be felt or seen curving backward to the olecranon when the joint is flexed. The trochlear prominence of the humerus is sometimes recognizable in the flexure of the elbow, and may be very prominent.

Treatment.—Reduction in recent cases is generally very easy, especially if the opposition of the muscles is overcome by anesthesia; it is then usually possible to slip the bones into place by pressure upon their projecting ends or by traction at the wrist. A plan that is often remarkably easy and successful without anesthesia is that in which the elbow is slightly over-extended and the bones then drawn into place by traction upon the forearm. There are cases in which the dislocation can be thus reduced and reproduced at will with the greatest ease and without causing any pain. The method by forcible flexion of the elbow about the surgeon's knee placed in the fold of the joint, while at the same time the forearm is forcibly pressed away from the arm by the knee, has been in use for centuries, and is generally successful, although theoretically

faulty. It is likely to fail whenever one or the other lateral ligament is insufficiently torn. If sufficient time has passed to have permitted the formation of strong adhesions, they must first be broken by forcible flexion, and by this manipulation it may happen that the olecranon process will be broken.

Compound dislocations are to be treated according to the principles governing in such injuries, and they often yield very satisfactory results. The choice lies between excision of the end of the humerus and reduction with ample provision for drainage. The former may be expected to give a movable but comparatively weak joint; the latter carries the greater chance of dangerous suppuration with ultimate ankylosis and a strong but stiff limb.

The *after-treatment* calls only for immobilization of the limb for about three weeks. Passive motion to prevent ankylosis is not required, and is likely to do harm; the stiffness that exists when the arm is removed from its dressings will gradually disappear under the natural use of the limb. Massage and hot and cold douches can be used with advantage at an earlier date. In children there is the chance that the irritation of the injury, and especially the stripping up of the periosteum from the humerus, may result in an abnormal production of bone that will mechanically limit the mobility of the joint; but passive motion will not prevent this result.

Lateral Dislocations of the Elbow.—The radius and ulna may be together dislocated incompletely to either side, or completely to the outer side, the coronoid process generally remaining anterior to the humerus. It would appear from the observations of some surgeons that incomplete dislocations, especially to the inner side, are tolerably frequent and often pass unrecognized, being mistaken for backward dislocation or for fracture of the humerus.

The *cause* is usually a fall upon the outstretched hand, and the mechanism appears to be an exaggeration of the outward angle of the elbow, by which the internal lateral ligament is torn and the ulna moved directly downward away from the trochlea, the radius and capitellum remaining in contact by their edges; a gliding lateral movement follows, by which the forearm is moved either inward or outward to produce one or the other form.

Incomplete Inward Dislocation.—The sigmoid cavity of the olecranon lies below and embraces the internal epicondyle, and the radius lies in front of and somewhat below the trochlea, the sharp inner edge of the latter being interposed between it and the coronoid process. Both lateral ligaments are torn.

The forearm is pronated and slightly flexed; its axis is parallel to and a little to the inner side of that of the arm. The olecranon and external condyle are prominent, the internal epicondyle masked, the head of the radius to be felt below and to the inner side of its normal position. Flexion and extension appear to be easy and not very painful.

Reduction is made by traction upon the extended forearm and direct lateral pressure at the elbow. In cases that have remained unreduced the usefulness of the limb appears not to have been much impaired.

Incomplete Outward Dislocation.—The radius and ulna are displaced outwardly so far that at least the central longitudinal ridge of the sigmoid cavity of the olecranon has passed beyond the outer rim of the trochlea; the radius lies partly below or entirely beyond the external condyle. Both lateral ligaments are torn, and in a considerable proportion of cases the epitrochlea is broken off, and even displaced so far downward and outward that it lodges in the groove of the trochlea. The elbow is more or less flexed, and the forearm pronated and either parallel to the arm and somewhat external to it or abducted. The internal condyle is prominent and the skin tightly stretched over it; the external condyle is masked by the projection of the

head of the radius. The olecranon is prominent, and the tendon of the triceps curves sharply backward and outward to it; the head of the radius can be easily felt (Fig. 180).

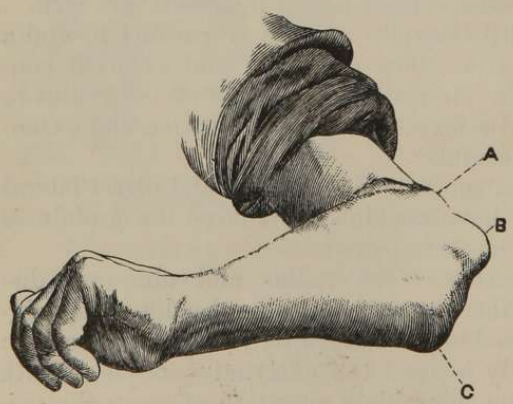
The first indication for **treatment** is to disengage the ridge of the sigmoid fossa from the groove between the trochlea and capitellum, which may be done by traction, or by hyper-extension, or by abduction of the extended forearm if the radius still rests against the external condyle so as to furnish a fulcrum; then the bones must be pushed laterally into place by pressure upon the head of the radius. If the broken epitrochlea is lodged in the groove of the trochlea, it may seriously oppose reduction, and in some cases it has prevented it.

FIG. 180.

Outward (Supra-epicondylar) Dislocation of the Elbow (original).

COMPLETE OUTWARD DISLOCATION.—There are three varieties, according to the extent of the displacement. In the first the radius and ulna are moved directly outward so far that the inner edge of the sigmoid cavity of the olecranon lies against the outer surface of the external condyle, and the radius is still farther to the outer side or has been moved upward by pronation of the forearm. In the second (sometimes called subepicondylar) the forearm is flexed and rotated inward ninety degrees, so that the anterior surface of the ulna looks inward and its sigmoid cavity embraces the outer aspect of the external condyle, the radius lying above it and in front of the supracondylar ridge. In the third (supra-epicondylar) the bones are moved still farther up along the outer border of the humerus, and sometimes also backward so that the coronoid process and the head of the radius lie behind the supinator ridge (Fig. 181).

FIG. 181.



Complete Outward Dislocation of the Elbow: A, radius; B, olecranon; C, internal condyle (Hamilton).

The **cause** is a fall upon the hand or elbow or a blow upon the inner side of the forearm near the elbow.

The **diagnosis** is made by recognition of the prominent ends of the bones, the broadening of the elbow, and the direction of the bones of the forearm. In the first variety the elbow is more likely to be extended; in the two others it is flexed.

Reduction is usually easy because of the extensive laceration of the ligaments. In cases in which reduction has not been made the limb has been very useful and motion at the elbow free.

Forward Dislocation of the Elbow.—Of this rare injury twenty cases have been reported, seven of which were compound, and six of these seven were further complicated by fracture of the olecranon. In most of the cases the cause was violence received upon the back of the flexed elbow. When the olecranon is broken its tip remains in place, and the ulna and radius are displaced upward upon the anterior surface of the humerus. The cases not complicated by this fracture present two varieties or degrees: first, that in which the upper end of the olecranon rests against the under surface of the humerus; second, that in which it has passed to the anterior surface of the humerus: in the latter the triceps always appears to have been torn away from the olecranon. Reduction was made in all but one of the simple cases, and in that one the nature of the injury was not recognized and the limb was amputated. Of the seven compound cases, four suppurated; two of these came to amputation, and one recovered with a stiff joint.

Divergent Dislocation of the Radius and Ulna.—Of this two varieties have been observed: the *antero-posterior* (11 cases), in which the ulna passed up behind, and the radius in front of, the humerus; and the *transverse* (1 case), in which the olecranon lay behind the epitrochlea and the radius on the outer aspect of the external condyle. The cause in several of the cases appears to have been forcible abduction of the forearm, by which the internal lateral ligament was ruptured, followed by internal rotation of the forearm. In two cases reduction failed, and in one, only the ulna could be replaced.

Dislocation of the Ulna Alone.—This is very rare. The ulna is displaced backward and more or less outward behind the radius by internal rotation of the forearm upon the head of the radius as a center, and then carried upward far enough to engage the coronoid process behind the humerus by adduction of the forearm. The mode of production appears to be hyper-extension or abduction of the extended forearm until the internal lateral ligament ruptures, and then internal rotation (pronation) and adduction.

The forearm is usually in full extension and adducted; flexion is very painful, rotation free. The trochlea is prominent in front, and the olecranon is prominent behind; the head of the radius is in place.

Dislocations of the Radius Alone.—Four forms are recognized,—backward, outward, forward, and downward; but the character of the latter is still disputed.

Backward.—The head of the radius is displaced backward, and sometimes carried a little upward behind the humerus by abduction of the forearm or by the aid of an associated fracture of the ulna or rupture of the interosseous ligament, which permits the radius to move upward independently of the ulna. The mode of its production is not understood. The orbicular ligament has been found torn, and also the external ligament at its posterior part. Reduction has been easily effected in recent cases by direct pressure forward on the head of the radius, but in some instances the interposition of the orbicular ligament has prevented reduction.

Outward.—This form is very rare, and most of the reported cases were of long standing when reported; in some of them the inner portion of the head of the radius had been broken off. The diagnosis is made by the recognition of the head of the radius outside of its normal position and of the ulna in its proper place.

Forward.—This is more common than the two preceding forms, and a not infrequent accompaniment of fracture of the shaft of the ulna by a fall upon the hand. The head of the radius is displaced forward, and perhaps upward by abduction of the forearm or by a total movement of the radius in that

direction, so that it rests, when the elbow is flexed, against the anterior surface of the external condyle above its normal position. The orbicular ligament and outer portion of the anterior ligament are torn. The limb can be abducted; full extension and flexion to a right angle are possible; supination is limited. The head of the radius can be felt in the fold of the elbow in front of its normal position. Reduction has been sometimes easy, sometimes difficult or impossible. The best method of reduction appears to be adduction of the extended forearm, followed by direct pressure upon the head of the radius. In cases of fracture of the shaft of the ulna this dislocation should always be looked for.

Downward, or Dislocation by Elongation, or Subluxation of Young Children.—This, though of frequent occurrence, is observed almost exclusively by the family practitioner or the dispensary surgeon. The theory of its nature which is most widely held is that offered by Duverney in 1751—namely, a displacement of the head of the radius downward so far that it engages under the lower border of the orbicular ligament.

The clinical history is characteristic: a child, usually under three years of age, is pulled by the hand; it cries out with pain, and refuses to use the limb, which hangs by the side, partly flexed at the elbow and pronated. There is sensitiveness on pressure over the head of the radius, and a slight interval can sometimes be felt between the latter and the condyle. Passive motion is free in every direction except supination. On forcible supination a slight click is sometimes felt, and the child at once begins to use the arm.

Old Unreduced Dislocations.—The solidity of the adhesions that unite the displaced olecranon to the back of the humerus is such, and the production of new bone by the irritated and loosened periosteum in the young is so prompt, that dislocations early become irreducible by ordinary methods. If the limb is extended and stiff, the position can be improved by forcible flexion, with or without fracture of the olecranon, or resort may be had to open arthrotomy with division or removal of the obstacles, or to excision. If open arthrotomy is done, the incisions must be so planned that the adhesions on the inner and outer sides of the humerus can be divided, and the sigmoid cavity freed of the fibrous tissue which usually fills it. The choice lies between two lateral incisions and a posterior transverse or U-shaped incision, through which the triceps is divided close above the olecranon and the joint freely opened from behind; the first-named method is generally preferred.

DISLOCATIONS AT THE WRIST.

Dislocation of the Lower Radio-ulnar Joint.—By general usage the ulna is spoken of as the dislocated bone. The dislocation may be forward or backward.

In the **backward** variety the cause has been exaggerated pronation, either voluntary, as in wringing clothes, or by external violence. The end of the ulna forms a marked prominence on the back of the wrist, and sometimes overlaps the radius slightly. Reduction by direct pressure is easy.

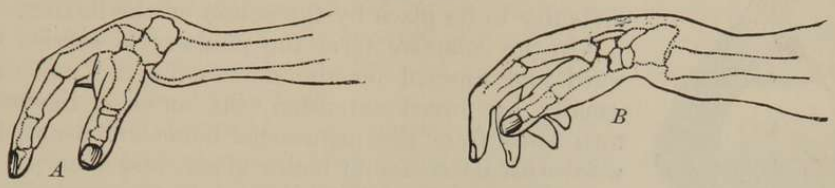
In the **forward** variety external violence is the common cause. The ulna projects anteriorly, and sometimes overlaps the radius as in the backward variety. Reduction by direct pressure is easy.

Dislocation of the Carpus from the Radius.—This may take place backward or forward, and in two cases was outward; it may be complete or incomplete, and may be accompanied by fracture of the anterior or the posterior lip of the radius. The cause is forcible flexion or extension of the wrist or

direct violence. In the incomplete forms the cuneiform maintains its relations with the triangular fibro-cartilage, while the scaphoid and semilunar are displaced from the radius; in one case the semilunar remained attached to the radius, while the rest of the carpus was displaced backward.

The common Colles's fracture of the lower end of the radius was long thought to be a dislocation of the wrist backward. The differential diagnosis is to be made by attention to the position of the styloid process of the radius, to its relations with that of the ulna and with the projecting mass on the back

FIG. 182.



Diagrammatic, to indicate the deformity in (*A*) dislocation of the wrist backward, and (*B*) Colles's fracture of the radius (Stimson).

of the wrist, and with the metacarpus. Fig. 182 shows the deformity in the two injuries.

In dislocation forward the carpal bones form a rounded prominence on the front of the wrist, and the lower end of the radius presents as a sharply-defined line posteriorly, with a well-marked depression below it corresponding to the prominence in front. Reduction is easy by traction and direct pressure.

Spontaneous subluxation forward has been recently described by Madelung. It occurs gradually in adolescents or young adults, and is characterized by the absorption or arrest of growth of the anterior portion of the articular surface of the radius, with corresponding displacement forward and upward of the carpus. The end of the ulna projects markedly, and the antero-posterior diameter of the wrist is much increased; dorsal flexion is limited.

DISLOCATIONS OF THE CARPAL BONES.—A very few cases of dislocation of the second row of the carpus backward or forward from the first have been reported.

Isolated dislocation of every one of the bones of the carpus except the cuneiform has been reported. The semilunar is the one most frequently dislocated, the injury having been compound in half the cases reported, and the displacement forward in all but one.

CARPO-METACARPAL DISLOCATION.—The metacarpal bone of the thumb is the one most frequently dislocated, the displacement being usually backward and more often incomplete than complete. The cause in backward dislocation is either forcible flexion of the member or direct violence. The base of the metacarpal bone can be seen and felt as a prominence between the tendons of the extensor primi and extensor secundi internodii. *Reduction* is usually easy by direct pressure, but there is often a marked tendency to recurrence, which must be opposed by a splint or by maintaining the member in abduction and extension for one or two weeks. Dislocations forward and outward of the same bone have been observed.

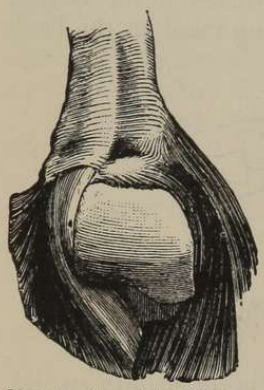
Isolated dislocations of the second and third metacarpals have also been observed, and dislocation backward of the four inner and forward of all five metacarpals.

DISLOCATIONS OF THE THUMB AND FINGERS.—Dislocation of the metacarpo-phalangeal joint of the thumb is quite common, and has received much atten-

tion because of the difficulty frequently experienced in reduction of the backward variety—a difficulty the cause of which is now generally believed to be the interposition of the anterior or glenoid ligament, with its included sesamoid bones.

Backward dislocation of the thumb presents three forms: incomplete, complete, and complex. The first is a form which can be voluntarily produced by many persons by contraction of the extensor of the first joint. The first phalanx moves backward and stands at a right angle to the metacarpal bone, from which position it can be returned without difficulty to its place by the action of the flexors.

FIG. 183.

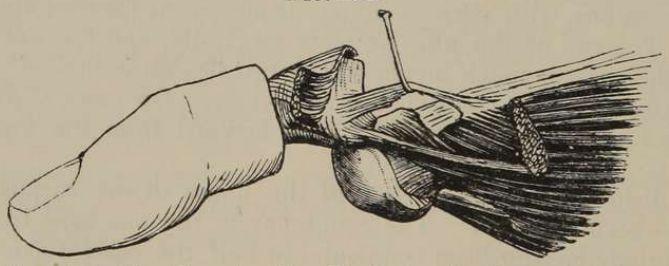


Simple Complete Dislocation of Right Thumb. The long flexor tendon is displaced to the inner side (Farabeuf).

In the *complete* form the phalanx is carried backward and upward on the dorsum of the metacarpal, usually by forced extension, the anterior ligament is torn away from the metacarpal bone and drawn backward with its sesamoid bones along, and even past, the articular surface of the head, while the tendon of the long flexor slips to one side of the head, usually the inner, although it may exceptionally remain in place, stretched along the head of the metacarpal. The first phalanx is in extension at a right angle, the terminal phalanx in flexion, the head of the metacarpal is prominent in the thenar eminence (Fig. 183).

In the *complex* form, a form produced from the complete by forced flexion of the thumb, the glenoid ligament is turned upward so as to lie between the phalanx and the head or dorsum of the metacarpal. The thumb is in straight

FIG. 184.



Complete Dislocation of the Thumb, outer side. The hook raises the periosteal continuation of the lateral ligament, exposing the reflected sesamoid bone (Farabeuf).

extension, parallel and posterior to the metacarpal; its base can be felt as a prominence behind, and the head of the metacarpal in front (Fig. 184).

The essential point in **reduction** is to avoid the transformation of the complete into the complex form. The extension must be maintained or even increased, and then the thumb should be pressed bodily downward until the anterior edge of its base overlaps the articular surface of the metacarpal, when it can be turned into place by flexion; in this way the glenoid ligament and the sesamoid bones are pushed before the phalanx. If this fails, the surgeon can sometimes succeed by combining rotation of the thumb with pressure downward, so as to free first one side and then the other—a sort of unbuttoning of the head of the metacarpal from the grasp of the glenoid ligament and the attached heads of the short flexor. In the complex form the same method must be employed, but it is necessary to use more force, so as to bring the

thumb farther downward and free the edge of the ligament which has been turned upward.

If manipulation fails, a longitudinal incision should be made, aseptically of course, on the palmar aspect of the joint, cutting directly down upon the head of the metacarpal; by drawing the edges of the incision apart the glenoid ligament is exposed, and its free edge should then be nicked at its center and lifted past the head of the bone.

In **forward** dislocation, usually due to forced flexion, the base of the phalanx lies anterior to, and perhaps a little to one side of, the head of the metacarpal, and the posterior and lateral ligaments are torn. It is recognized by the projection of the head of the metacarpal on the dorsum, and of the base of the phalanx in front. It is easily reduced by direct pressure aided by traction, or by increasing the flexion and then pressing the phalanx bodily downward as in the dorsal form.

METACARPO-PHALANGEAL DISLOCATION OF THE FINGERS.—These joints have a glenoid ligament similar to that of the thumb, and sometimes a sesamoid bone is developed in it. There is the same difficulty in reduction of the backward dislocations. It is due to the same cause and is to be met by the same measures.

DISLOCATIONS OF THE PHALANGES.—These may be forward, backward, or lateral. Reduction is usually easy, although it is possible that the thick anterior ligament may become interposed as at the metacarpal joint.

DISLOCATIONS OF THE PELVIS AND COCCYX.

The bones of the pelvis may be dislocated from each other or from the sacrum at the pubic or sacro-iliac symphysis, but the lesion is commonly associated with fracture of the pelvis, to which the reader is referred.

Dislocation of the coccyx is a rare injury, more common in women than in men, and is accompanied by symptoms of pain, disability, and nervous disturbances that are present also in cases in which there is no dislocation or fracture.

Forward dislocations have been caused by violence received upon the region of the coccyx. The pain is severe and radiates through the trunk and limbs, and is increased by any movement. The finger in the rectum recognizes the coccyx flexed forward, and if it is pressed backward into place the pain ceases. The tendency to recurrence is great, and if it is manifested the surest method of treatment would probably be to excise the bone—an operation that is very successful in the allied cases in which there is no dislocation.

DISLOCATIONS OF THE HIP.

These form, according to different statistics, from 2 to nearly 10 per cent. of all dislocations; they have been observed at all ages from six months to ninety-one and a half years, and are much more frequent in men than in women. The head of the femur may be primarily displaced in any of the four principal directions, and may undergo a number of secondary displacements. The "typical" cases, as shown by Bigelow, are those in which the Y-ligament remains untorn in whole or in part and imposes a definite attitude upon the limb. This ligament has the form of an inverted Y; the base of the Λ is attached to the anterior inferior spine of the ilium and the surface of the bone immediately external to it and above the edge of the acetabulum, and its fibers, diverging downward, form two strong bands, the inner and outer, which are

attached respectively to the inner and outer portions of the anterior intertrochanteric line.

Compound dislocations are very rare.

In the most common form the head of the femur passes backward out of the socket while the thigh is flexed, adducted, and rotated inward; if the flexion is in great part maintained, the head remains close behind the acetabulum, but if the flexion is diminished the head rises. The head may also pass directly to this higher position by leaving its socket when the thigh is but slightly flexed. The earlier writers made two classes of these two forms, calling the former "dislocation into the ischiatic notch," and the latter "dislocation upon the dorsum of the ilium," and supposed the latter to be the more frequent. Later investigations, notably those of Malgaigne and Bigelow, showed that the difference was generally due to a secondary displacement, the head most frequently leaving the socket at the lower point, and rising in the higher cases in consequence of the lowering of the knee. This has led to a general abandonment of the division, and to the grouping of all the cases as "dorsal," or "backward." The following classification, taken from Stimson, resembles that used for dislocations of the shoulder; the names of the principal classes indicate the direction of the primary displacement, and those of the varieties indicate either the place at which the head comes to rest or some marked clinical feature:

- Dislocations backward
  - Dorsal, comprising the "iliac" and the "ischiatic," or those "upon the dorsum ilii" and "into the ischiatic notch" of older writers.
  - Anterior oblique.
  - Everted dorsal, comprising the "supraspinous" and some of the "supracotyloid."
- Dislocations downward and inward
  - Obturator.
  - Perineal.
- Dislocations forward and upward
  - Suprapubic
    - Ilio-pectineal.
    - Pubic.
    - Intrapelvic.
- Dislocations directly upward (supracotyloid or subspinous).
- Dislocations downward on the tuberosity of the ischium.

BACKWARD DISLOCATIONS.

In this class the head of the femur passes over the posterior lip of the acetabulum, and lodges close behind it, or behind and above it, in the common "dorsal" form in which the limb retains the attitude of flexion, adduction, and inward rotation which it had when the dislocation occurred. Occasionally, but very rarely, the head undergoes further displacement forward and inward by outward rotation of the limb, with abduction, and extension—the "everted dorsal" variety; and Bigelow has described a still more rare variety in which outward rotation is combined with flexion and marked adduction, the head rests above the acetabulum, and the lower part of the neck lies at its upper and posterior margin—the "anterior oblique" variety.

1. Dorsal Dislocation.—This is by far the most common form; it includes those described as dislocations "upon the dorsum ilii," "into the sciatic notch," "iliac," "ischiatic," "dorsal," and "dorsal below the tendon" of various writers. The head of the femur leaves the joint posteriorly at a higher or lower level; it may pass below the tendon of the obturator internus, or between it and the pyriformis, or above the latter; it usually rests close to

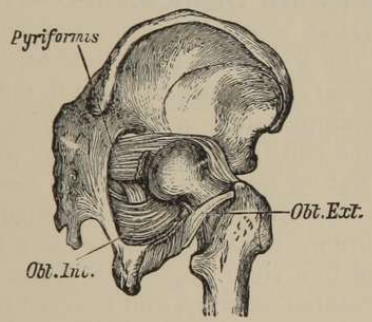
the margin of the acetabulum, seldom if ever reaching the great sciatic notch, but occasionally passing up to the dorsum of the ilium.

The **cause** is external violence acting from below upward in the direction of the long axis of the femur, and tending to push the knee toward the pelvis while the thigh is flexed, adducted, and rotated inward, or exaggerated adduction and inward rotation combined with flexion. It may be produced by transformation of a thyroid dislocation by flexion, adduction, and inward rotation.

The capsule is irregularly torn in its posterior and lower portion, and is occasionally detached from the femur, or, more rarely, from the acetabulum. In the regular or typical cases the Y-ligament is untorn. The ligamentum teres is torn away from the femur or ruptured. The quadratus femoris and the gemelli are usually ruptured, and the two obturators and the pyriformis may be more or less torn.

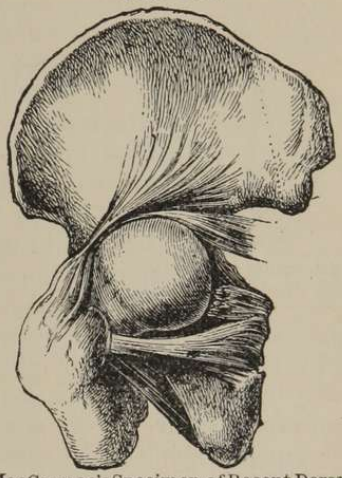
It seems to have been satisfactorily shown that in the greater number of cases the head leaves the socket at a relatively low point (the so-called ischiatic form), and then rises, as the knee is lowered, behind the obturator internus (Fig. 185), or pushes that muscle upward; less frequently it leaves the socket at a higher point (the primary iliac form) and remains in front of the obturator internus (Fig. 186). The lowest point at which it has been known to lodge is the base of the spine of the ischium, the highest (possibly with rare exceptions) a point on the ilium in front of the highest part of the great sciatic notch. The edge of the acetabulum may be chipped or even extensively broken; the head of the femur has been broken once or twice.

FIG. 185.



Dislocation below, and then behind and above, the Obturator Internus (Stimson).

FIG. 186.



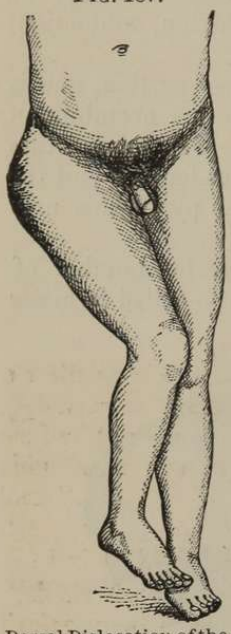
MacCormac's Specimen of Recent Dorsal Dislocation. The head of the femur lies just behind the acetabulum, below the pyriformis and above the obturator internus and the torn gemellus muscles (MacCormac).

The **symptoms** are marked: the limb is adducted, rotated inward, and more or less flexed (Fig. 187), so that its knee rests upon the front of the opposite thigh when the patient is recumbent, its toes on the dorsum of the other foot when he is upright. Flexion may be masked by the tilting of the pelvis, in which case marked lordosis of the lumbar spine can be recognized by passing the hand under the patient as he lies on his back. The upper and outer part of the thigh is broadened, the trochanter rises above a line drawn from the anterior superior spine of the ilium to the tuberosity of the ischium (Nélaton's line), and the head of the femur may be obscurely felt in the buttock.

Voluntary movements are lost, but passive flexion and adduction are possible; extension, abduction, and outward rotation impossible.

Because of its adduction the limb appears much shortened; actual shortening will be found on measurement if the other limb is symmetrically placed, but this is not usually needed to make the diagnosis. The symptoms and the whole appearance of the limb are so characteristic that the nature of the injury can hardly fail to be recognized; a much more common error is to mistake a fracture of the neck of the femur for a dislocation.

Fig. 187.



Dorsal Dislocation of the Femur (Cooper).

2. Everted Dorsal Dislocation.—As the name indicates, this exceptional form differs from the common one in the substitution of outward for inward rotation of the limb, a substitution that is made possible by rupture of the outer branch of the Y-ligament. If the head of the femur remains behind the socket, flexion and some adduction persist, but if it has moved upward and forward to a position near to and above the anterior inferior spine of the ilium, there will be extension and slight abduction.

3. Anterior Oblique Dislocation.—In this, of which there appears to be only one recorded case, the limb crosses the opposite thigh, everted, and with the knee extended.

Treatment of Backward Dislocations.—The essentials in making reduction are to relax the untorn portions of the capsule and the Y-ligament; then to bring the head of the bone, if necessary, opposite the rent in the capsule, and to lift it into place by traction or manipulation, or by abduction and outward rotation, which accomplishes the same end through the agency of the remaining ligaments. The patient is placed flat on his back, the pelvis steadied by downward pressure of the surgeon's foot or of an assistant's hand upon the anterior superior spine of the corresponding ilium; the knee is flexed at a right angle, the thigh rotated farther inward, flexed to a right angle (sometimes even beyond), and then lifted bodily upward and rotated outward and lowered in abduction. The lifting can be made easier by making a long loop of a bandage and passing it over the surgeon's shoulders and under the hollow of the patient's knee.

Or the patient may be laid on his face on a bed or table in such a way that his thighs extend beyond its margin. The sound limb is held horizontal by an assistant, and the dislocated one allowed to hang vertically down, the knee flexed, and the ankle held by the surgeon. While the surgeon gently swings the limb from side to side and diverts the patient's attention the muscles will be seen to relax, and the bone will often slip into place without further manipulation or with the aid only of a slight quick pressure downward upon the calf.

Occasionally these methods fail, the head seeming to be firmly caught by some opposing bony projection. After several failures another repetition of the attempt may instantly succeed, or traction made by an assistant in the direction of the axis of the slightly flexed and adducted thigh while the surgeon presses inward against the great trochanter may be successful. Anesthesia is a great help.

Occasionally the manipulation transforms the dislocation into a thyroid one; it can be restored to its original form by reversing the movement: flexion in abduction and outward rotation, followed by adduction and rotation inward.

The everted dorsal and anterior oblique are reduced by first converting them into the dorsal form and then treating them as such.

DISLOCATIONS DOWNWARD AND INWARD.

The head of the femur escapes at the lower or lower and inner part of the socket, and either lodges in the obturator foramen, *obturator* or *thyroid* dislocation, or passes farther inward to the perineum, *perineal* dislocation. The limb is flexed, abducted, and rotated outward.

1. Obturator Dislocation.—This is commonly caused by violence received upon the back of the pelvis while the thigh is somewhat flexed and abducted, but it may be produced by forced abduction alone. As the Y-ligament is untorn and the head is displaced downward and inward, the limb is held in abduction and flexion, and cannot be extended or adducted; after flexion it can be adducted. If the patient stands upright the injured limb is held forward and appears to be lengthened in consequence of the lowering of that side of the pelvis. If a comparative measurement is made while the thighs are well flexed, shortening will be found. The trochanteric region is flattened, the adductors tense. If the patient is thin, the head of the femur may perhaps be felt on deep pressure through the adductors.

It has been stated on excellent authority that a number of patients have been able to walk immediately after the accident and have not sought treatment until after several days.

Reduction is made by flexion of the hip to a right angle, traction while making adduction, and then rotation inward while lowering the knee; further outward instead of inward rotation in the last step may also succeed.

Fig. 188.

Perineal Dislocation of Hip (original).

2. Perineal Dislocation.—As the head of the femur in this form is displaced farther inward, the flexion and abduction of the limb are much more marked, more so than can be together obtained in a normal limb. There is half an inch shortening, perhaps more. The cause is forcible extreme abduction, and the laceration of the soft parts must be extensive (Fig. 188).

In two cases reported by Stimson **reduction** was easily made under ether by flexion, traction, adduction, and lowering of the limb.

DISLOCATIONS UPWARD AND FORWARD AND INWARD AND FORWARD (SUPRAPUBIC).

The head of the femur may rest upon the upper ramus of the pubes at the ilio-pectineal eminence or farther inward near the symphysis. In the latter case it is thought to have reached this position by rising from the obturator foramen, a transformation of an obturator into a suprapubic dislocation; in the former it leaves the socket at its upper and inner part by hyper-extension or abduction and outward rotation of the limb. The psoas and iliacus muscles

are stretched across the neck, and the femoral vessels are usually raised by the head.

The ilio-pectineal is the more common form; in it the limb is markedly everted and slightly abducted. The head of the femur can be readily felt in the groin. The outer and posterior aspects of the hip are flattened.

Reduction is made by traction in the axis of the limb as it lies, in order to bring the head down past the pubic ramus; then flexion while pressure is made against the head to prevent it from moving upward again; and finally rotation inward.

DISLOCATIONS DIRECTLY UPWARD (SUPRACOTYLOID).

In this form of dislocation, of which only a very few cases have been reported, the head of the femur is displaced upward and lodges below and a little to the outer side of the anterior inferior spine of the ilium. The cases are too few to permit much generalization, but it can be said that the limb is always everted and sometimes abducted; the trochanter is moved upward and backward, and the head may be felt on deep pressure. Some of the patients have been able to walk with a limp and have not sought treatment until after several days.

There is a close resemblance between these cases and those in which the head of the femur is brought above the acetabulum, but at a higher level, by adduction after a suprapubic dislocation or by eversion after a dorsal one (everted dorsal).

DISLOCATION DOWNWARD UPON THE TUBEROSITY OF THE ISCHIUM.

This form also is very rare, since the head can easily undergo secondary displacement upward and backward, transforming the dislocation into a dorsal one, or forward by abduction and eversion, transforming it into an obturator one. The limb is sharply flexed, and may be somewhat abducted and everted or inverted.

Reduction has usually been easy by traction in flexion.

COMPLICATIONS OF DISLOCATION OF THE HIP.

Compound dislocations are very rare, are produced by great violence, and are usually fatal. The complication has been observed only once in a dorsal, and two or three times each in anterior and obturator dislocations.

Injury of the femoral vessels has occurred only in suprapubic and obturator dislocations.

Fracture of the neck of the femur has occurred a number of times during attempts to reduce a dislocation. It is of much importance, for it makes reduction practically impossible, and if the fracture is at the narrow part of the neck, necrosis of the head is likely to follow. The most that can be done is to put the limb in a favorable position, or to excise the head and neck in young patients in the hope of getting a movable joint.

TREATMENT OF UNREDUCED DISLOCATIONS.

Attempts that have been made to reduce old dislocations of the hip by arthrotomy have mostly been unsuccessful, either through failure to effect reduction, through necrosis of the head of the femur, or through the death of the patient; the only successes (two cases) were obtained by the late Dr. Parkes of Chicago. Excision of the head, or of the head, neck, and trochanter, and subtrochanteric osteotomy, have been resorted to with consider-

able success in diminishing the disability. In many cases a fairly useful limb will ultimately result even without any operative interference.

PATHOLOGICAL DISLOCATIONS.

These may occur as the result of rhachitic changes in the bones, of paralysis of some of the muscles, of articular inflammations in the course of various specific fevers, and may occur even in a normal joint as the result of prolonged maintenance of the limb in flexion and adduction. It may occur gradually and painlessly, and perhaps escape observation until it is too late to remedy it.

DISLOCATION OF THE KNEE.

Dislocations of the knee are infrequent, and are divided into the *forward*, *backward*, *outward*, *inward*, and *by rotation*, occurring in that order of frequency. The dislocation is frequently compound, and often complicated by injury of the popliteal vessels, which may consist in complete rupture or in such bruising that a thrombus will form and lead to gangrene. Either popliteal nerve may also be injured. These possibilities add greatly to the gravity of the prognosis in all the severe forms of dislocation, and even the return of pulsation in the arteries at the ankle after reduction is not proof that the artery is uninjured and gangrene not to be feared.

DISLOCATION FORWARD may be complete or, more commonly, incomplete. The cause is hyper-extension of the knee or direct violence received on the front of the thigh or the back of the leg near the knee. When *complete*, the tibia lies in front of the condyles and may be displaced upward a considerable distance,—four inches in one recorded case; the laceration of the soft parts is extensive. In the *incomplete* form the articular surfaces of the tibia and femur are still partly in contact, and the laceration is much less. If the dislocation is compound, the wound in the skin is posterior and transverse. The character of the injury is readily recognized by inspection and palpation, and **reduction** is easily made by traction and direct pressure.

BACKWARD DISLOCATION may be complete or incomplete, and is most frequently due to violence received upon the front of the leg or the back of the thigh. The muscles behind the knee may be freely lacerated, and the patella is sometimes dislocated outward. The leg is usually in full extension or hyper-extension, and is sometimes deviated to one side.

Reduction is easy by traction and direct pressure. In a few cases in which reduction was not made the limb was fairly useful.

LATERAL DISLOCATIONS are much more infrequent than either the forward or the backward; they may be outward or, more rarely, inward, complete or incomplete, but the complete variety is extremely rare. The common cause of the *incomplete dislocation* is forced abduction of the leg for the outward, and forced adduction for the inward variety. The injury is recognized by the lateral projection of the head of the tibia on one side, and of the condyle of the femur on the other; the patella is usually deviated toward the side of the dislocation. **Reduction** has ordinarily been easy by traction and direct pressure. The importance of obtaining firm union of the ruptured lateral ligaments makes it advisable to keep the limb immobilized and unused for several weeks.

IN DISLOCATION BY ROTATION the leg is rotated about its long axis or about an axis parallel with it and passing through the center of one of its upper condylar surfaces. The dislocation is termed outward or inward according to the direction in which the toes are turned. In rotation about the central axis both condylar surfaces are displaced, one forward, the other backward, and the dis-

location is said to be complete; in the other form the condylar surface which corresponds to the axis of rotation remains in place, and the other is displaced forward or backward, constituting incomplete dislocation. The injury is rare, and almost all cases have been of outward rotation. Additional backward or outward displacement may be associated with the rotation. **Reduction** appears to have been easily effected.

DISLOCATION OF THE SEMILUNAR CARTILAGES.

Either semilunar cartilage may be detached at either end or peripherally, and displaced toward the intercondyloid notch or to the outside, or it may be lacerated. The injury may be produced during a dislocation or a sprain or by rotation of the leg or flexion of the knee. The internal cartilage is the one more commonly affected.

The symptoms are very like those excited by a loose cartilage in the joint: sudden, painful locking of the joint, usually occasioned by some definite movement, and recurring with greater or less frequency. Attention has been especially directed to the injury of late, and our knowledge has been increased by the data supplied by several operations undertaken for its relief. The displacement of the cartilage may sometimes be recognized by palpation along the upper articular edge of the tibia in front.

The locking of the joint can be relieved without much difficulty by various manipulations, such as extension followed by sudden flexion, rotation of the leg, or pressure upon the projecting cartilage. To prevent recurrence, various pads and braces have been recommended the object of which is either to oppose the displacement directly or to prevent the amount of flexion of the knee which is a necessary preliminary to the occurrence. The operation that has been most done of late consists in opening the joint by an incision along the side of the patella, exploration through it to determine the exact nature of the lesion, and then such treatment of the cartilage as may seem proper, usually excision of the whole or of a part, or fixation to the tibia along the peripheral border by suture.

DISLOCATIONS OF THE PATELLA.

The patella may be displaced to the outer or to the inner side, or may be more or less rotated about its longitudinal axis, "edgewise" or "vertical" dislocations, or the two forms may be combined in varying degrees (Fig. 189).

Fig. 189.

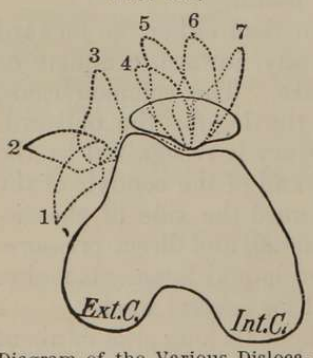


Diagram of the Various Dislocations of the Patella (Stimson).

Displacement upward or downward after rupture of the ligamentum patellæ or of the tendon of the quadriceps respectively will not be here considered as a dislocation. (See Rupture of Tendons.)

Displacement to the outer side is very much more frequent than displacement to the inner side. The causes and mode of production of the various forms are much the same, either muscular action or external violence acting directly on the patella. Gradual dislocation outward may result from hydrarthrosis of the knee or from genu valgum.

Outward Dislocation.—This may be complete or incomplete. In *complete* outward dislocation the patella rests against the outer surface of the external condyle either by its inner border, or, more commonly, by its posterior surface, or by its anterior surface, its outer border being directed forward (Fig. 189, 1, 2, and 3). It may reach this posi-

tion either while the knee is extended or while it is flexed at about a right angle. The internal lateral ligament of the patella—*i. e.* the fibrous expansion at the attachment of the vastus internus—is ruptured longitudinally, the rent sometimes extending several inches upward into the muscle, and this may be torn away from the patella.

The **nature** of the injury is easily recognized, for the patella can be felt in its abnormal position: when rotation of the patella is combined with outward dislocation it may be more difficult to determine whether its outer or its inner border is directed forward.

Reduction has usually been readily made by direct pressure, after the quadriceps has been relaxed by extension of the knee and flexion of the hip. In a case seen by the writer simple extension of the knee reduced the dislocation.

Incomplete dislocations are those in which, the knee being extended, the patella rests above and partly to the outer side of the articular surface of the femur, and those habitual dislocations in which, during flexion of the knee, the patella moves outward and its outward border turns backward.

Outward Edgewise or Vertical Dislocations.—In these the patella is moved outward and turned upon its longitudinal axis in such a way that its inner border rests in the groove of the trochlea, its outer border projects forward, and its articular surface looks outward. The degree of rotation may vary from, say, 45° to 100° or 110° (Fig. 189, 4 to 7). Its fixation in this position is due to the tension of the overlying soft parts. **Reduction** has usually been effected by extension of the knee and direct pressure on the patella.

Complete reversal, the outer border passing in front to the inner side, has been reported in only two cases.

Inward Dislocations are the same, *mutatis mutandis*, as the outward, but they are very much more rare.

Congenital and Pathological Dislocations.—Congenital dislocations appear to be very rare, most of the cases reported as such being actually habitual or permanent dislocations developed during infancy or childhood. The **causes** of these habitual dislocations are not always clear: in some the displacement seems plainly to depend upon a deformity of the limb, genu valgum, but in most it can only be said that the affection develops gradually, the patella usually slipping outward as the knee is flexed. The use of the limb is more or less interfered with by pain, and sometimes by diminution of voluntary control. The **treatment** consists in measures designed mechanically to oppose the occurrence of the displacement, such as a knee-cap or a splint that limits flexion. In a recent case benefit was obtained by excision of a portion of the internal lateral ligament of the patella; in another by pinching up a longitudinal fold and securing it by a continuous suture.

DISLOCATIONS OF THE FIBULA.

Upper End.—The upper end of the fibula may be dislocated outward and forward, or backward or upward. The injury is a rare one, even if those cases are included in which it is associated with fracture of the tibia.

Outward and Forward.—In the seven reported cases the occasion has been a fall, and the production of the dislocation appears to have been associated with forcible depression and inversion of the front part of the foot, so that it has been suggested that the immediate cause was traction exerted through the extensor muscles that are attached to the front of the fibula. The displacement is easily recognized, and **reduction** is readily effected by direct pressure upon the head of the fibula.

Backward.—In three of the five reported cases the cause appears to have been the forcible contraction of the biceps. **Reduction** was generally easy, but in two the dislocation recurred, and persisted in one of them.

Upward.—There are three reported cases, but in only one of them is the diagnosis beyond question. In this one (Boyer) the patient appears to have also suffered a dislocation outward at the ankle or a lesion resembling a Pott's fracture, in which, however, the fibula instead of being broken was pushed upward. The restoration of the foot to its place corrected the upper dislocation.

Lower End.—A very few cases have been reported in which the lower end of the fibula has been forced from its attachment to the tibia and the foot and has been dislocated backward. In a unique case observed by Stimson the lower end of the fibula had been dislocated backward from the tibia, but had preserved its connection with and its relations to the foot; the injury occurred while the patient was wrestling with another lad, and was apparently produced by forcible abduction of the front of the foot.

DISLOCATIONS OF THE FOOT.

Tibio-tarsal Dislocations.—Four principal groups are made, according to the direction in which the foot is displaced: *backward*, *forward*, *outward*, and *inward*.

Backward.—The cause is commonly extreme plantar flexion, by which the lateral ligaments are torn, when the liberated foot slips backward and the astragalus is fixed behind the tibia when the plantar flexion is relieved. Fracture of the external malleolus, less frequently of the internal, may coexist. Incomplete dislocation is a frequent accompaniment of Pott's fracture. The foot appears shortened in front and the heel lengthened, but if there is some swelling the dislocation may easily pass unrecognized unless a careful examination and comparison with the other foot are made.

Forward.—This form is very rare. The injury may be caused by exaggerated dorsal flexion or by direct pressure forward upon the heel. The foot appears lengthened in front, the heel shortened; the body of the astragalus can be felt in front of the tibia.

Inward.—There are two varieties: in one, by supination and adduction of the foot, the astragalus is turned down out of its mortise so that its upper articular surface lies below and in front of the external malleolus; in the other (thought to be secondary to a backward dislocation) the toes are turned more or less directly inward, the foot lying nearly or quite in the transverse plane. **Reduction** has always been easy.

Outward.—Most, if not all, of the cases described under this title appear to have been Pott's fractures, either typical or with unessential variations.

SUB-ASTRAGALOID DISLOCATIONS.

The other bones of the foot may be dislocated from the astragalus *backward*, *forward*, *outward*, or *inward and backward*. The first two forms are very rare: the outward and inward are more common, and are produced by forcible eversion and inversion of the foot respectively. Fractures of the astragalus and of the external malleolus have been observed as complications. Of 55 reported cases of all kinds (Stimson), 24 were compound. Of 24 simple cases in which reduction was attempted, it was effected in 14 and the ultimate result was good; of the remaining 10 cases and the 7 in which reduction was not attempted, secondary amputation was done in 4, and secondary excision of

the astragalus in 4; in 5 the functional result was good notwithstanding the persistence of the displacement. Of the compound cases, primary amputation was done in 3, and excision of the astragalus in 10.

DISLOCATION OF THE ASTRAGALUS.

This is a more common injury; the cause is usually a fall from a height, or forcible twisting of the foot. The varieties are very numerous: they may be grouped as *forward*, *backward*, *outward and forward*, *inward and forward*, and *by rotation*. In the first four groups more or less rotation of the astragalus about either of its axes is frequently associated.

Outward and Forward.—This is the most frequent form. The head of the astragalus rests on the outer cuneiform and the cuboid bones, or even on the fifth metatarsal, and its posterior part is still in contact with the articular surface of the tibia. The foot is adducted and inverted, the external malleolus prominent. If the dislocation is compound, the head of the astragalus presents in the wound. **Reduction** in cases not complicated by rotation of the astragalus is sometimes very easy by traction downward on the foot and pressure backward on the head of the astragalus.

Inward and Forward.—The astragalus lies in front of or below the internal malleolus, its head well depressed toward the sole; the foot is abducted and everted. Sometimes the head passes beyond the tendon of the tibialis anticus, which then tightly embraces its neck and prevents reduction.

Forward.—Only a very few cases, presenting no common features, have been reported.

Backward.—The displacement may be directly backward, or backward and to either side. Stimson has collected 16 cases, in 7 of which the bone was broken at the neck and only the posterior fragment was dislocated. The body of the astragalus can be felt behind the ankle, and the absence of its head from its normal position may be recognized. In 3 of the reported cases persistent flexion of the terminal phalanx of the great toe was present. Reduction was effected in only one-third of the simple cases.

Dislocation by Rotation.—Only those cases are here considered in which the astragalus remains in its mortise. The rotation may take place about the vertical or transverse axis (and it is then associated with more or less dislocation forward and inward, so that the separation from this class is arbitrary), or about the antero-posterior axis, without other displacement. Four cases of the latter kind have been observed and verified by direct examination, either post-mortem or during operation; in three of them the upper surface of the astragalus was directed outward; in one the bone was turned completely over, 180 degrees.

DISLOCATIONS OF THE TARSUS AND METATARSUS.

Dislocations of one or more of the other **tarsal** and of the **metatarsal bones** have been observed—namely, of the medio-tarsal joint, of every tarsal bone separately except the outer cuneiform, and of the metatarsal bones separately and in various combinations. The metatarsus as a whole has been dislocated in each of the four principal directions.

CHAPTER IX.

DISEASES AND INJURIES OF LYMPHATICS.

GENERAL CONSIDERATIONS.

THE lymphatic vessels pervade every tissue and organ in the body: the delicacy and transparency of their walls and the very close adhesion of these walls to surrounding tissues render it impossible to identify them under ordinary circumstances. In their anatomy and general properties, however, they bear a close resemblance to the veins, and the results of injuries to them and the diseases to which they are subject are analogous to those of the venous system. By reason of their function as absorbents they are the great agents of the introduction into the general circulation of the products of local septic infection. From their open mouths during the first hours following the receipt of a wound comes much of the serous flow to dispose of which drainage is necessary, and some of which, doubtless, later plays an important part in facilitating the active cell-changes upon which the healing process depends. All wounds involve lymphatics, but under ordinary conditions these vessels call for no special attention from the surgeon. Their walls collapse and become closed by the plastic exudate that is formed for the purpose of general repair. The superficial lymphatic plexuses of the skin are not only exceedingly numerous, but are also so superficially placed that they are readily influenced by antiseptic solutions applied to the surface of the skin; hence the value of external antiseptic lotions and fomentations in inflammation of the superficial lymphatics and of the somewhat deeper vessels into which they immediately empty, and the caution, likewise, with which solutions which may be toxic, as carbolic acid and corrosive sublimate, should be applied for any length of time to extensive surfaces of skin. Any consideration of the affections of the lymphatics will include those of the lymphatic glands, which are scattered along their course and form a part of the lymphatic system. In explanation of the greater frequency of affections of the lymphatic glands in youth, it must be remembered that the quantity of lymph in circulation is greater then than in later years, and that the lymphatic glands are, during that period of life, more largely developed and more active.

INJURIES OF LYMPHATICS.

Rupture of the Thoracic Duct.—This main lymph-duct, although so much protected by its anatomical position, may nevertheless, under exceptional circumstances, be wounded or ruptured. Of 17 such cases collated by Kirchner, 2 were due to contusions of the chest; 1 each to a puncture, a cut, and a shot wound; 3 to erosion from suppuration. In the remaining cases the account failed to assign a definite cause. The wound in these cases resulted in chylothorax in nine instances; in chylous ascites in six instances; in one (doubtful) in exudation into the mediastinum; while the remaining case was an instance of operative injury of the duct near its mouth. In a case reported by Krabbel, the patient on the fifth day after being run over by an empty coal-car died from suffocation due to an effusion into the right pleural cavity, which on post-mortem examination was found to be chyle and to have come from a rent in the thoracic duct opposite

the ninth dorsal vertebra, which had been transversely fractured. In one of Kirchner's cases a girl of nine years had been violently pushed against a window-sill, striking the front of her chest opposite the third rib; a gradual and increasing dyspnea developed after some days, with signs of pleural effusion, which on aspiration proved to be chyle; relief followed the aspiration, but dyspnea again became marked after some days; a proposed repetition of the aspiration was deferred on account of a spontaneous improvement which then took place; the dyspnea subsided, the signs of effusion gradually disappeared, and ultimately full health returned. Two American cases have recently been reported (Eyer, 1891; Manley, 1894). In the first a young man suffered a severe squeeze of his thorax, having been caught between a railroad-car and an engine. No bones were broken, and for some days a traumatic pneumonia of the right lung was the chief apparent result of the injury; on the seventeenth day, however, a fluctuating swelling was detected in the right inguinal region, which on being opened gave exit to much offensive gas and a foul feculent discharge. After two or three days this discharge lost its offensiveness and became opaque and milky: rapid emaciation followed, resulting in death on the thirty-eighth day from the original injury. Post-mortem examination revealed a rupture of the thoracic duct at the point where it passes through the aortic opening of the diaphragm; the escaping chyle had burrowed behind the peritoneum and had become superficial at the groin; in addition to this, some of the chyle had become diverted above the diaphragm and had dissected up the pleura from the posterior chest-wall on the right side so as to form a post-pleural cavity, filled with chyle, extending up as high as the apex of the thorax. In the second case the escaping chyle likewise burrowed behind the peritoneum and presented a superficial swelling at the groin which was incised, and gave vent for ten days to an abundant chylous discharge. The discharge then ceased, and the complete recovery of the patient followed.

There are no symptoms indicative of this rare injury until a sufficient accumulation of the escaping chyle has occurred to call for its evacuation surgically. The character of the evacuated fluid is the first indication that a wound of the thoracic duct has occurred. According to the location of the wound, the effused fluid may find its way into the peritoneal cavity or into the connective tissue behind the peritoneum, into the pleural cavity or into the connective tissue behind the pleura, or into the posterior mediastinum. The particular symptoms which the effusion will provoke must depend upon its location and extent. Rapid emaciation will result from the inanition due to the failure of the chyle-current to reach its destination.

Death from inanition is to be expected after rupture of the thoracic duct. The case already cited which recovered shows, however, that exceptions may occur, possibly due to the existence in a particular instance of a double duct or other abnormality whereby a collateral circulation is possible. Experiments on animals show that small recent wounds of the thoracic duct may heal spontaneously and quickly.

A wound of the thoracic duct is beyond surgical treatment. When, however, such a wound is demonstrated or suspected, the suggestion of Agnew is eminently rational that, instead of feeding the patient, no food should be given, in order that the walls of the duct may remain as much as possible in a state of collapse, and thus favor any attempt which nature may make toward closing the opening. Meanwhile, the possibility of introducing milk directly into the venous circulation suggests its utility as a method of nourishment during the period that must intervene before the ordinary processes of digestion and absorption can be resumed.

The thoracic duct may be wounded near its termination at the base of the left side of the neck in the course of operations for the removal of deep-seated growths in that region, especially when, as is sometimes the case, irregular terminal branches reach somewhat high into the neck. Keen has reported four instances of this accident. In two of these cases the fluid that exuded was unmistakably chyle; in the other two it was serous in character, but in all its abundance was great, and such as to make it extremely probable, even in the latter cases, that its source was the thoracic duct. In two of the cases the flow was controlled by a tampon, in one by a pressure forceps, and in one by a suture. Three of these cases recovered, having sustained no detriment from the injury to the thoracic duct. One died, but its fatal result was not especially influenced by the wound of the duct.

Lymphangitis.—Certain areas of lymphatic radicles, or the larger continuous lymphatic trunks, may become inflamed as the result of retention within them of irritants. To the first form the term *reticular lymphangitis*, to the second the term *tubular lymphangitis*, as proposed by Bellamy, may well be applied. In the vast majority of cases the irritants in question consist of septic material absorbed from an infected wound.

Reticular lymphangitis is seen in many cases of circumscribed skin inflammation attended with more or less œdema. It is present in the condition described as "erysipeloid" by Rosenbach, a term applied by that investigator to certain patches of superficial skin inflammation which slowly spread from a point of primary infection, usually on the fingers, the point originally affected returning to a condition of health, while the inflammation extends at the periphery, until at the end of from one to three weeks the disease has exhausted itself and entirely disappears, having possibly extended over the back of the hands as far as to the wrist. Rosenbach found the cause of this affection to be the invasion of the lymphatics by a specific thread-forming, spore-bearing micro-organism derived from decomposing animal matter. Ordinary erysipelas presents a typical form of reticular lymphangitis in which the inflammation is produced by the invasion of the lymphatic channels by the streptococcus of erysipelas. (See Erysipelas, p. 65.) In the rapidly-extending inflammations which attend certain poisoned wounds the infection is propagated along the lymphatics, which share in the general inflammatory condition that prevails, both types of lymphangitis being present in a marked degree. A lymphangitis of less virulence often develops in connection with injuries of hands or feet that are neglected and subjected to motion and irritation, or with scratches and abrasions that are brought into contact with decomposing material. This inflammation may at first be limited to a small area of the immediately contiguous lymphatic rootlets; if still further aggravated, the larger trunks leading away from the part become involved, and when seated in the skin are seen as red and tender streaks running in the direction of the lymph-current.

Tubular lymphangitis is invariably the result of the entrance into the affected duct of bacteria and bacterial products of more than usual virulence. Long before the agency of pathogenic micro-organisms in its production was recognized, the affection was appreciated as of serious import and demanding active treatment to subdue it. The entrance of septic material into lymphatic channels must always attend infected wounds, but it is exceptional that a spreading inflammation of these channels results. A previously existing state of general debility upon the part of the patient predisposes to it. Frequent irritation of the infected wound and the confinement of septic secretions in it are often exciting causes. The infection of trivial

wounds, as a prick or scratch, with virulent septic material, as in dissection-wounds and snake-bites, not infrequently causes it. Cases have been recorded in which the bathing of the hands, without any wound of the skin, in putrid fluid for some time has been followed by lymphangitis. The tender and somewhat cord-like minute red streak that is formed by the inflamed lymphatic vessel results from the blocking up of its lumen by a coagulated exudate infiltrating also the ensheathing connective tissue which shares in the inflammation, this attendant cellulitis being of variable extent and intensity according to the intensity of the primary lymphatic irritation.

To the ordinary inflammatory swelling of the affected part a certain amount of œdema is added from the interruption of the lymph-current along the thrombosed lymph-vessels. The extent and persistence of this œdema will depend upon the number of the lymphatic trunks involved and the freedom of the anastomosing communications.

Inflammation of the glands into which the affected lymphatics empty speedily ensues upon a primary lymphangitis. For the production of glandular trouble it is by no means necessary that any extensive inflammation of the ducts leading from the seat of infection to the gland should exist, for infective material is often carried through the lymphatics without producing any reaction until it has become arrested in a gland, where its irritative effects are developed. Likewise a second group of glands may become involved by transmission of infection from the first, without any disturbance of the connecting ducts.

Symptoms and Course.—In addition to the local signs of lymphatic inflammation that have already been described there are present constitutional conditions dependent upon the extent and severity of the septic infection. Rigors are not uncommon. Fever, usually marked, but of variable severity, develops. The more aggravated cases rapidly display the effects of profound septicemia. When the source of irritation is less virulent and is transient or is overcome by treatment, the inflammatory reaction soon subsides, the exudate liquefies and is absorbed, and the affected vessels readily return to their normal state. If pyogenic organisms in sufficient number and activity have formed a part of the infecting virus, suppuration along the course of the inflamed vessels or in the glands into which they empty results. In this process of suppuration the surrounding connective tissue becomes invaded, resulting in abscesses. This is true both of gland suppuration and of suppuration along the course of the vessels themselves.

Diagnosis.—Superficial lymphangitis is not likely to fail of recognition. The tender red streaks indicative of the tubular variety are pathognomonic; the diffuse redness of the reticular variety, with its attendant superficial œdema and its pain, and the general fever, distinguish it from ordinary erythema or dermatitis. Some cellulitis accompanies all lymphangitis, and some lymphangitis, on the other hand, attends all cellulitis. Which is the preponderating element may sometimes be a matter of uncertainty. Practically, however, the question is an unimportant one. Phlebitis is closely related to lymphangitis in its symptoms, but a thrombosed vein forms a deeper-seated, coarser cord than a similarly affected lymph-vessel, the cutaneous redness is not so vivid, the pain is less acute, the general fever is not so intense, and the tendency to glandular involvement is less. Inflammation of the deep lymphatics is not easily differentiated from ordinary cellulitis. If in a case of deep-seated inflammation there is early involvement of the neighboring lymphatic glands; if lymphatic œdema can be detected; if patches of superficial reticular lymphangitis appear at points of anastomosis with deeper trunks,—the existence of inflammation of the deep lymphatics can be assumed.

Prognosis.—The course of a lymphangitis will depend upon the virulence the amount, and the persistence of the infective cause, and the constitutional vigor of the patient. The milder attacks upon the withdrawal of the cause and the institution of proper treatment speedily subside; when suppuration has occurred it may be limited in amount, and upon the evacuation of the abscess or abscesses a steady return to health ensues. In the more virulent forms successive groups of glands may become involved and suppurate; extensive abscesses develop; septic absorption, with or without the formation of metastatic abscesses in distant parts, imperils life; and if recovery finally takes place, it is after a prolonged illness; not rarely death from exhaustion is the inevitable end. In a certain class of cases lymphangitis assumes an insidious and chronic form, affecting large areas of vessels and producing such widespread obliteration of them as to block up permanently the flow of lymph from a considerable territory and to entail a permanent lymphœdema of the affected part. (See Elephantiasis or Lymphœdema.)

Treatment.—The recognition of the septic cause of the lymphatic inflammation at once gives direction to the treatment that is to be employed. Prompt and thorough disinfection of the original wound from which the infection has proceeded should be done. The affected limb should be put at rest and elevated. Tension, wherever present, should be relieved by free incision, without waiting for suppuration to take place. The whole affected territory should be covered with compresses kept wet with a 1 : 2000 aqueous solution of corrosive sublimate until the inflammation has fully subsided. All foci of suppuration should be freely incised, evacuated, disinfected, and drained. The constitutional treatment must be conducted in accordance with the general principles of support and elimination. Pain may require opiates, but, as a rule, all the secretions should be promoted. Stimulants and nutrients should be freely administered in the more severe cases. Persistent œdema remaining after the subsidence of the inflammation is to be overcome by bandaging and massage.

Lymphadenitis.—Lymphatic glands are prone to inflammation. Their function as reservoirs, to which the lymphatics hurry whatever material they gather, renders them certain to become places of arrest for whatever irritants may have gained access to the lymphatic circulation. The extent to which they become involved in attacks of lymphangitis has been mentioned in the preceding paragraphs, as well as the fact that they are affected by absorption from septic wounds without involvement of the trunks that transmit the septic matter. The amount of inflammatory reaction which they display may be of every grade from a slight transient tumefaction and tenderness to a rapid necrosis and suppuration, or to chronic enlargement and induration—according to the character of the irritant acting upon the gland and to the local and general resisting power of the individual. Syphilis, tuberculosis, carcinoma, glanders, are all characterized by specific glandular inflammation, for the peculiarities of which reference must be made to the sections devoted to these several affections.

Exposure to cold and over-exertion are often accessory causes of ordinary gland inflammation. They act as local depressants, favoring the activity of infective organisms that otherwise would have been inert. A state of general debility predisposes to glandular inflammation. The glands of the neck, axilla, and groin are more frequently affected than those of other localities, which is the natural result of the many sources of infection continually arising through affections of the mouth, throat, and extremities.

The degree of inflammation excited often falls short of suppuration, in which case either complete resolution and rapid return to the normal state occur, or, what is by no means uncommon, some induration and enlargement

of the gland persists for some time. Suppuration is a very common event. In cases of adenitis of sufficient intensity to entail suppuration, the surrounding connective tissue usually becomes involved in the inflammation and suppuration, and the resulting abscess when opened displays a pus-cavity in the connective tissue enclosing the more or less thoroughly destroyed gland.

Symptoms.—Pain, heat, and swelling are the characteristics of an inflamed gland. The swelling is nodular, and may be either well defined or diffused, according to the amount of periadenitis. The degree of heat will depend upon the intensity of the congestion. The location of the gland and the looseness of the tissue in which it is imbedded will largely determine the amount of pain attending the attack, although tenderness on pressure is always present. The constitutional reaction is likewise variable; in the more acute attacks considerable pyrexia is developed, with rigors on the occurrence of suppuration.

Distinct fluctuation may not be discernible for some time even after suppuration has begun, since the gland which is breaking down is likely to present more than one focus of suppuration, and for this reason will give at first only a boggy feeling to the touch. This, again, will be rendered indistinct by the periglandular congestion. If the surgeon waits to obtain well-defined fluctuation before deciding that suppuration has occurred, he will find it only after considerable destruction of tissue has taken place.

Treatment.—The sources of infection should be removed or receive adequate antiseptic treatment if possible. The part in which the gland is located should be kept at rest and free from irritation. From the onset of the glandular symptoms cold should be kept applied if practicable. Injections of five to ten minims of a 3 per cent. solution of carbolic acid into the substance of the inflamed gland, if made early, may suffice to prevent suppuration. If from any cause it seems best to encourage suppuration, warm fomentations may be kept applied. When pus has formed, the pus-cavity should be freely incised, all necrotic tissue should be scraped away, and the cavity after having been cleansed should be stuffed with iodoform gauze. On the third day this tampon should be removed. In many cases healthy granulating surfaces will already have formed, the adhesion of which may now be secured by the application of an absorbent compress. In other cases a more prolonged use of the iodoform tampon may be required before the desired healing surface of the cavity is produced. If sinuses have formed, they must be followed up, opened freely, and treated in the same way as the original cavity. If the healing process is sluggish, free applications of naphthaline and Peruvian balsam will serve to stimulate it, due attention being paid to the general health.

Chronic Adenitis is, with rare exceptions, either tubercular or syphilitic in its nature. In the exceptional cases not referable to these specific causes nor belonging to the malignant degenerations, inunctions of iodine, blisters, and compression will be of service. Interstitial injections of a few minims of tincture of iodine, or of alcohol alone, will promote absorption. If the mass resists these measures and its presence is a cause of functional disability or a serious disfigurement, it may be excised. Very extensive operations are now often practised in the removal of tubercular glands, especially in the neck, and with great advantage. The operation should be very thorough. Every gland that can be found should be removed. The wound, if made antiseptically, usually heals in a short time, even in the most serious cases. Every measure calculated to promote the general health should be resorted to, in addition to the local means named.

Lymphangiectasis and Lymphangioma.—The lymphatic vessels, like their congeners the veins, are subject to dilatations and varicosities, which may

be of every degree and extent. To such dilatations in general the term *lymphangiectasis* is applied, but when these dilatations by their size, their confluence, or their aggregation form distinct tumors, the term *lymphangioma* may be substituted.

Dilatations of the cutaneous lymph-radicles may be recognized as soft transparent sacs or vesicles filled with lymph, situated manifestly in the substance of the skin, and not on its surface. They occur most frequently on the inside of the thigh, on the genitals, and on the anterior wall of the abdomen, localities rich in superficial lymphatic plexuses. They are usually superficial outcroppings of a deeper, more extensive chain of lymphatic dilatations due to obstructive changes in distant trunks. Rupture of these vesicles is not infrequent, and is liable to be followed by a flow of lymph of variable amount and duration. This is known as **Lymphorrhagia.**

Rupture of a dilated lymphatic along the urinary tract and the consequent lymphorrhagia produce **Chyluria**—an intermittent accumulation of chylous lymph in the urinary bladder. Similarly the tunica vaginalis testis may be the seat of a lymphorrhagia, and **Chylocele** result.

A group of dilated lymphatic radicles may be present in the shape of many closely-aggregated vesicles of varying size; or if the enlargement extends along the course of the ducts, cylindrical and tortuous cords, with nodular swellings at the site of the valve, are produced. The two varieties may coexist; or still greater dilatation at various points may have taken place, so that the varicosities are converted into cystic tumors. Such varicose swellings in the inguinal region may be confounded with herniæ. Ectasiæ or dilatations of the blood-vessels may coexist with those of the lymphatics, producing a tumor of mixed character. Such mixed growths have been noted in the tongue, producing an enlargement of it known as **Macroglossia,** and in the lips, **Macrocheilia.**

Etiology.—In a large proportion of cases of lymphatic dilatation the condition is congenital in its origin; it may be due to an essential vice of development of unknown character, or more likely to obstructions to the lymph-stream of a mechanical or an inflammatory nature arising during embryonic life. In the acquired variety inflammation and thrombosis are the chief agents which are active in the production of the condition, the direct result being dilatation of the radicles and of the primary channels, with lymph-stasis and œdema of the tissues within the area from which the narrowed or occluded vessels are supplied. Occlusion may also result from cicatricial contraction, from the presence of tumors, and from the blocking up of the lymphatic channels by tubercular or cancerous material. The presence in certain lymphatic vessels of a minute parasitic worm, the *filaria sanguinis hominis*, has been demonstrated to be the cause of lymph-thrombosis and inflammation in a large class of cases most frequently occurring in tropical regions.

Causes and Symptoms.—The cystic and tubular enlargements of the lymphatics which have been described are observable only when they are situated superficially or when they form circumscribed swellings that are distinguishable as distinct tumors. A very marked and surgically important series of symptoms may arise when in the substance of a limb or part there is a diffused dilatation with lymph-stasis. Such a condition results when there is obstruction of so large a number of the ducts converging to the root of the extremity or part that but little relief through collateral trunks is possible. The affected part becomes swollen by a hard, compact, brawny œdema, **Lymphœdema,** which is not readily reducible either by position or pressure. Attacks of diffuse lymphangitis are prone to recur, each successive attack causing an aggravation of the local condition. Thickening and induration of the skin and connective

tissue take place. Dilatation and multiplication of the blood-vessels keep pace with the general connective-tissue hypertrophy. The muscles waste. In the more advanced and aggravated cases of this class an enormous deformity results; the skin becomes coarse and hypertrophied, with a tendency to eczema and seborrhea; papillary excrescences are numerous and the development of ulcers is frequent; the swollen limb presents lobulated masses heaped up at different parts, separated from one another by deep sulci, which are especially marked at the flexures of the joints. If the scrotum is the part affected—a not uncommon occurrence—it may form a huge tumor reaching below the knees or even to the ground. This constitutes the disease known as **Elephantiasis Arabum.** While it is more common in certain intertropical countries (Barbadoes, India, Cayenne, etc.), where its frequent dependence upon the presence in the lymphatics of the filaria sanguinis hominis has been demonstrated, occasional instances of it are met with in all climates. The accompanying illustration (Fig. 190) shows the condition of the limb of a girl of twenty-one years of age, the subject of lymphœdema, five years after the inception of the disease. The changes in the limb were as yet moderate. The photograph from

FIG. 190.

Lymphœdema of left leg five years after its onset (original).

which the cut was made was taken in 1875. At the present time, seventeen years later, the case presents the typical condition of the worst form of elephantiasis. Repeated attacks of lymphangitis have occurred during this period, each producing an aggravation of the previous condition. The leg below the knee has become enormously deformed by the production of the elephantoid masses; the outer side of the thigh remains healthy, but the skin of the inner side has developed so as to form a very large and pendent lobulated mass. A similar condition has begun to develop in the other leg, which now is about in the condition of the first as shown in the figure. Fig. 191 shows an example of the changes produced by this disease in its most aggravated form.

Treatment.—Circumscribed dilatations and isolated cystic enlargements may be extirpated with the knife. In the diffused dilatations and œdema due to persistent obstructive causes, in cases in which collateral channels may in time become sufficiently developed to relieve the stasis, relief will be given by massage, elastic bandaging, and support in an elevated position. In the absence of the possible relief of the stasis all such attempts will be fruitless. Ligation of the main artery of supply of the limb in a few recorded cases has been followed by rapid improvement. In others no benefit has resulted. A resort to it would be justifiable when other means had failed. When the disease is confined to an extremity and causes serious disability, amputation may be done. Similar tumors involving the genitals should be excised. In the latter class of cases attempts should be made to preserve the penis and testes by dissecting them out of the hypertrophied mass in which they are imbedded. The chief difficulty attending the ablation of the growths is the prevention of hemorrhage; but this has been greatly facilitated by the use of the elastic bandage for constricting its base.

Fig. 191.

Lymphœdema in its Later Stage (original).

Lymphadenoma.—Under this head are to be classed lymph-gland tumors, in which the essential change is purely a hyperplasia of normal gland elements. Simple overgrowths affecting one or perhaps two or three adjacent glands, without a tendency to local degeneration or the development of constitutional cachexia, have been described, but it is probable that in most of such cases, if not in all, either foci of tubercular infection would be found in them, if a sufficiently thorough examination were made, or they would in time show themselves to be the precursors of a more generalized process.

Enlargement of lymphatic glands consisting of hyperplasia of the normal structure is an important element of leukemia. Single glands may attain the size of a man's fist in this disease, and sometimes all the lymph-glands of the body become involved. Associated with the lymphatic tumors are enlargements of other glands, notably the spleen, thymus, and liver. Changes in the marrow of the bones accompany these glandular changes. The resulting alteration in the blood—namely, the great increase of the white corpuscles and the diminution of the red—affords a certain means of identifying this form of glandular disease, which has a place more properly in internal medicine than as a surgical affection.

Malignant Lymphoma.—Differing from these glandular tumors of leukemia chiefly in the absence of the blood-changes are the cases of diffuse glandular enlargement to which the term **Malignant Lymphoma** (*Hodgkin's disease, Pseudo-leukemia*) is applicable (Pl. IX, Fig. 2). In this affection there first

appears a moderate painless swelling of one or more glands, most frequently in the neck, more rarely in the axilla, groin, or mediastinum. After a time other glands enlarge, until great tumors may result, producing much disfigurement. For a time no disturbance of the general health is observed. The glands, if removed, show simply great hyperplasia of the normal elements. Gradually groups of glands in other parts of the body become similarly enlarged, until finally almost all the glands of the body are affected. Some enlargement of the spleen may now be discernible, but it is not constant. Coincident with this generalization of the swellings the health begins to suffer; emaciation declares itself; progressive anemia develops, which, unless death from some accidental complication occurs, becomes extreme; dropsies arise; diarrhea sets in; and finally collapse and death terminate the case.

The **etiology** of malignant lymphoma is totally unknown. It attacks young adults most frequently. During its early history it is impossible to distinguish it with certainty. The element of time is required to develop its malignancy. When the swellings have become generalized and the constitutional symptoms have declared themselves, the diagnosis is plain. The characteristics of the glands of lymphoma are these: they preserve their proper shape; they do not soften and degenerate, as do tubercular glands; they do not become fused together or adherent to surrounding parts by inflammatory adhesions; they have a certain elasticity when compressed, different from the board-like hardness of unsoftened tubercular glands.

The **prognosis** is hopeless. Its course varies in its rapidity, usually extending over about one year, although a more prolonged course is not infrequent. Pressure of the enlarged glands upon the trachea, œsophagus, or important nerve-trunks may precipitate the fatal termination.

Treatment.—There is little to be gained from surgical interference except when pressure-symptoms call for relief. The internal use of arsenic, combined with its parenchymatous injection, has appeared to exercise a favorable effect on the disease in some cases; in others it has been inert. It should be tried in all cases, and pushed to the maximum of toleration. Its administration should be persevered in for a long period, and resumed whenever evidences of renewed glandular hyperplasia appear.

Sarcoma of Lymphatic Glands, Lympho-Sarcoma.—A lymphatic gland may be the seat of a primary sarcoma. In the early history of such a tumor it will be impossible to distinguish it positively from other varieties of glandular hypertrophy. As it continues to develop it will, after a time, display its special malignant features as it involves the adjacent tissues and becomes attended by secondary deposits in various internal organs, as the lungs, liver, kidneys, brain, and bones. (See the chapter on Sarcoma.)

Treatment.—Soon after its development, if not already very large, it should be thoroughly extirpated, the incision going wide of the gland. If it returns, amputation should immediately be done if the tumor be on an extremity.

CHAPTER X.

SURGICAL DISEASES OF THE SKIN AND ITS APPENDAGES.

Comedo.—This is a disease of the sebaceous glands occurring chiefly about the face, neck, chest, and back, resulting from accumulation of the altered sebum, producing small yellowish or whitish elevations marked by a central black spot, due to staining by dirt of that portion of the retained secretion occupying the orifice of the duct. Pressure will express a small plug of inspissated sebum mingled with epithelial cells, popularly called a "worm." Partly due to idiosyncrasy, and usually a disease of puberty, it is apt to coincide with dyspepsia and constipation, and in young women with chlorosis and menstrual irregularities.

Treatment.—Frequent bathing with hot water and stimulating ointments rubbed in at night (such as sulph. præcip. ʒj to ung. aquæ rosæ ℥j), or weak alkaline ointments (such as borax, grs. xx to ℥j), may be tried. To remove the comedones apply night and morning the following paste—aceti ʒij, glycerinæ ʒiij, kaolini ʒiv,—after which gentle pressure by a watch-key applied over the spots will dislodge the plugs.

Milium.—This appears as small, rounded, pearly, superficial elevations in the skin, occurring chiefly on the face and genitals; they are not painful, and result from the accumulation of sebum from obliteration of a small secondary duct.

Treatment.—Each elevation must be opened, the cheesy matter squeezed out, and the interior touched with tincture of iodine or a nitrate-of-silver point.

Sebaceous Cysts or Wens.—These form variously-sized firm or somewhat soft, rounded tumors, usually seated in the skin or subcutaneous tissue of the scalp, face, back, or scrotum, although they occur elsewhere. The superjacent integument is unaltered. If injured they may inflame and ulcerate, or, in the old, degenerate into epithelioma. Although usually originating from obstruction of a duct, they often have no opening, but at times one persists, admitting a small probe. Their contents are cheesy or milky, and are often fetid.

Treatment.—Excision should be performed either by carefully dissecting out every particle of the cyst, or, after transfixing this and the overlying skin, seizing and tearing out each half of the cyst-wall with a pair of forceps.

Molluscum Contagiosum *vel* Epitheliale is characterized by small, semiglobular, or conical, whitish, sometimes translucent elevations, from the size of a pin's head to that of a pea, with a central dark spot or depression, which is the aperture of a duct. They occur chiefly upon the eyelids, cheeks, chin, neck, breast, and genitalia, and are not painful, although terminating by disintegration and sloughing of the masses. The question of contagiousness is still a mooted point. It is liable to be confounded with molluscum fibrosum, but may be distinguished from it by the absence of the central black opening in this latter affection and the more general dissemination.

Treatment.—Thorough inunctions with white precipitate or sulphur ointment will sometimes suffice; if not, each tumor should be opened, its contents squeezed out, and the cavity cauterized with nitrate of silver.

Dermatitis Venenata.—Tincture of arnica and the wearing of garments colored by aniline dyes containing arsenic will sometimes produce dermatitis, but it usually results from the rhus venenata or rhus toxicodendron. Owing to the volatility of the poison, actual contact with the plants is not necessary.

After a few hours or even days of incubation, in children fretfulness or slight fever may be noticed, but ordinarily the local symptoms first appear—viz. heat and itching, probably of the face and hands, with surface redness and some subcutaneous œdema. Eczematous vesicles now appear, usually first between the fingers; next the genitals are apt to be attacked in the male, whence the eruption may spread to other parts. The inflamed portions of the skin are intensely red, somewhat œdematous, and covered by groups of papules or vesicles, these latter being often confluent, while from scattered excoriations a clear, yellowish, gummy fluid exudes, forming a soft crust on drying. The eyelids, lips, nose, ears, and genitals are sometimes enormously swollen, and exude large quantities of serum. Sometimes the constitution sympathizes, as is shown by fever, coated tongue, and constipation. The burning, stinging pain is occasionally so severe as to deprive the patient of sleep, when anodynes will be required. The disease remains at its height for several days, but usually in a week the acute symptoms have subsided, although the disease may recur from time to time.

The **diagnosis**, especially from erysipelas, must depend on the history of exposure, on the appearance of the vesicles first between the fingers, next on the dorsum of the fingers and hands, finally on the palms; the eruption is more scattered than in eczema; the vesicles usually do not pass through the papular stage, as is common in eczema, but often spring directly from the skin. The disease is not contagious, although in recent cases the poison itself may be conveyed from person to person or to other parts of the same individual, as from the hands to the genitals.

Treatment.—Cloths kept wet with black-wash, provided the extent of surface be not too great, or with weak solutions of sulphate of zinc, or fluid extract of grindelia robusta in the proportion of ʒij–ʒiv to the pint of water, keeping the cloths just damp with the solution, are very useful; for the face, when the patient cannot remain confined to the house, equal parts of starch and precipitated carbonate of zinc may be dusted over the parts.

Furuncle, or Boil.—This is a disease, probably due to microbic infection, in which one or more small, circumscribed, acuminated, dusky-red, firm, painful spots form in the skin, the result of localized inflammation, the central portion of skin dying, forming a slough or "core" around which suppuration takes place, ending in the separation of the "core," the subsidence of the inflammation, and the healing of the cavity by granulation. The maturation of each boil takes about a week or ten days; sometimes no suppuration occurs, when the condition is called a "blind boil." The pain is throbbing, and often quite severe until suppuration and loosening of the slough have occurred, when it subsides. Although any portion of the integument may be attacked, the face, ears, neck, back, axilla, buttocks, perineum, scrotum, labia, and legs are the favorite sites; the nearest lymph-glands may become enlarged, and sometimes constitutional disturbance results. Erroneous hygiene and diet even in the robust, overwork, nervous depression, improper food, irregularity of the bodily functions, and certain atmospheric conditions prevalent in spring and autumn are predisposing causes. The differences from carbuncle, with which alone a boil is likely to be confounded, will become clear when the former disease is described.

Treatment.—The cause should be ascertained and removed. The diet must be regulated and varied. Exercise in the open air, quinine, iron, and strychnine are useful in debilitated patients. Arsenic, with or without iron, is at times of benefit. The sulphite or hyposulphite of sodium, grs. xv–xxx every three hours, sulphide of calcium, $\frac{1}{8}$ gr. every two or three hours, and

proper doses of sulphur internally have been thought to do good at times, but there is no specific. When a hair occupies the center of the boil its avulsion will sometimes abort the furuncle. Locally a 10 per cent. salicylic-acid ointment, or ichthyol combined with an equal quantity of collodion, will prove beneficial. White has reported a series of cases of furunculosis in which the obstinate recurrence of boils was arrested by the administration of bichloride of mercury in full doses. It is possible that this acts through its bactericidal properties, the origin of the condition being perhaps microbic.

Carbuncle.—This is a circumscribed, deep-seated inflammation of the skin and subcutaneous tissue, terminating in a slough. Constitutional disturbance is usually marked, the disease being ushered in by a chill followed by fever. The skin becomes hot, painful, and dusky red, and a flattened, fairly circumscribed inflammatory induration of the subcutaneous tissue forms; the pain is usually burning. Steadily progressing and extending, until it may be from three to six inches in diameter, by the end of from ten days to two weeks the mass begins to soften, and the skin ulcerates at numerous points, which are usually filled with yellow sloughs, whence issues sanious pus. The sieve-like appearance presented by the skin surface, due according to Warren to pus in the columnæ adiposæ, is characteristic, but in most large carbuncles the overlying integument sloughs away sooner or later, leaving a large, slowly-healing ulcer. Carbuncle lasts for from four to six weeks, is usually single, and its favorite sites are the back of the neck, shoulders, back, and buttocks: it is especially dangerous when occurring on the scalp, abdomen, and upper lip; in these locations, occurring as it does in the young, it runs an acute course and is apt to terminate fatally from pyemia. It is a serious disease when extensive and attacking the elderly, especially if complicated with Bright's disease or diabetes, which latter affection stands in a causative relation to it. The causes, other than diabetes, are probably the same as those of boil. The possibility of microbic origin should be remembered. The size, flatness, multiple points of suppuration, and extensive slough distinguish carbuncle from furuncle.

Treatment.—Large amounts of easily digestible, nourishing food should be given, but stimulants only when distinctly indicated. Quinine and tincture of iron in large doses, with anodynes to procure rest, are requisite. Different plans of local treatment may be adopted: one, of doubtful utility, is compression by the concentric application of adhesive straps, limiting the spread of the inflammatory exudates and seeming to lessen the destruction of cellular tissue; another and far better plan is applicable even in the early stages, before the skin is seriously damaged, and consists in making under anesthesia multiple crucial incisions or one long incision—after freezing the parts to render them friable—and thoroughly curetting away all dead or dying cellular tissue, carefully disinfecting, suturing, and draining, as in an incised wound. This is done upon the theory that the spread of the disease is due to the micro-organisms flourishing in the sloughs. Or warm moist antiseptic dressings covered with oiled silk, early removal of loose sloughs, and the free use of iodoform may be employed, but poultices should be avoided.

Burns and Scalds.—These two classes of injuries may be conveniently discussed together. Scalds are apt to be more extensive, because the clothing diffuses the fluid over a greater area and the hairs remain, while in burns these are destroyed and the tissues are often more deeply involved; the effects of concentrated acids and alkalies resemble burns rather than scalds. The old classification of Dupuytren needs revision since the introduction of modern methods of wound-dressing, so far as prognosis goes, although if asepsis is not secured and maintained, in the more severe cases the old rules will still hold

good: moreover, the ability rapidly to remove the drain of free suppuration and relieve pain by Thiersch's method of skin-grafting lessens the secondary mortality of extensive burns or scalds. For practical purposes only three classes of burns and scalds need be made, viz.: (1) those presenting erythematous inflammation of the skin without vesication; (2) those in which the inflammation of the skin results in the formation of vesicles and bullæ; (3) those in which partial or complete carbonization of the part results, or in which from the secondary effects of inflammation more or less extensive and deep sloughs form.

Death, when it occurs, results early from shock; after reaction, from congestion of internal organs produced by reflex vaso-motor paresis, or from these congestions going on to actual inflammation of the pulmonary or gastro-intestinal mucous membrane, of the serous membranes, etc.; after suppuration is established, exhaustion, erysipelas, pyemia, septicemia, and tetanus may end life. Œdema of the glottis from scalds of the mouth is a very fatal complication, while perforating ulcer of the duodenum sometimes occurs.

The **prognosis** depends upon the extent and depth of the injury; thus mere reddening of two-thirds of the cutaneous surface will almost inevitably result in death, while destruction of one-third of the skin will probably produce the same result; yet most burns of the first and second classes of the extent commonly met with in practice will recover; in burns of the third class the region affected, the depth to which the tissues are destroyed, the age, sex, and previous health of the patient, will determine the result; thus even slight burns of the third degree may be fatal to the young or old.

Symptoms.—These are local and constitutional. The local vary with the depth of the injury, from mere reddening and swelling, up through vesication, excoriation, and partial destruction, to charring. The pain may be of every grade, from moderate burning up to intense agony, the most painful variety of burns being that in which the outer layers of the skin are destroyed, exposing the nerve-endings, less pain being complained of when total destruction of the skin has taken place. The constitutional symptoms vary from slight fever in burns of the first class to profound shock in the deeper forms, followed by reaction, and this succeeded by congestion or inflammation of some one or of many of the viscera. Thus death may result from cerebral coma; later, the exhaustion incident to suppuration, pain, or hemorrhage, with the inflammation of the kidneys or nervous centers liable to set in at this stage, is apt to carry off the patient.

Local Treatment.—In slight or moderate burns and sunburn nothing else relieves the pain so well as wrapping the part in cloths wet with a saturated solution of bicarbonate of sodium or ordinary "baking soda," or a weak dilution, 1 : 8, of phénol sodique.

In severe burns remove the clothing with great care, lest the cuticle be torn off; relieve the tension in the blisters by pricking them with a needle; avoid exposure to cold during the removal of the clothing and during the after-dressing; disinfect the parts with warm boric acid or boro-salicylic lotions; dress the parts so as to exclude the air and keep them antiseptic by boric acid, iodoform—in reasonable amounts—oil of eucalyptus, or other non-poisonous drugs, and by enveloping the parts in cotton rendered aseptic by prolonged heating. Subsequent dressing should be done only when absolutely necessary on account of the pain, the sloughs being carefully removed or trimmed away, and the most unirritative germicidal solutions employed for cleansing the surfaces. Where destruction of tissue has occurred, splints, elastic traction, and position must be employed to prevent or overcome cicatricial contraction, while early attention must be paid to the condition of the granulations, with free skin-grafting—

either from human sources or from the lower animals—after Thiersch's method. Weak solutions of sulphate of copper, or of chloral, grs. x–ʒj, to stimulate the formation of granulations, and repression of the same by the solid nitrate of silver and pressure when flabby or redundant, will suffice in many cases to ensure healing, and should precede skin-grafting when this is indicated.

Constitutional Treatment.—If shock is severe, stimulants, such as ammonia and alcohol, with warm coverings, hot bottles, etc., and opium internally, should be used; later, fluid nourishment, regulation of the bowels and of the cutaneous and renal secretions, with iron, quinine, and treatment calculated to support the system under the drain of prolonged suppuration, and treating such complications as pneumonia, pleurisy, peritonitis, enteritis, or hemorrhage on general principles, constitute all that can be done.

The scars resulting from burns and scalds are almost certain to contract more or less for a long time afterward, and produce in bad cases most terrible deformities. These are to be prevented as far as possible by position, splints, active and passive motion, etc., and later by operative measures. (See Orthopedic Surgery, Surgery of the Face, and Plastic Surgery.)

LIGHTNING-STROKE.—Instantaneous death or only temporary unconsciousness may result. Sometimes superficial or deep burns, or paralysis of the special nerves or of those of general sensation and motion, may be occasioned.

Treatment.—The application of external warmth, artificial respiration, and stimulants are indicated during the stage of shock; later, galvanism and strychnia internally may aid in the restoration of the paralyzed nerves. The local lesions must be treated in the same manner as burns of the same class.

FROST-BITE.—This term is used to designate the local results of cold, the destructive effects being either direct or more usually indirect from inflammation. The depressing effect of cold upon the circulation of the part is such that this ceases, and the part may be actually frozen. With due care the vitality may yet be restored; but even when actual congelation of the part has not occurred, unskilful treatment will determine gangrene.

Symptoms.—First numbness and tingling, then loss of power, usually commencing in the fingers and toes, and a sense of weight, are complained of; finally, absolute loss of sensation is noted, and the parts are bleached, white, and icy cold to the touch. Those parts which are hopelessly frozen, at first white, cold, and insensible, after reaction either become swollen and discolored, or may shrivel up and contract. Gangrene does not usually set in for some little time, it being not unusual for the parts to look quite well for some days, then to become discolored, bluish, next dark-blue, and finally black. A line of demarcation forms, evidenced by inflammation in the contiguous living tissues, and then a line of separation—*i. e.* ulceration—sets in, resulting eventually in the separation of the dead tissues.

Treatment.—As the result to be dreaded is partial or total death of tissues the vitality of which has been seriously lowered by cold, and as undue reaction will either determine the immediate death of the parts or give rise to such a degree of inflammation as will destroy them by the compression exerted by the exudates upon the feeble circulation, the indication is clear—viz. *gradually* to induce a return of the heat-producing power of the parts. The transition must be slowly progressive; thus, gently rubbing the parts with snow or employing friction while they are immersed in iced water is advisable, this being done in a room where the temperature is low; even the warmth of the bed has been known to set up inflammation, which tends, as has been shown, to run on into gangrene. Of course anything like approach to a fire must be avoided. As soon as the general bodily temperature and that of the part have become about

normal, stimulating friction with soap-liniment, alcohol, and water or spirit of camphor, with elevation of the parts, should be tried, after which, the air of the room having been gradually warmed, exposure to the air for a time is advisable; then cover the parts with cotton: as reaction progresses, stimulants and warm drinks may be cautiously administered. If excessive reaction takes place, evaporating lotions of equal parts of alcohol and water are indicated. Should gangrene set in, the treatment must be such as is proper for this condition.

Constitutional Effects of Cold.—This is first stimulating, the circulation being increased in force and frequency; then pain and uneasiness supervene; general numbness and coldness, with drowsiness, inducing an almost irresistible desire to sleep, are finally experienced, which if yielded to means death from congestion of the viscera, the slowing respiration and failing nervous power and circulation making up a complexus of symptoms like those of apoplexy. Sudden chilling produces death by cerebral anemia, slow prolonged exposure to cold kills by cerebral congestion, while sudden exposure to warmth produces a fatal result from embolism; partial freezing usually causes fatal congestion or sometimes anemia, both induced by capillary embolism.

Treatment.—In addition to the local means advised to prevent sudden reaction, artificial respiration should be tried, and the temperature of the apartment must be raised even more gradually than when dealing merely with a frozen member.

Chilblain or Pernio.—This results from the sudden application of cold to any exposed part, as the nose, ears, lips, fingers, or toes, of debilitated persons. Moderate exposure to dry cold, or even to cold, damp air, followed by the sudden increase of temperature induced by approach to the fire, is a prolific cause of the slighter forms, especially in children and those with feeble circulation.

Symptoms.—These may be only a slight degree of redness, swelling, heat, and itching, which subside almost without treatment; or a more severe condition may exist, marked by considerable swelling, such deep congestion as often to produce a bluish tinge of the skin and very annoying heat, pain, and itching. Although usually a favorable termination is to be expected, cases occur where the inflammation runs higher, and vesicles form, which rupture and leave obstinate ulcerations. If neglected, these ulcers may degenerate into foul sores, even the bones becoming bared and carious; but such results are decidedly exceptional, the variety characterized by slight local congestion, tenderness, and itching being that usually seen.

Treatment.—This should be prophylactic as well as curative. Persons once attacked are liable to relapses upon slight provocation. Warm woollen socks, gloves, and proper mufflers for the ears and face should be worn. As a feeble circulation favors pernio, frictions of the parts to stimulate the circulation, with general tonics, are advisable. Avoid any sudden approach to the fire after exposure to cold. In mild acute chilblains gentle frictions with snow and the application of iced water, with rest and the use of lead-water and laudanum, usually suffice. In the more chronic forms, when the skin is unbroken, stimulant and astringent applications to the locally sluggish circulation, such as tincture of iodine, alcohol, camphorated soap-liniment, oil of turpentine, oil of peppermint pure or diluted up to even six parts of glycerin, and numerous other similar applications, have all been successfully employed; in especially chronic or recurring cases the constant galvanic current has proved serviceable. When ulcers form they must be treated upon general principles.

Callosities.—These are flattened, irregular, translucent, yellowish, dense

thickenings of the cuticle, which are developed by prolonged pressure and friction, and are usually seated over bony prominences. According to their situation and cause their appearance varies; thus various mechanical trades will show thickenings on the hands differing in situation and appearance. The soles and sides of the feet are common situations. So long as the exciting cause persists, the thickening will remain, but usually when this has ceased to act for a considerable time they gradually disappear, either exfoliating *en masse* or more gradually desquamating. The only troubles to which they give rise, beyond slight diminution in sensibility and freedom of movement of the parts, are the tendency to form fissures over the flexures of the joints, and the occasional excitation of pain, heat, and suppurative inflammation from irritation of the subjacent tissues.

Treatment.—Except in the event of the last two contingencies, treatment is rarely needed. For fissures the application of softening ointments, as diachylon spread upon lint, unirritating warm antiseptic washes or fomentations, and quiet of the parts if the cracks be deep, secured by firm coaptating strapping with adhesive plaster, are usually sufficient; if abscess forms, treat it as such.

Clavus, or Corn.—A corn is a circular, flattened, hemispherical, circumscribed thickening of the horny layer of the epidermis, extending in the form of a cone below the normal level of the corium, constant pressure having produced some localized absorption of this structure. Corns result from pressure or friction either of the shoes or of adjacent surfaces, as those of contiguous toes; in the latter situations, from the constant moisture, the usually yellow, horny, epithelial masses being substituted by soft, whitish collections of epithelium (soft corns), which, being removed, leave a slightly elevated margin of white, sodden cuticle with a central reddened depression—*i. e.* the deepest layers of the epidermis—through which is seen the congested corium. Pressure always produces pain by driving the conical mass of epithelium down upon the sensitive corium, while, from constant irritation, inflammation and even suppuration are not uncommon.

Treatment.—Since pressure from improperly-shaped shoes is the usual cause, these must be improved in form, pressure must be taken off by felt rings, and after prolonged soaking in warm water containing washing-soda the outer layers of the corn should be gently scraped away with a sharp knife—this is better than digging them out with the point; the tender surface should be protected by a little patch of salicylic rubber plaster. Or the reverse process may be employed—*i. e.* hardening by applications of tincture of iodine or nitrate of silver at night, and in the morning removing with the knife the hardened tissue. The following prescription, painted on at night and scraped off in the morning, is excellent:

℞	Acid. salicylici,	ʒiss;
	Ext. cannabis indicæ,	grs. x;
	Collodii,	℥j.
M. Sig.—Paint on daily.		

Soft corns should have the softened epithelium gently removed, and be desiccated by keeping the surfaces separated, at the same time removing pressure by proper disposition of pads of absorbent cotton, preceded by free dusting with equal parts of boric acid and oxide of zinc. Inflamed corns must be treated by rest, and warm, moist antiseptic dressings, the pus being let out when formed, remembering that in the old, in whom senile vascular changes have occurred, erysipelas and gangrene not infrequently result from trimming a corn too closely.

Horns (Cornu Cutaneum).— These are solid, wrinkled, dry, hypertrophic outgrowths of the skin; they may be twisted, elongated, flattened, or mush-room-shaped, and are brownish-yellow, gray, or black in color. They vary from the size of a mustard-seed to several inches in length, may be single or more rarely multiple, have flattened or concave bases attached to normal or inflamed skin, and, while found on any part of the body, are most common upon the face. Elderly persons are most liable to this affection, the young being rarely attacked. Of slow growth, and painless unless injured, they sometimes drop off, a new horn springing from the shallow ulcerated base. In structure they consist of hyperplasia and cornification of the epidermic cells, with hypertrophy of the papillæ; or, again, they may spring from the interior of a sebaceous gland, an old ulcerated sebaceous cyst being often their starting-point. Warty growths may also be the origin of horns, and the bases of all forms may undergo epitheliomatous degeneration.

Treatment.—Owing to their tendency to re-form, the base from which they spring must be freely dissected out, or destroyed by chloride of zinc, caustic potassa, or the thermo-cautery.

Warts (Verrucæ).—Warts are circumscribed, elevated hypertrophies of both the papillary and epidermic layers of the skin. The common variety (*V. vulgaris*) most commonly appears upon the hands of children, but may occur on other parts and at any age, forming flattened or semiglobular projections, varying in size from that of a pin-head to half an inch in diameter. Primarily of the same color as the surrounding skin, they become darker and harder after a time, and the elongated papillæ, covered with cornified epithelial cells at first, may become partially denuded of these and present the appearance of a number of projecting points, with a circumvallation of thickened cuticle: this is popularly termed a "seed-wart." Warts may be single or multiple, may rapidly attain their full size, may last indefinitely or spontaneously disappear at any stage, and are not contagious: if picked or wounded, they bleed freely, being often very vascular. The *filiform wart*, occurring in narrow lines along the free edges of the nails or elsewhere in patches, is formed by excessive elongation of the papillæ, without the surrounding epidermic rim of the ordinary form. The flat wart (*V. plana*) is never much raised above the surface, retains its outer layer of epidermis, and therefore possesses a smooth surface. Warts may occur upon the scalp singly or in small numbers, and consist of numerous projections, compressed at their bases, but standing out at the periphery; they are often very vascular. Anatomically they consist of hyperplasia of the papillæ, of the blood-vessels, and of both the rete and the horny layer of the epidermis. A form appearing congenitally, or even later in life, apt to be pigmented and to become hairy, is called *nævus verrucosus*. When such pigmented hairy growths occupy considerable portions of the surface and coincide with the courses of important cutaneous nerves, they are called *papilloma neuroticum*, and cause great disfigurement.

Treatment.—Painting the growths with the juice of the milk-weed, with tincture of iodine, or with a solution of perchloride of iron, or applying moistened powdered chloride of ammonium, will often cause their disappearance. If these means fail, or if time is an element, free painting with bichloride of mercury, gr. xxx to ʒj of collodion, touching once or twice with one of the strong mineral acids, or repeated applications of glacial acetic acid, may be resorted to: care must be exercised when employing any of these agents over superficial joints, lest they penetrate too deeply. Excision by the knife, snipping them off with curved scissors, or curetting them away when soft, is of course the quickest means of removing warts. Hypodermatic injections of cocaïne will avoid pain.

DISEASES OF THE NAILS.

Although chronic inflammatory affections of the neighboring skin often produce changes in the form, color, and thickness of the nails, these so rarely call for surgical interference that they will not be described here.

HYPERTROPHY.—This can result only from hyperplasia of the papillæ of the matrix, the thickening of the nail occurring at the base, front, lateral edges, or over its whole extent, according to the parts diseased. The nail may be evenly thickened or variously curved or twisted, while its structure becomes brittle, opaque, and discolored. Removal of the most projecting portions of the nail will reveal the papillæ elevated far above the normal level of the matrix. The change is slow, progressive, and when pronounced is usually permanent. The causes are not well understood: pressure, however, seems to be an exciting cause, this being more efficient in the nails of the toes, especially those of the great and little toes. The old, whose epithelial structures tend to overgrowth, are more liable to hypertrophy of the nails than the young. When attacking the fingers, beyond the blunting of the tactile sensibility and the deformity, no special trouble arises, unless painful cracks form from the splitting of the brittle nails. When affecting the feet, however, it is difficult for the patient to wear shoes, the pressure leading to inflammation of the adjacent soft parts. It is thought that mere abnormal broadening of the nail is one of the causes of "ingrowing toe-nail."

Treatment.—When the deformity seriously interferes with the appearance or use of the foot, the nails must be reduced to normal dimensions by strong scissors, with the knife or a fine saw, removing at the same time as deeply as possible the elongated papillæ, which may be cut across during the operation, and then cauterizing with perchloride of iron. When lateral hypertrophy without thickening or incurvation is present, before inflammation has been excited, frequent trimming of the anterior margins and corners of the nail has been recommended. When actual ulceration of the lateral fold has occurred, removal of an elliptical portion of the hypertrophied fold, suturing of the wound, removal of a strip of nail, including the matrix underlying it, followed by the use of wide-toed shoes, are the measures best adapted to cure the disease. Thinning the nail by scraping a groove with a piece of glass, and packing a little cotton beneath the buried edge of the nail, if persevered in, aided by repression of the granulations by dusting with nitrate of lead, touching with nitrate of silver, etc., will eventuate in the cure of a certain number of cases.

INFLAMMATION OF THE MATRIX (ONYCHIA).—As a result of traumatism in unhealthy individuals inflammation and suppuration sometimes occur at the root of a finger-nail and in the contiguous portion of matrix ("run-around"), and often stubbornly continue unless the loosened, sharp edge of the buried nail be carefully trimmed away from time to time and a little iodoform cotton be employed to press back the inflamed tissues. From lateral hypertrophy of a toe-nail the sharp lateral edge of the nail becomes imbedded in the lateral fold, or from improper lateral compression of the toes the same portion of soft tissues is forced up against the margin of the nail, in either case causing inflammation, suppuration, and ulceration, resulting in the formation of red, exuberant, excessively painful granulations, constituting the condition called **ingrowing toe-nail**, though more correctly, in most instances, it should be termed "up-growing pulp." Sometimes both edges, or even the whole matrix, become involved, producing pain on any movement of the member. When inflammation and ulceration of the whole matrix occur, especially where a finger is involved, the condition is termed "**onychia maligna**:" it attacks only those in depressed health.

Treatment.—The treatment suggested for hypertrophy of the nail is indicated for all inflammation of the matrix, so far as removal of the portion of nail producing irritation is concerned, but in onychia maligna the whole nail usually requires removal under anesthesia, with destruction of the matrix by caustics, or, better, dressing with powdered nitrate of lead or iodoform, and the internal administration of iodide of iron, cod-liver oil, etc.

TUMORS OF CICATRICES.

Hypertrophied Scars.—Commonly these are masses of dense fibrous tissue resulting from prolonged cicatrization due to extensive losses of substance. Hypertrophied scars assume a nodular, stellate, and reticular band or bridle form, either by the time cicatrization is completed or shortly afterward from further contraction; or, again, long subsequently to the healing, apparently normal, non-elevated scars take on this hypertrophic process, resulting in the formation of tumors presenting the most varied appearance. No cause can be assigned for these secondary fibroid alterations of scars, which sometimes attack those resulting from small linear incisions. The condition differs from keloid chiefly in the disarrangement of the component bundles of fibrous tissue and the entire absence of the papillary layer of the skin. The vascular supply, free at the outset, diminishes as the scar contracts.

Treatment.—Excision, followed by a plastic operation, is all that can be recommended, and that for exceptional cases only, because the resultant scarring will of necessity be greater than that of the original trouble, and too often the new cicatrix undergoes hypertrophy; doubtless some of the cases are closely allied to, if not a variety of, keloid.

Fig. 192.

Keloid (original).

Keloid.—This is a connective-tissue neoplasm arising in a scar, and may develop single or multiple tumors (Fig. 192).

Symptoms.—Commencing usually as a small elevated nodule, as it slowly enlarges it tends to assume an elongated oval form with irregularly radiating, well-defined projections, presenting a rude resemblance to a crab; or, again, it may affect a linear form. The growth—generally devoid of hair—is a smooth, firm, elastic, pale-red, elevated, cicatrix-like mass, usually painless, but some-

times, especially on pressure, the reverse; more rarely itching is complained of. Its favorite site is over the sternum, but it is met with over the mammæ, on the neck, ears, arms, and elsewhere. In those rare instances where it becomes inflamed, keloid may present a temporary appearance of malignancy, but this condition usually subsides spontaneously. The course may be either rapid or slow, but, having reached a certain point, a keloid is apt to remain stationary for a time or for life, although it sometimes disappears. Although it is stated that keloid can arise spontaneously, it usually starts from some trauma of the skin, as the scars of burns, cuts, floggings, or the perforations in the lobes of the ears for ear-rings. The colored race is decidedly more liable to the development of keloid than the white. Microscopically, the growth consists of dense fibrous tissues involving the corium and extending especially along the adventitious tissue of the vessels.

Prognosis.—Although, as has been stated, keloid sometimes disappears, the outlook is not very favorable; temporary arrest in growth may continue for years, yet the growths may again enlarge.

Diagnosis.—This is easy, the only condition with which it can be confounded being a simple cicatrix, which differs in color, outline, elevation, and consistence; moreover, scars do not increase in size.

Treatment.—This is unsatisfactory. Removal by the knife or caustics should never be undertaken while the growth is enlarging; if any caustic is used, the best is potassa fusa. Repeated scarifications (see Lupus) or multiple electrolytic punctures may succeed. Anodyne liniments or morphine hypodermatically may be required to relieve pain.

LUPUS.

As lupus vulgaris is the variety of chief interest to the surgeon, lupus erythematosus will be merely incidentally described under the head of differential diagnosis. Lupus vulgaris is a chronic new-cell growth, due to the bacillus tuberculosis, which forms variously-sized reddish or brownish masses consisting of an aggregation of papules or tubercles, the usual termination being ulceration followed by cicatrization.

Symptoms.—The disease commonly begins in youth as small, yellowish or reddish-brown points beneath the skin, which increase and coalesce, forming irregular roundish or serpiginous, ill-defined patches; papules usually form and enlarge until they become tubercles; the lesions vary from the size of a pin-head to that of a pea, and are covered with ill-formed epidermis. They may be either firm or soft, and are painless. One of two changes follows: viz. retrogression by absorption of the lesions takes place, leaving a thin cicatricial tissue covered with desquamating epithelium; or ulcerative destruction of the infiltrated skin occurs, with subsequent cicatrization, producing much disfigurement. While the limbs and trunk may be attacked, the nose, cheeks, and ears are the favorite sites; it destroys the nasal and palpebral cartilages, and even the eye when attacking the face, sometimes also extending into the mouth. The extremities are frequently attacked, especially the fingers, the disease then often resulting in serious deformity. It is never congenital, is rarely hereditary, is uncommon among native Americans, and usually attacks only debilitated, underfed persons of the lower classes.

Diagnosis.—Syphilitic lesions most closely resemble those of lupus, and the distinction must depend chiefly on the history, in conjunction with the following facts: lupous ulcers are relatively superficial and less extensive; syphilitic ulcers are deep, excavated, and extensive; the numerous spots of ulceration in lupus tend to become confluent; syphilitic ulcers usually remain distinct, and,

moreover, have sharply-defined margins; the secretions of lupous ulcers are thin, brownish, scanty, and inodorous, while those of syphilitic ulcers are thick, often greenish, abundant, and offensive; lupous ulceration is slow, taking years to reach the same size that a syphilitic ulcer would attain in the same number of weeks; the lupous scar is yellowish, hard, and distorted; that of syphilis is smooth, thin, whitish, and small compared to the extent of the original ulceration; finally, a history of other syphilitic manifestations is often obtainable in syphilitic ulceration. (See p. 159.) Lupus erythematosus usually appears after puberty, beginning as an erythema; the orifices of the sebaceous glands are often gaping and distended with hardened sebum; ulceration never occurs, and after the disease disappears a cicatricial appearance of the skin is left. Epithelioma is more localized, is painful and circumscribed; induration exists; epithelial ulceration usually extends from one point, while that of lupus has a multiple origin; finally, epithelioma is rarely a disease of youth.

Prognosis.—If limited, the prognosis is fair, but when the disease is extensive it is very stubborn and results in marked scarring and deformity.

Treatment.—In the early stages cod-liver oil, combined with iodine and phosphorus, should be faithfully tried, with stimulating absorbent applications, such as equal parts of tincture of iodine and glycerin, mercurial plaster, tar ointment, or the ointment of red iodide of mercury. Linear scarifications, repeated as often as necessary, making numerous parallel cuts which must be crossed at various angles by others similarly disposed, is often very successful, leaving eventually a healthy scar; or the galvano-cautery may be employed under anesthesia. When milder measures fail, recourse must be had to caustics, of which chloride of zinc and pyrogallic acid are the best. Caustic potassa, in stick form, should be bored into the diseased parts, and be promptly neutralized by dilute acetic acid or vinegar. The papular and tubercular masses can sometimes be successfully treated by working a stick of nitrate of silver into them, while the patches should be repeatedly painted over with a saturated solution of the same: this is said not to leave scars. One dram of pyrogallic acid to the ounce of ointment, applied thickly on lint twice daily, often does well. Freezing the parts with rhigolene or ether and curetting with small, sharp curettes, supplemented by applications of pyrogallic acid, is an excellent measure; or still better the patient may be etherized and thorough erasion of the patches be done with the sharp spoon. Where the patches are of suitable size and in a favorable position, excision is proper. Koch's lymph, especially in the modified form (see p. 80), has seemed to be of more service in lupus than in any other form of tuberculosis.

Perforating Ulcer of the Foot.—This is often a misnomer, no true ulcer being present, but an opening communicating with a sinus, the orifice being perhaps surrounded with granulations, and the neighboring skin only slightly inflamed; sometimes, however, the skin is extensively ulcerated: the opening may be in the center of a corn. The usual position is over the metatarso-phalangeal joint of the great or the little toe, although other parts may be affected and several points at the same time; one or sometimes both feet may be attacked. The discharge is generally slight and sanious, and the opening is found by probing to be the orifice of a sinus leading down to diseased bone. There is marked insensibility of the diseased part, and a varying amount of anesthesia exists over an irregular area, extending sometimes to just below the knee; the toes are especially anesthetic. The local temperature is usually reduced; during the early stages abnormally free sweating occurs, and later, owing to organic changes in the tendons, distortion of the toes follows: the nails are yellow, cracked, and twisted laterally. Increased epithelial formation occurs

upon the sole and dorsum of the foot, while the hairs and the depth of color of the skin are increased. Dissections show the foot to be traversed by sinuses leading to carious bone, inflamed bursæ, and opened joints with eroded cartilages. These changes result from thickening of the endoneurium, with compression and destruction of the sensory nerve-fibers. Contusion of the foot by injuring a peripheral nerve may cause perforating ulcer, or the nerve lesion may possibly be central.

Prognosis.—This is doubtful, owing to the liability to recurrence from the persistence of the nerve lesions, even if healing should occur after rest.

Treatment.—In its early stages prolonged rest in bed, or even the use of an artificial limb attached to the bent knee, will often secure temporary healing, but, in most cases, as soon as the member is used again the sore recurs. Excision of the ulcer is useless, nothing short of a Syme or a Pirogoff amputation availing. These measures are usually successful, for, although the whole anesthetic area is not removed, experience shows that the skin of the heel is able to bear the pressure without ulceration; occasionally amputation below the knee is requisite, beyond which point the anesthesia probably never extends.

MALIGNANT DISEASES OF THE SKIN.

Epithelioma may be either superficial or deep-seated, the former appearing as small yellowish-red papules or flattened aggregations of the same, situated in the upper layers of the skin, which eventually crack or become excoriated, giving vent to a scanty watery or viscid secretion drying into thin brownish crusts; the patch enlarges by additions to its periphery, and finally breaks down into a superficial, spreading, rounded or irregular ulcer, its border usually elevated into a "pearly ridge," although this may be level with the skin, with a sloping or sharply defined edge: the base is infiltrated, hard, bleeds readily, and secretes a scanty viscid fluid. Pain is rarely complained of, and involvement of the lymphatic glands seldom occurs. Unless the disease develops into the infiltrating variety, the ulcer when once formed remains almost unchanged in extent for a long time.

Rodent Ulcer, a variety of epithelioma, in this superficial form is most frequently situated at the inner canthus or upon the side of the nose. It is a disease of late adult life. It commences as a thickening of the skin which continues to extend as a flattened nodule, and, becoming centrally abraded, degenerates into an ulcer, at first of a rounded form, later irregular in outline. The base and margins are indurated, the latter being somewhat abrupt or rounded, firm, and slightly elevated. The surface of the ulcer is smooth or slightly granular, glossy, dry and of a pinkish-red color. Progressing slowly and attended with but little pain, although cicatrization may occur at spots, the disease is never spontaneously arrested, everything in its course being destroyed, including the bones, until the orbits, nose, and mouth may form one crater-like opening; in advanced cases severe hemorrhage from ulceration of large vessels is not uncommon.

Deep-seated Epithelioma begins as a small reddish tubercle or warty growth involving the whole skin and subcutaneous tissue, with an indurated, infiltrated base; usually within a few months, from failing nutrition, ulceration begins at the older portions, producing an irregular ulcer with a foul, bleeding, indurated base. Pain is often severe, lymphatic involvement occurs sooner or later, and death results from exhaustion due to pain, discharge, and septic absorption. The most common sites are the lips, tongue, nose, eyelids, forehead, scalp, penis and scrotum, and labia. Chronic ulcers, old cicatrices which have become irritated, and psoriasis may all degenerate into epithelioma,

and chronic irritations, such as those caused by a jagged tooth, by pruritus ani, etc., may give rise to the disease.

Diagnosis.—This must depend upon the points already given, upon the rapid growth and early ulceration of a flattened tubercle or wart, induration of the base of the ulcer, age over forty years, and involvement of the lymphatics.

The **treatment** is free removal, including an area of healthy tissue. The knife, galvano-cautery, or caustics such as potassa fusa or pyrogallic acid, after freezing and curetting, may be employed.

CARCINOMA.—This occurs in three forms: 1. The **lenticular** or **scirrhous** form commences as slowly-growing, smooth, shiny, brownish-red, flat, disseminated papules or tubercles, which later become confluent; these are painful, ulcerate, involve the lymphatics, and recur after removal, finally destroying life. 2. The **tuberous** form occurs as firm, hard, flattened, raised, rounded, or oval nodular masses, varying in size from that of a pea to an inch or more in diameter, involving the skin and the underlying tissue. They are dull red, multiple, discrete, or confluent, and terminate by ulceration, lymphatic infection, and death. 3. **Melanotic carcinoma** commences as small, multiple, rounded or oval, soft or moderately firm papules, finally becoming confluent. They are brownish, purplish, or black, ulcerate, often forming gangrenous fungating ulcers, involve the lymphatics, and eventually cause death: this variety usually commences in a mole or pigmented wart on the hands or feet during early adult or middle life.

Cancerous ulcers differ from simple ulcers as follows: The malignant ulcer is excavated, with elevated, everted, knobby, sinuous margins. The base is nodular, infiltrated, and therefore *fixed*, often readily bleeds when touched, is granular, livid, or covered with yellowish or grayish sloughs, and exudes a profuse offensive ichorous or sanious discharge, which usually excoriates the surrounding skin. The ulcer tends to spread continuously in extent and depth, involving all the tissues, even bone, in its path. The breaking down is preceded by a nodular irregular infiltration of the tissues and skin, the latter often presenting a livid-red or violaceous, glazed appearance. Here and there nodular or tubercular cancerous infiltrations are often seen, situated some distance from the ulcer, with comparatively or—to the eye—absolutely normal skin intervening. Again, much of the surrounding skin may be more evenly infiltrated and fixed to the subjacent parts, presenting the well known "hog-skin" appearance.

Treatment.—The same as for epithelioma.

SARCOMA occurs as small single or multiple, variously-sized discrete tubercles or tumors, which may or may not be pigmented. Smooth, firm, elastic, slightly tender on pressure, the non-pigmented tumors are reddish, purplish, or brownish red. The multiple pigmented sarcoma is described as invariably commencing on the plantar and dorsal surfaces of the feet. Sarcoma occurs toward middle life and pursues a malignant course. Ulceration of sarcoma of the skin does not usually produce much destruction of tissue. When involving the deeper parts or organs, as the breast, and ulceration occurs late, secondarily attacking the skin, and extends rapidly, the ulcer presents a foul, fungous appearance, the margins are not indurated to any extent, and the discharges are abundant, often bloody, and sometimes offensive. Free hemorrhage is not uncommon.

Treatment.—Fowler's solution diluted with two parts of distilled water, given hypodermatically twice daily, commencing with two drops and increasing to its physiological limit, seems to be the only remedy which has proved successful. Early amputation is to be done where possible.

BOOK III.

REGIONAL SURGERY.

CHAPTER I.

DISEASES AND INJURIES OF THE HEAD.

I.—GENERAL CONSIDERATIONS.

Injuries of the head are peculiarly important from the fact that they may not be limited to the external soft parts and the bones, but may involve the brain, the great nervous center on the integrity of which life itself depends. The brain is well protected against ordinary injuries by moderate violence. Not only is the head covered with the dense, fibrous scalp, but the brain is further encased and defended by the hard, bony skull, which is practically a closed box, the thickness of which varies in different persons and in different regions. This bony case is arched on its upper surface, so that blows which would otherwise fracture and penetrate the skull glance from this curved surface and do but little harm. Moreover, the bones are distinctly resilient and elastic, yielding before a blow, but springing back to their former position without fracture unless the violence be too great. Its elasticity of course diminishes from youth to age. It is made up also of a number of bones united edgewise at the sutures, which to some extent diminish and dissipate the violence inflicted upon the skull, although a fracture often crosses the sutures. Moreover, a blow of sufficient violence may produce a fracture either at the point where it is inflicted, or, occasionally, though rarely, at a point opposite that at which the blow was received. This last form of fracture is called fracture by *contre-coup*, or counter-stroke. It should be observed that injury by counter-stroke is much more frequent in the brain than in the skull. There are a number of instances on record where a blow received on one side of the head has produced laceration of the brain, and even of the middle meningeal artery, on the opposite side. It will be seen, therefore, that in such cases if an operation is done, the question on which side of the skull it shall be done is to be determined by localizing brain symptoms rather than by the external evidences of injury.

Inside of this bony case lies the brain surrounded by its membranes, and more or less steadied and protected by a small amount of fluid normally existing in the skull, both on the outside of the convolutions and in the ventricles themselves. Not uncommonly there is a distinct area of œdema in the pia which undoubtedly acts as a buffer in fending off a blow, but in spite of this the brain must be looked upon as a soft mass of tissue more or less easily lacerated by commotion or shaking from blows and falls, even without any fracture of the bones.

Both the brain and its membranes are subject to inflammation, which is followed by irritation and later by exudation, swelling, and pressure, and the exudate cannot escape through the thick skull and scalp except a means of

exit be offered by the surgeon. Hence the frequent need for trephining. The pressure of this exudate may be relieved to some extent by the escape of some of the intracranial blood and of some of the cerebro-spinal fluid into the spinal canal; but if the pressure increases, the functions of the brain must be interfered with and become altered or even abolished, while the irritation may cause an exaltation of function. This alteration or abolition may apply to the intellectual, the sensory, or the motor functions of the brain, so that there may be mania or coma, hyperesthesia or anesthesia, and spasm or paresis or paralysis.

Moreover, the interference with function may be general, or if the pressure be local the alteration or abolition of function will be local, at least at the beginning, so that there will be paresis or paralysis of an arm or a leg, or of half the face; alteration or abolition of speech, either sensory or motor; hemianopsia if one cuneus be involved; and, if there be inflammation of or pressure on the optic nerves or tracts, optic neuritis will develop. Sometimes the alteration will be obscure, and functional rather than organic, so far as we can discover, and will produce headache, epilepsy, or insanity, without any perceptible change in the brain substance. When pressure is produced by a blood-clot, caused by a blow with or without fracture, and followed not uncommonly by a cyst, epilepsy is a not infrequent sequel. It seems also to be probable that the scar resulting from laceration of the brain tissue, even in simple fracture or contusion, may be followed by epilepsy, and that this may be relieved by the excision of the ragged scar and the substitution of a clean cut in the brain tissue. So far as we know, such an incised wound of brain tissue made antiseptically heals without being followed by the irritation which occurs after laceration of the brain.

While the general anatomical facts here stated have been of course long known, yet the localization of function in various parts of the brain has been proved and accepted only in the last twenty years, while cerebral surgery founded upon it practically began only in 1884. Broca in France, Goltz, Fritsch, and Hitzig in Germany, and Ferrier and Horsley in England, have done the principal work in solving the neurological problem, while Macewen and Horsley in England have created a new department in surgery. Until ten years ago the skull was regarded as a region so dangerous that Dante's motto might have been an appropriate warning: "Abandon hope, all ye who enter here;" and though there were occasional accounts of extraordinary and unexpected recoveries from accident, yet purposeful interference with the brain and its membranes was never to be thought of except where compound fracture with serious brain symptoms made it absolutely needful, and then it was undertaken with reluctance and fear. This was due, first, to our ignorance of the localizing value of the different parts of the brain, which differ from one another in function as much as the different viscera of the abdomen *inter se;* and secondly, to our ignorance of the fact, now amply proved, that if we employ the rigid antiseptic details practised by Macewen, and fully formulated by Horsley so late as 1886 and 1887, we can invade the skull-cavity with far less danger than was formerly thought possible. Inflammation and suppuration should rarely follow, provided antiseptic precautions are strictly followed. These precautions are given in detail under the head of Technique. They must be observed to the letter in every operation, no matter how slight, which can possibly involve the brain-cavity.

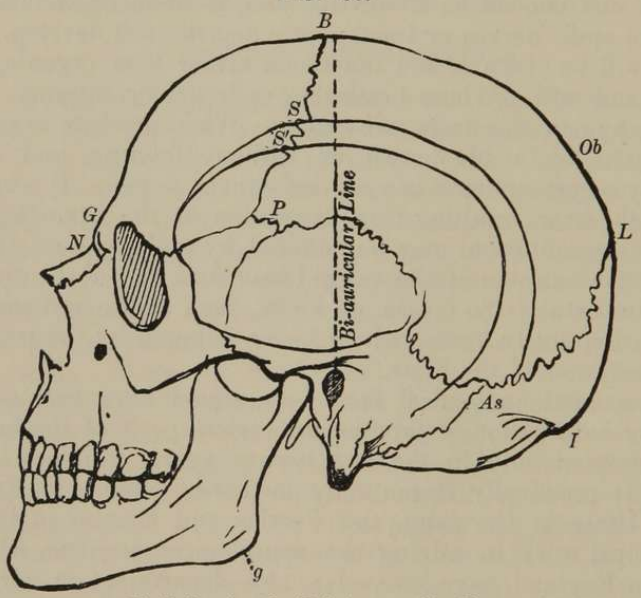
This revelation of the function of the various parts of the brain, and the similar revelation of the operative possibilities, have exercised a marked influence upon recent surgical practice. The aim of the present text-book will be

to place the surgeon abreast of the most recent experience; but, where treatment is of doubtful or as yet unproved value, a proper conservatism will be advocated; for it must still be recognized that any operation involving the brain is a very serious one and may be attended with danger to life.

II.—TOPOGRAPHY OF THE BRAIN IN ITS SURGICAL RELATIONS.

The situation of the chief fissures and convolutions of the brain, and therefore of the various ascertained cortical centers, has of late assumed the greatest importance, and they have frequently been mapped out on the exterior of the skull with almost absolute accuracy, without any other guide than the rules given below. Fig. 193 shows the points named by Broca on the skull,

FIG. 193.



Skull showing the Points named by Broca.

As, asterion (junction of the occipital, parietal, and temporal bones); Basion, middle of anterior wall of foramen magnum; *B*, bregma (junction of the sagittal and coronal sutures); *G*, ophryon (on a level with the superior border of the eyebrows, and corresponding nearly to the glabella, the smooth swelling between the eyebrows); *g*, gonion (angle of the lower jaw); *I*, inion (external occipital protuberance); *L*, lambda (junction of sagittal and lambdoidal sutures); *N*, nasion (junction of the nasal and frontal); *Ob*, obelion (the sagittal suture between the parietal foramina); *P*, pterion (point of junction of great wing of sphenoid and the frontal, parietal, and squamous bones. This may be H-shaped or K-shaped, or "retourné," in which the frontal and temporal just touch); *S*, stephanion (or, better, the superior stephanion, intersection of ridge for temporal fascia and coronal suture); *S'*, inferior stephanion (intersection of ridge for temporal muscle and coronal suture).

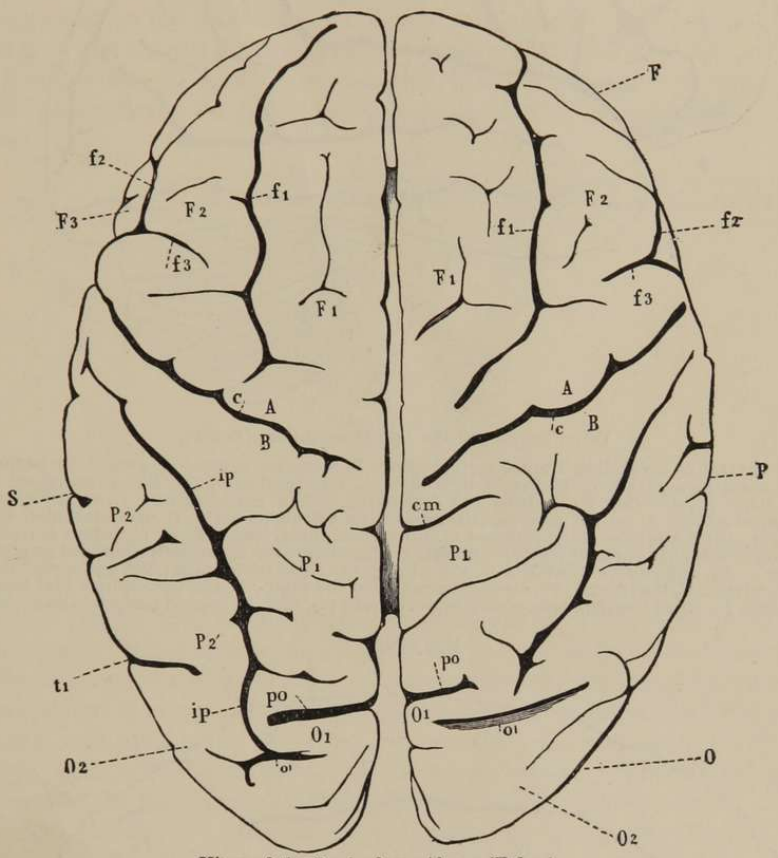
and Figs. 194, 195, and 196 show the chief fissures and convolutions of the brain.

The **fissure of Bichat** between the cerebrum and the cerebellum corresponds to a line drawn from the inion to each external auditory meatus. The **median fissure** between the two hemispheres is slightly to the right of the median line, the left hemisphere in right-handed persons being slightly larger than the right, and *vice versâ* in left-handed persons. The two lines just given also correspond respectively to the lateral and superior longitudinal sinuses.

The other three leading fissures which it is important to be able to locate on the exterior of the skull are, 1, the fissure of Rolando; 2, the fissure of Sylvius; and 3, the intraparietal fissure; especially the first two.

1. **The Fissure of Rolando** (Figs. 194, *c*, and 195, *c*), as Thane has shown, starts from a point which lies back of the glabella 55.7 per cent. of the distance from the glabella to the inion, and runs downward and forward at an angle of 67°, its average length being $3\frac{3}{8}$ inches. The lower third of the fissure changes to a somewhat more vertical direction. Practically, the fissure of Rolando commences half an inch behind the mid-point between the glabella and the inion. Mr. Horsley states that in a head with a cranial index of 75[1] the fissure

FIG. 194.



View of the Brain from Above (Ecker).

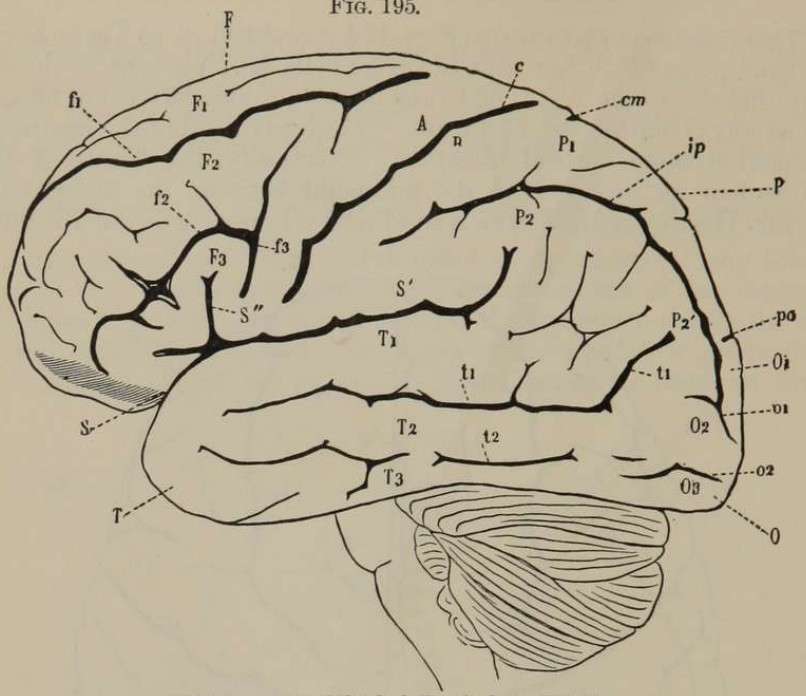
A, anterior central or ascending frontal convolution; *B*, posterior central or ascending parietal convolution; *c*, central fissure or fissure of Rolando; *cm*, calloso-marginal sulcus; *F*, frontal lobe; F_1, upper, F_2, middle, F_3, lower frontal convolution; f_1, superior frontal sulcus; f_2, inferior frontal sulcus; f_3, vertical fissure (sulcus præcentralis); *ip*, intraparietal sulcus; *O*, occipital lobe; *o'*, sulcus occipitalis transversus; O_1, first occipital convolution; O_2, second occipital convolution; *P*, parietal lobe; *po*, parieto-occipital fissure; P_1, upper or postero-parietal lobule; P_2, lower parietal lobule, constituted by P_2, gyrus supramarginalis, and P_2', gyrus angularis; *S*, end of the horizontal branch of the fissura Sylvii; t_1, upper temporal fissure.

runs at an angle of 69°, the angle increasing or diminishing one degree for every two degrees of increase or decrease in the cranial index. In all ordinary cases, however, the fixed angle of 67° will be found sufficient.

Chiene's Method.—Mr. John Chiene of Edinburgh has proposed a method of fixing the position and length of the Rolandic fissure which is at once simple, ingenious, and always available. He folds a square piece of paper once (Fig. 197, ABCD), on the diagonal line AC. The angle BAC is then evidently 45°. The angle DAC (45°) is then halved (22.5°) by folding the

[1] The cranial index is found by dividing the transverse diameter of the head by the antero-posterior diameter.

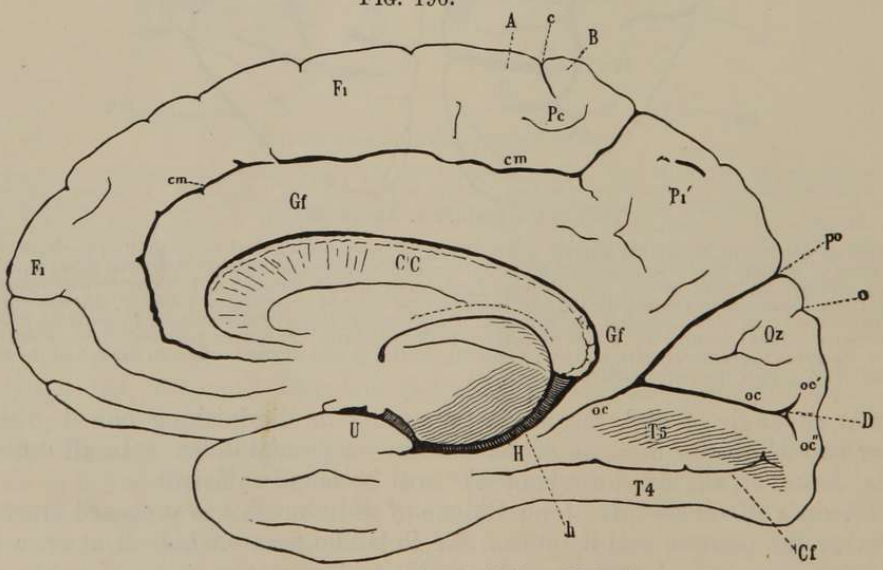
FIG. 195.



Outer Surface of the Left Hemisphere (Ecker).

A, anterior central or ascending frontal convolution; B, posterior central or ascending parietal convolution; *c*, sulcus centralis or fissure of Rolando; *cm*, termination of the calloso-marginal fissure; F, frontal lobe; F_1, superior, F_2, middle, and F_3, inferior frontal convolutions; f_1, superior, and f_2, inferior frontal sulcus; f_3, sulcus præcentralis; *ip*, sulcus intra-parietalis; O, occipital lobe; O_1, first, O_2, second, O_3, third occipital convolutions; o_1, sulcus occipitalis transversus; o_2, sulcus occipitalis longitudinalis inferior; P, parietal lobe; *po*, parieto-occipital fissure; P_1, superior parietal or postero-parietal lobule; P_2, inferior parietal lobule, viz.: P_2, gyrus supramarginalis; P_2', gyrus angularis; S, fissure of Sylvius, S', horizontal, S'', ascending ramus of the same; T, temporo-sphenoidal lobe; T_1, first, T_2, second, T_3, third temporo-sphenoidal convolutions; t_1, first, t_2, second temporo-sphenoidal fissures.

FIG. 196.



Inner Surface of Right Hemisphere (Ecker).

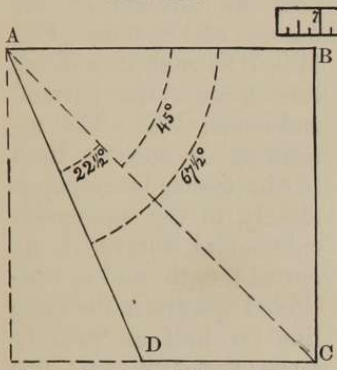
A, ascending frontal; B, ascending parietal convolution; c, terminal portion of the sulcus centralis, or fissure of Rolando; CC, corpus callosum, longitudinally divided; *Cf*, collateral or occipito-temporal fissure (Ecker); *cm*, sulcus calloso-marginalis; D, gyrus descendens; F_1, median aspect of the first frontal convolution; Gf, gyrus fornicatus; H, gyrus hippocampi; *h*, sulcus hippocampi, or dentate fissure; *o*, sulcus occipitalis transversus; *oc*, calcarine fissure; *oc'*, superior, *oc''*, inferior ramus of the same; *Oz*, cuneus; *Pc*, paracentral lobule; *po*, parieto-occipital fissure; P_1', precuneus; T_4, gyrus occipito-temporalis lateralis (lobulus fusiformis); T_5, gyrus occipito-temporalis medialis (lobulus lingualis); U, uncinate gyrus.

paper again on the line AE. The sum of the angles BAC and CAE is evidently 67.5°, which is near enough for all practical purposes to the angle of the fissure of Rolando. The side AB is then applied to the middle line of the head, the point A being placed half an inch behind the mid-point between the glabella and the inion, when the line AE will correspond to the fissure of Rolando.

The length of the fissure being $3\frac{3}{8}$ inches, Mr. Chiene suggests that every man who has seen his mother measure her tape on her right forefinger should know what point on his own right forefinger corresponds to $3\frac{3}{8}$ inches in length. This will give the length of the fissure of Rolando on the line AE.

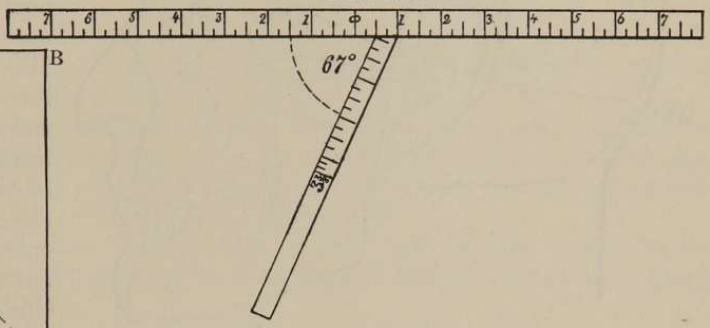
Mr. Horsley has devised an instrument made of metal or of two strips of parchment paper, as shown in Fig. 198, the antero-posterior arm being 14 inches

Fig. 197.



Chiene's Method of Fixing Position of Rolandic Fissure (original).

Fig. 198.



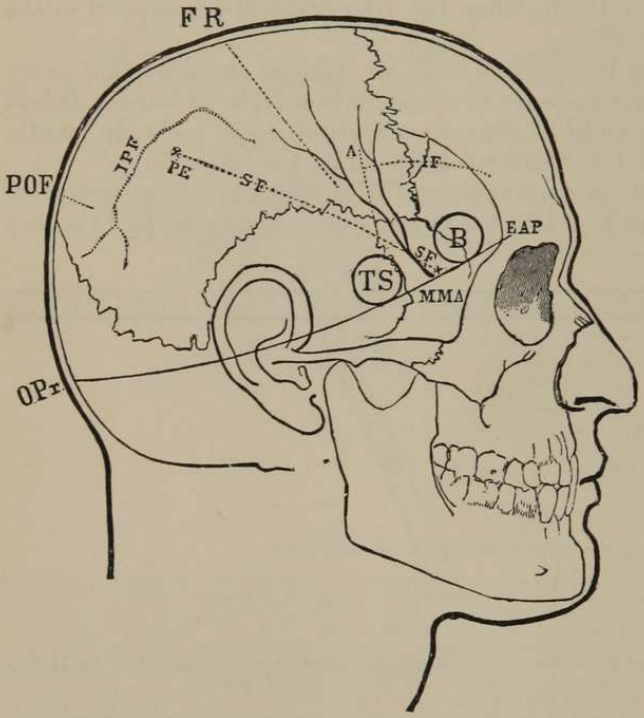
Horsley's Cyrtometer (as modified by Dr. Morris J. Lewis).

long, and the lateral arm being placed at an angle of 67°. The scale of this instrument starts from the zero point (half an inch in front of the lateral arm), and runs both forward and backward. To determine the fissure of Rolando, place the antero-posterior arm in the middle line in such a position that the glabella and the inion will each mark the same distance from the zero point on the scale; for instance, each six or six and a half or seven inches. The lateral arm will then correspond to the fissure of Rolando, except in the lower third, where, as already stated, the fissure becomes slightly more vertical. To admit of its use on both sides of the skull the lateral arm should be made reversible right and left, or the whole instrument may be reversed from side to side if it is graduated on both sides. Or one may use Wilson's cyrtometer, consisting of two strips of flexible metal at right angles to each other, forming a letter T, the horizontal strip secured to the head by a tape, with the lower border corresponding to the glabella and the antero-posterior arm in the middle line. On the antero-posterior arm there are two scales numbered from A to Q and from *a* to *q*. These are so placed that in any position the distance from the glabella to *a*, *b*, *c* is 55.7 per cent. of the distance from the glabella to A, B, C. If, then, A corresponds to the inion, the lateral arm is placed at *a;* if the inion corresponds to B, the lateral arm is placed at *b*, etc., and when placed in its proper position will indicate the position of the fissure of Rolando. In children below nine years of age the fissure is much more oblique (even down to 52°), and lies farther forward on account of the slighter development of their frontal lobes.

The importance of fixing the fissure of Rolando will be especially appreciated in observing the motor centers which cluster around this by far the most important of the cerebral fissures.

2. **The Fissure of Sylvius** (Fig. 195, S, S′, S″, and Fig. 199, SF and A).—To fix this fissure, draw a line from EAP (Fig. 199), the external angular process, to OPr, by the shortest route between these points. This usually passes at about half an inch above the meatus. The fissure of Sylvius begins one and one-eighth inches posterior to the external angular process on this line, and from this point the main line of the posterior branch of the fissure of Sylvius (Fig. 199, SF) runs in a direct line toward the parietal eminence, PE. The ascending or anterior limb of the fissure corresponds closely to the squamoso-sphenoidal suture in its entire length, and is continued upward in the same line for half an inch or more (Fig. 199, A). The middle meningeal artery is shown in the same figure in its relation to the Sylvian and Rolandic fissures.

FIG. 199.



Head, Skull, and Cerebral Fissures (adapted from Marshall by Hare).

B corresponds to Broca's convolution; EAP, external angular process; FR, fissure of Rolando; IF, inferior frontal sulcus; IPF, intraparietal sulcus; MMA, middle meningeal artery; OPr, occipital protuberance; PE, parietal eminence; POF, parieto-occipital fissure; SF, Sylvian fissure: A, its ascending limb; TS, tip of temporo-sphenoidal lobe. The pterion (to the left of B) is the region where three sutures meet, viz., those bounding the great wing of the sphenoid where it joins the frontal, parietal, and temporal bones.

The **pre-central sulcus**, or, as it is often called, the **vertical sulcus** (Fig. 195, f^3) is of great importance, as it limits the pre-Rolandic convolution anteriorly. It is sometimes joined by the inferior frontal sulcus (Fig. 195, f^2). It runs parallel to and just behind the coronal suture, at the width of one convolution in front of the fissure of Rolando. Its upper end does not extend as far as the superior frontal sulcus. The pre-Rolandic or ascending frontal convolution bends around the lower end of the pre-central sulcus, and forms a crescentic convolution which lies in the hollow of the two limbs of the fissure of Sylvius and is continuous anteriorly with the third frontal convolution. It is called the **operculum**, and in it, especially in its anterior portion (the base of the third frontal convolution), is Broca's center for speech.

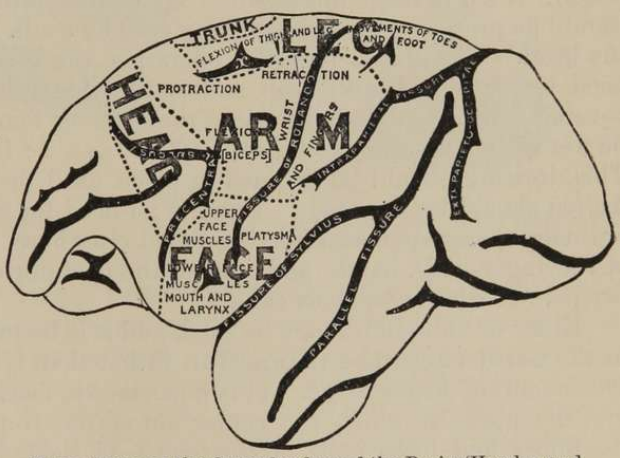
There are two **frontal sulci**, the superior and inferior, which divide the frontal lobe into three convolutions: the superior, middle, and inferior, or first, second, and third, frontal convolutions. The *superior frontal sulcus* (Figs. 194 and 195, f^1) starts from the pre-Rolandic convolution about midway between the fissure of Rolando and the line of the pre-central sulcus. The *inferior frontal sulcus* (Figs. 194 and 195, f^2) starts from the vertical sulcus and runs forward parallel with the superior frontal sulcus. It lies about on a level with the superior temporal ridge or superior stephanion (Fig. 193, S).

3. **The Intraparietal Fissure** (Figs. 194 and 195, *ip*) lies posterior to the fissure of Rolando, and is the posterior boundary of the motor region. It begins opposite the junction of the middle and inferior thirds of the fissure of Rolando. Passing upward, it lies midway between the fissure of Rolando and the parietal boss. It then diverges from the fissure of Rolando posteriorly, and thus widens the upper end of the post-Rolandic convolution to such an extent that the upper end of this convolution is known as the *superior parietal lobule* (Figs. 194, 195, and 196, P^1). In the middle of its course the intraparietal fissure runs about parallel to the great longitudinal fissure and midway between it and the parietal boss. Farther back it passes by the parieto-occipital fissure and downward and backward into the occipital lobe. Below its curve, at the ends of the Sylvian and first temporal fissures respectively (S^1 and t^1, Fig. 195), are the supramarginal (P_2) and angular (P_2') gyri. Once these fissures are determined from the outside of the skull and the brain exposed, the latter can be faradized, and the exact localization of the motor cortical centers can be determined by the movements produced by faradization. This has been done in a number of cases with unexpected accuracy.

For a more minute localization of the other fissures and convolutions of the brain the reader is referred to the last American edition of Gray's *Anatomy*, p. 681, and to the article on "The Surgery of the Brain," Buck's *Reference Handbook of the Medical Sciences*, vol. viii. p. 201.

Figs. 200 and 201 show the position of the chief **motor areas** in the brain of the monkey, as determined by Horsley and Schafer, which correspond closely, as has frequently been shown, to the same cortical centers in man. Roughly speaking, the upper third of the convolutions in front of and behind the fissure of Rolando corresponds to the center for the movements of the **leg**; the middle third corresponds to those for the **arm** (beginning at the upper end with the **shoulder center**, the middle part the **elbow center**, and the lower the **hand center**). In the lower third lie the **face center** and the center for the **mouth** and **larynx**. The centers for the face, leg, and trunk, it will be noticed in Fig. 201, are largely situated on the median surface of the hemispheres as well as on their external surface. Broca's center for **speech** lies just in front of the end of the fissure of Rolando, and in the angle formed by the main trunk and the anterior limb of the fissure of Sylvius.

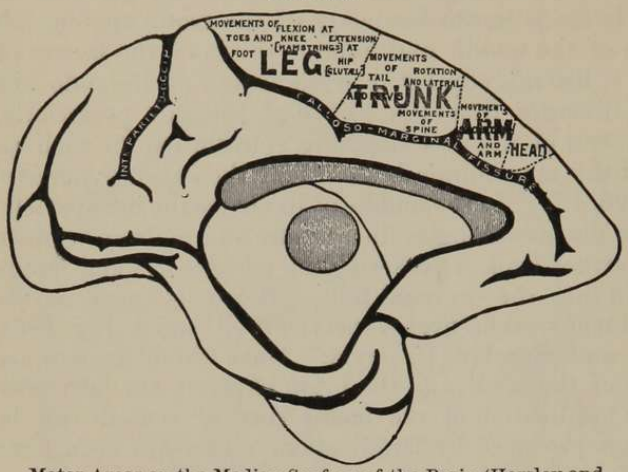
FIG. 200.



Motor Areas on the Outer Surface of the Brain (Horsley and Schafer).

The center for **vision** is situated chiefly in the **cuneus** (Fig. 196, *Oz*), a lesion of which produces blindness of the corresponding (right or left) half of both retinæ. The **supramarginal** and **angular gyri** are also probably concerned to some extent in **vision**. These same convolutions (supramarginal and angular) are the seat of certain **mental processes**, the abolition of

FIG. 201.



Motor Areas on the Median Surface of the Brain (Horsley and Schafer.

which produces sensory aphasia, alexia, agraphia, apraxia, etc.; for the details of which see page 534. The center for **hearing** is probably situated in the middle and posterior parts of the **first temporo-sphenoidal** convolution (Fig. 195, T^1). The center for **smell** is probably situated in the **uncus**, near the lower part of the hippocampus major (Fig. 196, U).

III.—TECHNIQUE OF CEREBRAL OPERATIONS.

We owe this chiefly to Mr. Horsley's brilliant papers. It is always of the utmost importance that the head should be shaved. This will often reveal scars, etc. hitherto unsuspected, and no definite diagnosis should ever be reached or an operation determined on without this procedure. The **fissures,** so far as is necessary, may be marked out on the shaven scalp by means of an aniline pencil, which is itself antiseptic. Of course, after being shaved, the patient should be protected against catching cold by a silk handkerchief or cap around the head. The day before the operation the head should be shaved anew if need be, scrubbed with soap and water, next cleaned with ether, and then covered with a sublimate dressing, the three or four inner layers of which may be wet with a sublimate solution 1 : 2000, as a 1 : 1000 solution might vesicate. This dressing should be retained in place until the operation, when the disinfection should be repeated. There is no need for the spray. Of course all the ordinary operative precautions described elsewhere, as to the thorough cleansing of the finger-nails, hands, and arms of the operator and his assistants, should be carried out with scrupulous care.

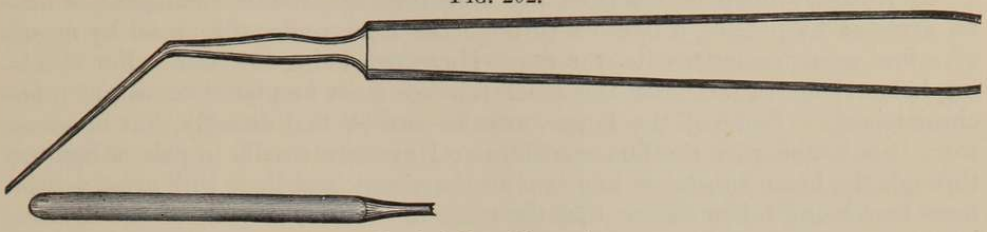
Ether or chloroform may be used, and it is better to operate with the patient in the **semi-recumbent position** rather than lying flat, in order to diminish the amount of hemorrhage. It is important to mark three points on the **bone:** viz. the place at which the center pin of the trephine is to be applied, and the upper and lower ends of the fissure of Rolando at points just outside the flap, in order that the fissure may be recognized after the flap has been raised. This is best done by using the center pin taken out of another trephine, by means of which a little triangular point can be marked on the bone, using the rongeur forceps, for example, as a hammer, or a very small gouge will nick the bone sufficiently to enable it to be recognized.

The **flap** to be raised should be of a horseshoe shape, with a diameter of about three inches. As a rule, the base of the flap should be below, on account of the more favorable blood-supply. The flap of periosteum should be raised with the scalp. The hemorrhage is best controlled by seizing the edge of the flap at the bleeding points with hemostatic forceps.

The **trephine opening,** with rare exceptions, should be large, not less than $1\frac{1}{2}$ inches. Once the trephine opening is made, it can be enlarged by the rongeur forceps (Fig. 203) to any extent desired. Before enlarging it the dura

should be separated from the bone by Horsley's dural separator (Fig. 202), by means of which also the inner surface of the skull can be explored, and any irregularities detected, two inches or more from the trephine opening.

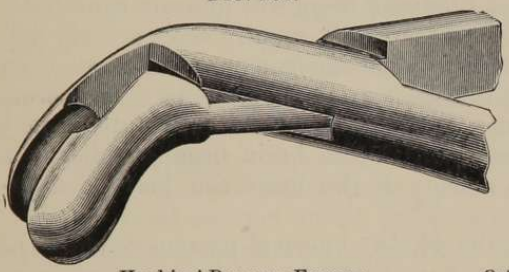
Fig. 202.



Horsley's Dural Separator.

Osteoplastic Resection.—In 1889, Wagner, following an earlier suggestion of Wolff, proposed to make a temporary osteoplastic resection by chiselling loose the piece of bone to be removed, except at one portion where it was fractured and turned back on the scalp as a hinge. The scalp is incised down to the bone, the flap not being loosened from it. By mallet and chisel the bone is then nearly cut through at every point excepting its base, the separation being completed by an osteotome. It is then lifted by means of elevators, the base being fractured, a window, so to

Fig. 203.



Hopkins' Rongeur Forceps.

Fig. 204.

Osteoplastic Resection of Skull by the Wagner-Wolff Method (Esmarch and Kowalzig).

speak, being opened by turning back the flap (Fig. 204). By this means access can be had to a very large area of the brain-cortex; even three, four, or five inches have been thus exposed. When the operation is terminated the opening is closed by replacing the flap, which is sutured in place as usual. In chiselling such a piece loose it is best to chisel it obliquely, so that the opening in the inner table will be a little smaller than that in the outer, the inner table thus forming a shelf on which the flap rests. The base of the flap, which serves as a hinge, should always be in that part of the flap having the largest blood-supply.

The surgical engine with a special drill and an electrical motor with a saw have been also used in place of the chisel.

"Trephining" in the remainder of this chapter will be used in the sense of opening the skull to obtain access to its interior, irrespective of whether the opening is made by the trephine, the chisel, or any other means.

As a rule, the dura should be opened. The additional danger is very slight, and the additional information may be very great. With rare exceptions, if we trephine at all the brain itself should be examined by sight and touch. The opening in the dura is best made parallel with the edge of the bone and a quarter of an inch away from its margin. Care should be taken

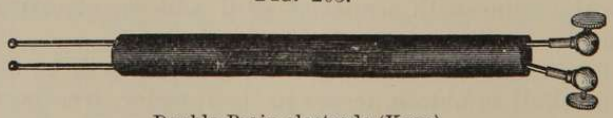
not to wound the large and troublesome veins of the brain immediately beneath the dura. This can best be avoided by lifting the dura with rat-toothed forceps while making the first incision by a knife, and then by using a blunt-pointed pair of scissors.

If **hemorrhage** occurs from any branch of the middle meningeal, it may be arrested by passing a ligature through the dura under the vessel by means of a fine semicircular needle, the finest Hagedorn being the best. For checking hemorrhage in the brain the chief reliance must be placed on catgut (non-chromicized). Some of the larger arteries can be tied directly, but in many cases it is better with the fine semicircular Hagedorn needle to pass a ligature through the brain substance and around the vessel, and tie it with great gentleness, care being taken to see that the traction on the two ends of the ligature is exactly even, in order not to tear the vessel. The knot must not be tied too tightly, or it will cut through the fragile vessel. Pressure continued for a few minutes by gauze or sponge and hot water at 105° to 115° will often serve a good purpose. Sometimes, especially in hemorrhage from the sinuses, the hemostatic forceps may be left for from thirty-six to forty-eight hours. Usually, however, pressure upon the sinuses or plugging them is the best means of controlling such hemorrhage. A lateral ligature may be used if the wound is small, or the entire sinus may be ligated if need be.

After opening the dura the first point to be observed is whether the **brain bulges** into the trephine opening, for if it does there is a pathological increase in the intracranial pressure, due to tumor, abscess, internal hydrocephalus, etc. Next observe the color. *Lividity* or *a yellowish tinge* will indicate a probable tumor beneath the cortex. An old laceration will usually show a dirty yellowish-brown. *Œdema* of the membranes is not uncommon, even to such an extent as in great measure to obscure the sulci and convolutions. The serum will escape on nicking the membranes, and the sulci and convolutions may then be recognized. *Absence of pulsation* in the brain usually indicates a large tumor, abscess, or cyst. The density of the brain can best be determined by touch.

If the *brain tissue* be *abnormal*, the whole abnormal portion ought to be removed. In doing so we can cut much more freely antero-posteriorly than vertically without doing damage, as in the vertical direction other centers than the one we seek are more quickly encroached upon than by excision antero-posteriorly. (Compare Fig. 200.) When the brain is exposed, if we wish to *recognize any motor center by faradization*, no antiseptics should be used, as they all dull the reaction of the cortex to electricity, but only sponges or sterilized gauze wrung out of hot water. For faradization of the brain the ordinary faradaic battery suffices. The current should not be too strong, lest it do harm to the cortex. A current sufficient to stimulate the thenar muscles is that usually employed. A double brain electrode (Fig. 205) may be used

FIG. 205.



Double Brain-electrode (Keen).

with advantage. The points should be sterilized and the handle wrapped in antiseptic gauze. By applying the electrodes to various parts of the cortex the motor centers can be readily determined in most cases, even without opening the dura. Notes should be taken of the phenomena following each

application, and the situation of the points stimulated should be determined by exact measurements. A stenographer should be present to take the dictation of the observed phenomena rapidly and exactly. As a rule, it is *better not to drain* after cerebral operations, but occasionally, especially in cysts, drainage is a matter of importance. In abscesses, gunshot wounds, hemorrhage, etc. it is of course a necessity. Rubber tubing is the best means.

Not uncommonly the *bone* can be *replaced.* Even a $1\frac{1}{2}$-inch button of bone will retain its vitality and re-establish its connection with the skull if properly cared for. In all cases, therefore, where there is a possibility of the replacement of the bone, the moment it is removed it should be placed in a bowl containing a 1 : 2000 sublimate solution, and the bowl be placed in a basin of hot water the temperature of which is kept at 105° to 100° F. This should be the sole care of one assistant. Instead of replacing it in one large piece, it may be bitten into small pieces by bone forceps. The pieces bitten away by the rongeur forceps may be similarly utilized. Sometimes Senn's decalcified ox-bone can be better used than the bone which has been removed. Of course if the bone be diseased or very compact, or it be desired to change the intracranial pressure, as in cases of headache, insanity, etc., the bone should not be replaced. In this case a small disk of tin can be advantageously secured to the inside of a skull-cap to protect the brain. To prevent adhesion of the brain disinfected gold-foil has been inserted. Fraenkel has recently filled the opening by a disinfected celluloid plate. König has proposed to fill the gap of an old fracture by chiselling a neighboring piece of the outer table away with a flap of scalp, sliding it into the opening, and covering the wound thus made by transplanting skin by Thiersch's method. If the dura has been removed, and it is still desired to replace the bone in one large piece, this may be perforated and secured to the under surface of the flap by catgut, then preferably chromicized.

After the operation on the brain is completed the dura should be sutured by interrupted or continuous catgut sutures as is desired. The scalp should now be replaced and secured by the ordinary interrupted sutures, and an abundant sublimate dressing, of which the inner layers may be again wet with a solution of the strength of 1 : 2000, should be applied. This should be covered with rubber dam, and be retained in place by a bandage and, especially in children or in restless adults, by a night-cap. As soon as the dressing is moistened to its margin by serous or bloody discharge the wound should be redressed. If a drainage-tube has been used, it should be removed at the end of from twenty-four to forty-eight hours, except in cases of abscess, etc., when it should remain for some days. In case no drainage has been provided, if too much blood and serum or cerebro-spinal fluid accumulates under the flap, as shown by its marked bulging and possibly by paralysis, the wound-fluids can be evacuated by inserting a probe or a pair of forceps between two stitches. As a rule, by the fifth or sixth day about half the stitches may be removed, and all of them usually by the seventh or eighth day. Absolute quietude, both of mind and of body, should be insisted upon, especially for the first week. No letters, visitors, or other causes of excitement should be allowed for some time. Though sometimes less severe restrictions may be required, yet this course should be enforced for two weeks, and in some cases even for months, after the operation.

Operation in Two Stages.—The severe shock in serious operations on the brain has led Horsley and other surgeons to modify the procedure by dividing it into two stages. The first stage consists in merely effecting an opening into the skull. This is then closed by a few temporary sutures.

After an interval of from three to six days the wound is reopened and the operation completed. This method is especially applicable to operations for brain-tumors and the removal of the Gasserian ganglion.

Secondary operations are not uncommonly required when the brain, its membranes, and the bone will all be adherent, and must be dissected free from one another with great care. Some of the brain tissue will of necessity be torn away, and more or less pronounced paresis of the centers corresponding to the interference may be produced. After removal of a motor center there is of course entire paralysis of the part supplied by this center; and the pressure caused by the blood-clot which accumulates and the later cell-proliferation is apt to cause widespread paralysis, amounting even to a hemiplegia. After some weeks this invariably disappears to a greater or lesser extent, leaving, however, the affected muscles, it may be, somewhat paretic.

If any portion of the **dura has been removed,** and especially if this is followed by removal of the brain substance, there is a marked tendency to proliferation of the cerebral tissue, with danger of a fungus cerebri forming. This may be prevented by taking a bit of the pericranium from the under surface of the scalp, turning the osteogenetic surface upward, and attaching it to the dura by interrupted sutures. The pericranium will very quickly contract adhesions to the dura, and the gap will be closed (Keen).

The **limits of operative procedure** are constantly being enlarged. Once the skull is trephined, we can explore the inner surface of the skull over a wide area by the dural separator or probe. If the dura has been opened, the finger can be gently inserted between the brain and the dura and the surface of the brain explored for at least an inch all around the opening in the dura. The brain can be readily depressed by the finger or the knife-handle used with gentleness, and the eye can see for an inch beyond the dural opening. If the opening be toward the base of the brain, the brain may be lifted either with or without the dura and the base of the skull explored for a considerable distance. The cerebellum can be lifted and the finger and the eye can reach to the foramen magnum. The sinuses can be safely uncovered and separated from the skull, and the frontal lobe lifted far enough to discover the anterior clinoid process, while laterally the surfaces of the petrous bone can be explored. The brain can be punctured almost with impunity, especially if a blunt instrument like a grooved director be used, so as not to wound the large vessels, and the ventricles can be tapped.

IV.—DISEASES INVOLVING THE SCALP.

I. **Inflammation of the Scalp.**—This is a frequent sequence of wounds, and will be referred to later. It is often caused by the poison ivy or poison oak and by erysipelas, and is described under these heads.

II. **Tumors of the Scalp.**—1. The most frequent of all are the *Sebaceous Tumors*, or *Wens*. The pathology of these tumors will be found in the chapter on Tumors. Their diagnosis is easy. They are frequently multiple, are of slow growth, vary in size from that of a pea to that of a small egg, are painless, and have an elastic, cystic feel. Occasionally, especially near the angle of the eye, they are dermoid in character, having a number of hairs intermingled with the sebaceous contents. Sometimes they ulcerate.

The **treatment** is extirpation. In removing them it is not necessary to shave the scalp, but the hair should be neatly parted over them, all grease removed from the scalp, which is next thoroughly disinfected with a bichloride solution. An incision is then made down to the wall of the tumor, when it

can usually be enucleated without difficulty. It is very important to leave none of the cyst-wall behind, or the tumor will be reproduced. A simple bichloride dressing and a bandage complete the operation. Unless the tumor is large, neither drainage nor sutures are necessary. Usually the wound will be entirely well in three or four days.

2. **Fatty Tumors** occur rarely in the scalp, and are very difficult to diagnosticate from the sebaceous, as they resemble them in almost all respects. They are apt, however, to be somewhat flatter and less globular, and also to be situated more deeply than the sebaceous tumors, not uncommonly being next the pericranium. An error in diagnosis is of no importance, however, as the treatment is identical—extirpation.

3. **Congenital Cysts and Fibromata** may occasionally occur in the scalp. The diagnosis is perfectly clear, and the treatment equally so—entire removal.

4. **Warts and Horns** are not uncommon. Horns should be removed by the knife. Warts, when they are inconspicuous and non-irritating, may be disregarded, but if they show the least tendency to grow they should be removed by the knife, as they sometimes become malignant.

5. **Moles** are a local hypertrophy of the skin. There are two forms: first, the *hairy mole*, covered with more or less stiff, bristle-like hairs, and without discoloration of the skin; and, second, the *pigmented mole*, in which the skin is discolored and of a brown or black tint. Sometimes they are of sufficient size to become serious disfigurements, and must then be removed by the knife after local anæsthesia by cocaïne. If very large, sometimes either transplantation of skin or a plastic operation may make good the defect produced by their removal.

6. **Pneumatocele,** or a tumor filled with air, is very rarely met with. Treves states that only ten cases are on record. It is most frequently a result of spontaneous atrophy of the osseous tissue producing a communication with the mastoid cells. The air then escapes under the pericranium, forming a tumor which may vary in size up to that of a pigeon's egg. It is painless, elastic, smooth, and tympanitic to percussion. Pressure will ordinarily obliterate the tumor. The treatment is usually compression after emptying the sac of its air by pressure or by the needle of a hypodermatic syringe.

III. **Arterial Varix, or Cirsoid Aneurysm.**—This is a peculiar dilatation of the arteries resembling the varix of varicose veins, but as it exists in arteries it is called arterial varix. It occurs most frequently in the scalp and the hand. The arteries become dilated, the middle coat especially undergoing atrophy, and are elongated and tortuous, like ordinary varicose veins. True aneurysmal pouches as large as the last joint of the finger or thumb are felt at various points. The whole mass pulsates synchronously with the heart, and a marked bruit is heard with the stethoscope (see Fig. 30).

There is no difficulty in making the **diagnosis,** but the **treatment** is much less satisfactory. Ligation of one or both carotid arteries has been done, but only occasionally has it been satisfactory. Excision has occasionally been resorted to, and is perhaps the best method, but it should be done only by an experienced surgeon, as it is apt to be very bloody and difficult. Hypodermatic injections of tincture of chloride of iron and of pure alcohol have both been successful, as has also galvano-puncture. Direct ligation all around the periphery by multiple ligatures tied over compresses of gauze has also proved successful. The ligature should be inserted by means of a curved Hagedorn needle, and should go all the way to the bone, in order to include the dilated deep branches. Subcutaneous ligature has been tried, the so-

called Barwell's scarless method, by a curved needle carrying the thread from point to point, being inserted anew at each point of exit and carried to the next point. This method can be adapted to the ligation of the aneurysm in sections, or if small the entire mass can be secured by one ligature. If not increasing and not a source of annoyance, it may well be let alone.

IV. **Capillary Varix, Nævus, or Mother's Mark.**—These are of two varieties: 1. One made up of capillary vessels of good size, presenting a small, *strawberry-like tumor*, somewhat elevated above the skin. Nævi of this variety are very apt to increase steadily in size until they become a serious danger from hemorrhage. They should be removed early in life, especially if they show any tendency to enlarge and invade the surrounding healthy skin. If they are small, the best way is to put a pin underneath them and strangulate them by means of a silk ligature, tied tightly under the pin, which prevents its slipping off. It is very important that the whole of the nævus shall be included in the ligature, and if it is too large to be thus included by the ligature and a single pin, it is better to insert two pins at right angles to each other; or a double ligature may be passed under a single pin, each half of the ligature being tied separately. Excision will sometimes answer the purpose where the nævi are small. When very large, however, they must be ligated in sections.

2. The *Port-wine Mark* is a nævus with very small capillary vessels, which very rarely tends to enlarge, but may in itself be a serious deformity by its color and its original large size. Its name describes very well its appearance. The best treatment is excision, and, as the tissues of the face are very elastic, such a nævus, even of considerable size, may easily be removed, leaving only a linear scar. If too large for this method, it may sometimes be destroyed by passing through its substance parallel threads of silk soaked in a tincture of chloride of iron or Monsel's salt. Or the nævus may be frozen a part at a time, cross-hatched with a cataract needle or knife, the hemorrhage arrested by steady pressure with blotting paper, this process being repeated from time to time. This is practically painless and leaves no appreciable scar. Escharotics and the cautery have also been successfully used. None of these methods, however, is as good as excision, since most of them leave unsightly scars.

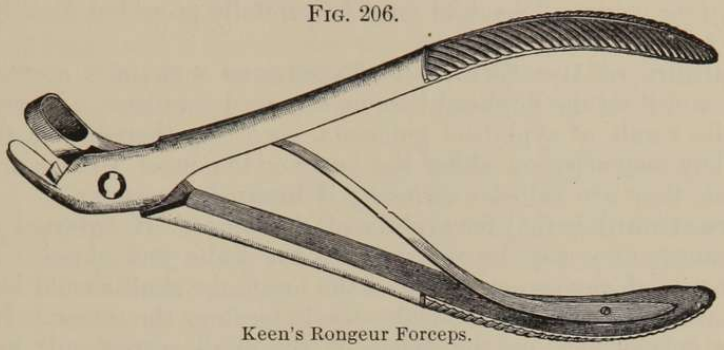
V. **Lupus,** the tubercular origin of which is now certain, is not so frequent on the scalp as on the face. It is a persistent ulcer, following tubercular infiltration of the skin, which gradually invades the surrounding sound structures and makes wide havoc. If small it may be excised: Koch's lymph seems to have had a beneficial influence in a number of cases. It may also be cured sometimes by thorough cauterization by Paquelin's cautery.

V.—DISEASES AND MALFORMATIONS INVOLVING THE SKULL.

I. **Microcephalus.**—Occasionally a child is born with complete ossification of the skull, even at the fontanelles, or the ossification may be completed soon after instead of at birth. While there is no doubt that, as a rule, the growth of the encasing hard parts is dominated by the growth of the contained soft parts, yet it is very possible that while a healthy brain may overcome the normal resistance of the skull, a brain with feeble powers of development may be arrested in its growth by the slight resistance offered by the skull. Accordingly, Lannelongue recently proposed to exsect a portion of the skull, about a quarter of an inch wide, extending from the forehead to the occiput. The excision, in order to allow more rapid expansion and growth of the brain, may be made on one side of the sagittal suture or

on both sides, may extend from the middle of the forehead well back into the occipital bone, and may have lateral branches, converting the side of the skull into a bony flap. The incision in the scalp should not go beyond the front line of the hair, so as to avoid any visible scar. By a transverse incision just behind this line the scalp may be displaced so as to give access to the frontal bone. The operation should be done on only one side at a time. Wyeth seizes the edges of the groove and forcibly separates them, a proceeding which would seem to be of doubtful utility, if not dangerous. To facilitate the operation Keen has devised a rongeur forceps (Fig. 206), which reduces the time of

FIG. 206.



Keen's Rongeur Forceps.

the operation to not more than twenty or thirty minutes, a very important element in diminishing the shock.

Whether the operation will stand the test of time is uncertain, but considerable initial improvement has followed in a small number of cases. Owing to the congenital weakness of such children about 20 to 25 per cent. die.

II. **Periostitis, Ostitis, Caries,** and **Necrosis** all occur in the bones of the skull as elsewhere. They very often follow injuries, are rarely tubercular in origin, and still more rarely may follow typhoid fever. By far their commonest cause is syphilis, which may make extensive ravages and destroy large parts of the skull. The dura seems in these cases to resist with singular power the extension of inflammation as a meningitis. Large portions of necrosed bone may lie on a bed of granulations springing from the dura, the inflammation being absolutely local and without any tendency toward a general meningitis. There will usually be either the history of an injury or the plain history of constitutional syphilis, with evidences of its existence in other parts of the body.

The **treatment** of all these conditions is the same as elsewhere. If pus accumulates, it must be evacuated as early as possible. If sinuses form, they must be opened speedily and be scraped and disinfected thoroughly. If caries exists, the bone must be laid bare and all carious bone removed with sharp spoon, gouge, and chisel. Necrosis may affect only the outer table or the entire thickness of the bone. The sequestrum and necrosed fragments must be entirely removed. In no part of the body is it more important to insist on frequent dressings, absolute cleanliness, and the securing, so far as possible, of an aseptic condition; otherwise the odor becomes almost intolerable. Corrosive sublimate, carbolic acid, iodoform, aristol, peroxide of hydrogen, and pyoktanin are all of use in attaining these ends.

III. **Hypertrophy of the Bones of the Skull,** with sclerosis and disappearance of the diploë, is a not uncommon result of osteitis deformans, and especially of hereditary syphilis, but usually requires no treatment.

IV. **Atrophy of the Bones of the Skull** is often seen as a simple

senile change. All the bones of the skull become thin and light, and even the base of the skull may become translucent or may be perforated as a result of the gradual thinning and absorption of the bones. When occurring in early life it was formerly thought to be especially the result of rickets, but later researches have shown it to arise more commonly from hereditary syphilis. The cranial bones may become so thin that they will crackle like parchment under very slight pressure. It is sometimes called *craniotabes*, and especially affects the occipital bone. A similar thinning sometimes occurs from brain-tumors.

The general treatment for inherited syphilis, together with cod-liver oil and the hypophosphites of lime and soda, etc., will sometimes produce speedy and very happy recovery. The child must be carefully protected from blows, falls, and other mechanical injuries.

V. **Tumors of the Skull.**—1. **Exostoses** sometimes occur as a result of injury, and if on the forehead become serious deformities. More commonly they are the result of syphilitic gummata, occurring therefore in the tertiary stage. They may arise on either the outer or the inner surface of the skull. If external, they are called exostoses; if internal, enostoses.

The **treatment** is that for syphilis of the bones. If external and a serious annoyance, they may be removed by the knife and chisel. If internal and productive of any serious lesion of the brain, the skull should be trephined and the mass removed. The difficulty lies in locating the tumor. Not uncommonly the development on the inside of the skull corresponds to a similar growth on the outside. Failing this, the only other indication of the internal tumor is the localizing symptoms in brain disease which are described later.

2. **Sarcoma** affects the bones of the skull in all of its three forms, round-celled, spindle-celled, and giant-celled. It may arise in the periosteum, the diploë, or the dura. If it develops to any size, it is accompanied with great deformity and in all cases with great danger.

The only proper treatment is excision by the knife, chisel, and saw, but this is usually unavailing in preventing relapses, and the operation itself involves such danger as often to be fatal, especially when, as is sometimes the case, the superior longitudinal sinus is involved. Except in very favorable cases, therefore, as a rule no operation should be attempted.

Sarcoma arising from the dura perforates the cranium and spreads sometimes widely under the scalp, and finally perforates it externally. It was known to the older writers as *fungus of the dura mater*. The diagnosis is best made by discovering the opening in the bone by touch and by the evidences of pulsation of the mass, its partial or complete reducibility, generally accompanied with symptoms of pressure, and the optic neuritis which often results from it. It may occasionally be removed, but will always recur. and is a fatal disease.

3. **Epithelioma** is occasionally seen, and is to be treated on the same principles as stated under Sarcoma.

VI.—DISEASES AND MALFORMATIONS INVOLVING THE BRAIN.

I. Meningocele, encephalocele, and hydrencephalocele are allied malformations of the brain which are fortunately not common.

1. **Meningocele** consists in the protrusion of the membranes of the brain through an aperture in the bones of the skull, the sac formed by the membranes being distended to a greater or lesser extent by fluid which is extra-cerebral.

2. **Encephalocele** consists in the protrusion of a portion of the brain itself, as well as of the membranes, usually with a smaller amount of fluid in it, the fluid again being external to the brain substance.

3. **Hydrencephalocele** consists in the protrusion of the brain substance itself as well as of the membranes, but in this case the interior of the mass communicates directly with the ventricles, and is often filled with a large amount of the ventricular fluid, so large in some cases that the layer of brain substance enclosing the fluid is reduced to a very thin film.

All three forms of the disease arise in intra-uterine life, and are therefore congenital. The most frequent is unfortunately the gravest form—viz. hydrencephalocele—and the least frequent is meningocele. As a rule, they are apt to be fatal early in life. Their commonest situation is first in the median line, especially in the occipital region; next, the fronto-nasal; and lastly, the sides of the skull or about the base. Of 93 cases collected by Houel, 68 were occipital, 16 fronto-nasal, and 9 at the sides and base.

Diagnosis.—They have been mistaken for abscesses, nævi, sebaceous cysts, etc. The following points of diagnosis will generally enable the surgeon to reach a proper conclusion:

All of them are congenital, commonly median, and especially occipital in position. *Meningocele* is usually cystic in its feel, is translucent, fluctuates, rarely pulsates, is more or less pedunculated, generally becomes tense in forced expiration, and is easily reducible. *Encephalocele* is usually small, is opaque, does not fluctuate, pulsates distinctly, has a wide base, becomes more tense in forced expiration, and symptoms of pressure are produced on attempting to reduce it. *Hydrencephalocele* is generally large, is lobulated, is partially translucent, fluctuates distinctly, pulsates but rarely, is usually pedunculated, is made only slightly more tense in forced expiration, and is not reducible.

All three forms are apt to be combined with other deformities, and paralysis often accompanies hydrencephalocele.

Treatment.—As a rule, hydrencephalocele is not amenable to treatment. The child, fortunately, dies early. The other two forms hold out more hope, especially if they are small. Sometimes an encephalocele by retrograde development may be changed into a meningocele, and occasionally by gradual concentric ossification, resembling that of the fontanelles, the bony aperture is lessened and may even be closed. The intracranial communication with the interior of the sac may be narrowed and finally obliterated, thus partially or completely effecting a spontaneous cure. Until the late improvements in cerebral surgery nothing was usually recommended in the way of treatment, certainly not unless there was danger of rupture. A number of successful cases of excision, however, have been recently reported, and, unless the size of the tumor or the condition of the patient forbid, this should be attempted, of course with all the antiseptic care bestowed on all other brain operations. Enough scalp should be preserved to make sufficient flaps to close the opening. If operation be thought inadvisable, electrolysis may be used as a substitute. Pressure and the injection of Morton's fluid (iodine gr. x, potass. iodid. gr. xxx, glycerin ℥j) may be tried, but with little prospect of benefit.

II. **Hydrocephalus,** or dropsy of the brain, exists in two forms: 1. **Acute hydrocephalus,** which is usually the result of meningitis, especially of tubercular origin. It consists in an accumulation of fluid which is occasionally extra-ventricular, but more commonly is in the ventricles themselves. There will usually be headache, fever, more or less stupor or delirium, with symptoms of pressure, producing strabismus, rigidity of the muscles of the neck, twitching of the muscles of the face or of the extremities, and convulsions, followed by paresis or paralysis of one or more members. As a rule, optic neuritis will be present. Generally nothing will check the progress of the disease. Tapping of the ventricles has been done in several instances, but without success except

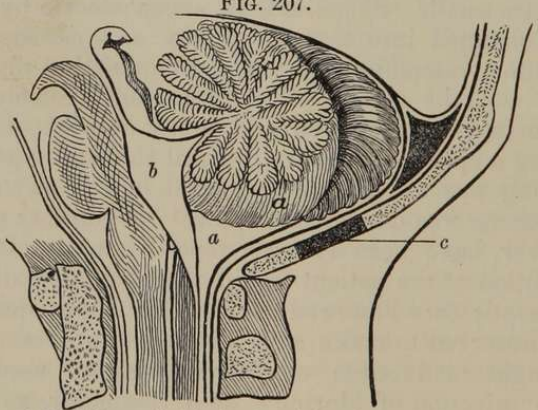
in one non-tubercular case of Mayo Robson's. Success must necessarily be rare, but every life saved is one rescued from otherwise certain death.

2. **Chronic hydrocephalus** is entirely different in its origin and course. It is usually congenital, although it may not be observed until some months after birth. The first symptom is enlargement of the cranium, which goes on until the bones become separated from one another. The protuberant forehead gives a characteristically strange facial expression. The child very rarely becomes able to walk or to talk. The sight is often affected, intelligence is absent, and convulsions are common. The post-mortem will show enormous distention of the ventricles, so that the brain consists merely of a soft bag of cerebral substance distended with cerebro-spinal fluid. Fortunately, most such defectives die early, but occasionally they live even to adult life.

The **treatment** is unsatisfactory and usually unsuccessful. Pressure does but little good. Tapping has been done by two different methods. First, by a fine trocar the ventricle has been punctured through the widely-dilated anterior fontanelle. This puncture should be made away from the middle line, so as not to puncture the superior longitudinal sinus. Not more than two or three ounces of the fluid should be evacuated, for the removal of large quantities, and very often even of small ones, is followed by convulsions and death. Occasionally larger quantities have been removed successfully. In this case pressure must be carefully maintained during and after the operation. Second, when the ossification of the skull is complete, tapping the lateral ventricles has been done, but so far without success. Quincke has recently proposed the tapping of the theca of the lumbar spinal cord, thus draining the ventricles at a distance, while pressure is made on the skull.

Parkin has suggested in place of lumbar puncture to substitute puncture of the subarachnoid space under the cerebellum. He reports 4 cases with

FIG. 207.



Vertical Section of Base of Skull immediately to the right of the Median Line: *a*, basal subarachnoid cavity and its relation to the cerebellum; *b*, fourth ventricle; *c*, site of trephine aperture (*Lancet*).

2 recoveries, and Ord and Waterhouse record another recovery from an almost certain tubercular meningitis. The occipital bone is trephined. The dura is opened, the cerebellum lifted, and the subarachnoid space punctured by a grooved director or other similar instrument (Fig. 207).

VII.—INJURIES OF THE HEAD.

I. **Cephalhematoma, or Caput Succedaneum,** is a soft tumor usually in the parieto-occipital region in new-born children. It consists of an accumu-

lation of blood and serum under the scalp, the result especially of prolonged labors and consequent mechanical injury to the scalp. Generally no treatment is necessary, as the mass is, as a rule, absorbed within a few days after birth.

II. **Wounds of the Scalp.**—These differ in no respect from wounds elsewhere in the body, except that wounds of the scalp are more prone to erysipelatous inflammation and abscesses than wounds of the skin in other parts of the body, unless the greatest care is taken in their proper treatment.

The blood-supply of the scalp is so abundant that even a slight pedicle of attachment is sufficient to ensure the vitality of a large flap. Hence in lacerated wounds an attempt should be made to save most of the torn pieces unless absolutely detached. In any wounds, except very small ones, in order to ensure disinfection the scalp should be shaved over a very wide area. Even in women appearance must give way to safety. It should then be thoroughly disinfected by the removal of all dirt and other foreign matters by rubbing in sweet oil, then washing well with soap and water, following this by a thorough scrubbing with a bichloride solution 1 : 1000, trimming off the infected edges if the wound is lacerated, and lastly by accurate suturing. The bleeding vessels will require ligation only when exceptionally large, provided the hemorrhage has been arrested by crushing the vessels in the jaws of hemostatic forceps. The forceps may seize the entire thickness of the scalp with impunity. If these precautions are taken, usually no drainage will be necessary, but should there be necessity for it a few strands of disinfected horsehair will answer the purpose. These should be removed in a day or two. Silkworm-gut interrupted sutures may be used. A large sublimate dressing may then be applied and retained in place by an ordinary recurrent bandage. The most important point in such wounds is the careful and wide disinfection. They will then follow the usual aseptic course of other wounds. If this be neglected, even small wounds have a large reserve of danger.

III. **Abscess of the Scalp** is first a consequence of inflammation, often of an erysipelatous character, and occasionally it is a sequel of typhoid fever; secondly, it is a sequel of contusions; and thirdly, it often follows wounds the edges of which have been closely coaptated without sufficient preliminary disinfection. Very often such patients are first treated in drug-stores, where usually a very elaborate stellate dressing of adhesive plaster is put on without any attempt at disinfection. All such dressings should be removed at once and the wound re-dressed after proper disinfection.

Abscess is accompanied usually with pain of a throbbing character and inflammation of the scalp, which is almost always erysipelatous in appearance, though it may not be caused by the microbe of erysipelas. Not uncommonly there is marked œdema of the surrounding parts, which if it extends to the eyelids produces blindness mechanically by the swelling of the lids. There is almost always pitting on pressure. The constitutional symptoms are marked and sometimes very severe, the fever running high and being accompanied not infrequently with delirium. The chief dangers here are that the pus may burrow widely; if under the aponeurosis of the occipito-frontal muscle it will be limited by the attachments of this muscle and its aponeurosis, and the location of the effusion can thus be readily diagnosticated; and if it be under the pericranium, and sometimes even if it be more superficial, that the inflammation may extend to the brain through the vascular perforations in the skull and cause meningitis. Occasionally it may produce necrosis of the bone.

The **treatment** is very clear. As soon as the abscess is diagnosticated a free incision should be made at what will be the most dependent point in

the recumbent posture, with disinfection of the wound as far as possible, and drainage.

IV. **Contusions of the Head** are very common as a result of falls, blows, etc. They may be slight or severe. After a slight contusion the patient is more or less stunned, and swelling very quickly follows, due chiefly to hemorrhage under the scalp. This hemorrhage is very apt to give the impression of depressed bone, and may mislead one into supposing that there is a fracture, the hard ridge on the curved edge of the swelling being mistaken for the edge of the depression. But after a simple contusion this ridge is elevated considerably above the general contour of the head, the edges are rounded, and pressure will not uncommonly cause pitting. If there be fracture with depression, the edge is usually about on a level with the surrounding skull or below it, and the margin is sharper, more irregular, and less circular.

Ordinarily pressure, with perhaps some cooling lotion, as simple tincture of arnica or lead-water and laudanum, will cause the major part of the swelling to disappear within twenty-four hours. Rather rarely, however, abscess will follow.

If the contusion be somewhat more severe, the bone may become involved, producing sclerosis as a result of the chronic inflammation, or if the blow be sufficiently severe to destroy its vitality even necrosis may follow, although this is a comparatively rare result. Severer contusions may involve the brain itself. These are described under the next head.

V. **Concussion or Laceration of the Brain.**—The term "concussion" of the brain is an unfortunate one, as it conveys the idea of a functional rather than an organic lesion. While there may be slight injuries of the brain that may in this sense be properly called concussions, it is far better to consider concussion as usually equivalent to *laceration* of the brain tissue.

The brain may be injured either by direct or by indirect force. A blow on the head is an example of direct force; an instance of indirect force is a fall in which the patient lights fully upon his feet or sits down upon his buttocks. What happens in such cases is best explained by an experiment made by Felizet. He filled a skull with paraffine and dropped it on the floor. On opening the head no fracture was found, but at the point of impact the bone had been driven down upon the paraffine and flattened it, and, while the bone had sprung back to its original position without fracture, the flattening of the contents remained. Had the skull been living and filled with brain tissue, the same depression and temporary compression of the brain would have taken place; and we can scarcely imagine that such an amount of mechanical disturbance of the brain can occur without more or less laceration of brain tissue and rupture of blood-vessels, followed by some slight hemorrhage. Moreover, as Duret has shown, the wave in the cerebro-spinal fluid created by a blow produces what is often its maximum effect on the opposite side of the skull from the point struck, tearing the vessels of the pia and the cortex. This undoubtedly explains injuries of the brain by so-called *contrecoup*, or counter-stroke. Miles has shown experimentally that at the point of impact there is a "cone of depression," accompanied by a "cone of bulging" at the opposite pole, thus confirming Duret's observations. If the cone of bulging is sufficiently ample, a fracture may be produced.

The patient who has received such an injury, if it be slight, will perhaps lose his balance and fall, become pallid, confused, and giddy, and may be nauseated and even vomit, but after a period of rest he will gradually recover. If, however, the injury be more severe, there may be grave laceration of the brain or of its membranes, or of both, and the patient will fall and lie quietly,

with a feeble, fluttering heart, cold, clammy skin, and apparently be unconscious. He can usually, however, be aroused by shouting and loud questioning, but will reply in monosyllabic answers or unintelligible sounds. He will not be paralyzed, but may move the extremities, which will not have lost entirely their sense of feeling. Not uncommonly urine and feces will be passed involuntarily. The pupils will vary, being either contracted or dilated to a moderate extent, and possibly unequally, but, as a rule, they will react to light. Occasionally convulsions occur. As he reacts he will very probably vomit. Usually within twenty-four hours or more his condition as to consciousness will become better, but he will suffer from considerable headache, lassitude, and indisposition to exertion. After partial recovery, and sometimes for a long period, he will suffer more or less with vertigo, headache, and indisposition to mental exertion. Occasionally more serious results will follow, even after a long interval, and abscess of the brain should be especially watched for. Sometimes epilepsy or insanity may follow. If the patient, instead of recovering, grows worse, either coma will set in or the symptoms of meningitis or encephalitis as described below.

Prognosis.—The uncertainty as to the degree and even the character of the cerebral injury should make us especially careful as to prognosis and treatment. Any contusion which has been severe enough to produce unconsciousness should be considered a serious injury, for we may be sure that there has always been such an amount of laceration as to make serious danger a possibility and often a probability.

Treatment.—As soon as possible the patient should be placed in bed without any pillow, and his body surrounded with hot-water bags or hot-water bottles suitably protected. He should be kept quiet and as free from the excitement of conversation or business as possible, and restful sleep should be encouraged. Aromatic spirit of ammonia during the period of shock is better than alcohol, for the excitement of alcohol, which is quickly felt in the brain, should be avoided. Hot water or ice water, as may be most agreeable to the patient, may be given. A careful diet, with occasional purgatives, and attention to the general hygiene are necessary for days or weeks.

In case inflammation of the brain supervenes, surgical opinion is at present somewhat divided as to the proper course to be pursued. Many surgeons, perhaps the majority, would treat it as an Encephalitis (see p. 518) and not trephine; others, on the contrary, believe that if serious symptoms arise, indicating intracranial mischief, especially if this be localized, a semicircular flap of scalp should be raised over the seat of the injury and the bone inspected. If an unsuspected fracture is discovered and the symptoms are serious, showing meningitis or encephalitis, an exploratory trephining should be done and the dura opened. Once such inflammation with its attendant proliferation and exudation has begun, it is essential in their view that a means of escape for the exudate be provided before the inflammation shall have proceeded so far as the production of dangerous pressure or even of suppuration itself. In other words, they would treat contusion followed by symptoms of serious intracranial mischief precisely as they would treat such injuries in other parts of the body; always remembering that in the brain there is no possible means of escape for the hemorrhage or exudate without surgical assistance, because of the bony case in which it is retained; but remembering also that while trephining is equivalent to incision down to the injury in any other part of the body, yet that it is always a grave operation and never to be undertaken without earnest reflection and good reason.

In many cases of severe contusion it is proper immediately (with all the

antiseptic precautions so often insisted on) to raise a horseshoe-shaped flap in order to determine at once the question of fracture, as the swelling of the scalp if this be thick or very dense makes it difficult without such an incision to ascertain whether fracture exists or not. The objection that if a simple fracture exists by such an incision we convert it into a compound one no longer holds good, for a simple incision through the scalp is not attended with grave danger in these days of antiseptic surgery, and the very slight dangers of the wound are as nothing compared to a certain diagnosis and suitable treatment.

After the patient has recovered from a severe contusion or laceration of the brain he should not be allowed to return to business or other occupation for at least a number of weeks, or even for a longer period; and if at any time he shows indications of hebetude or is attacked by headache, especially if accompanied with little or no rise of temperature or even a somewhat subnormal temperature, an abscess should be suspected and its symptoms watched for. (See Abscess.)

After severe concussion of the brain the patient sometimes passes, in the course of a few hours or more, into a peculiar condition well termed by Mr. Erichsen *cerebral irritability*. Instead of recovering consciousness, he is apt to lie on his side, with his eyes closed, his legs drawn up, and his back curved. The pupils are contracted, but respond to light. If disturbed, he is restless and irritable or may even show some delirium. He may answer questions sometimes in a vexed way, or may refuse to respond. There is sometimes no rise of temperature, either general or local, and it may even be subnormal. The pulse is weak and slow. Not uncommonly the bowels and bladder are evacuated involuntarily, though sometimes the patient will indicate his wants. Recovery will usually take place slowly, with no recollection of his condition or conduct. Occasionally, however, the mental faculties will not recover. The treatment for this irritability must necessarily be a symptomatic one.

VI. **Compression of the Brain.**—The surgical causes of compression of the brain are intracranial hemorrhage, tumor, depressed fracture, foreign bodies, and the products of inflammation. Hemorrhage and inflammatory exudate produce the symptoms of compression almost immediately when they are sudden and severe, but if the blood or exudate accumulate gradually, the compression symptoms will arise as soon as the amount of blood or pus becomes large. In very slight but steadily increasing hemorrhage or a slowly-forming abscess the brain accommodates itself for a time to the gradually increasing pressure. Even considerable depression of the bone may for some time be followed by no symptoms of compression.

Symptoms.—In compression unconsciousness is complete. The patient lies supine and does not move, or if he moves it will be an occasional restless change of place of an arm or a leg. He will not respond to any questioning or to the loudest shouting in his ear. The pupils are dilated and do not respond to light, the breathing is slow and stertorous, with a peculiar puffing respiration, due to expiratory distention of the cheeks and lips, the facial muscles being paralyzed. The skin is usually hot rather than cold, and is covered with a profuse perspiration. The pulse is slow, full, and often irregular. The bladder and bowels are, as a rule, paralyzed: hence the urine is not voided until the bladder becomes over-full, when the incontinence of retention sets in. Sometimes the whole body is paralyzed, though hemiplegia is more common. If the lesion is limited and not too large, the paralysis will be limited, for example, to a monoplegia, that is to say, paralysis of one arm or one leg or one side of the face, if the cause of the compression is limited to one of the cortical centers supplying these regions. The significance of such

a localized paralysis is extremely valuable in the diagnosis of the seat of the lesion; and if the paralysis begins in one part of the body and spreads to other parts, the cortical centers of which are adjacent to the center for the part first paralyzed, the diagnosis may be regarded as positive.

If the cause of the compression is *hemorrhage* in the interior of the brain —*e. g.* from the lenticulo-striate artery, the "artery of cerebral hemorrhage" of Charcot—unconsciousness usually occurs instantaneously or almost so. If it is from a rupture of the middle meningeal artery, a point of the greatest importance in the diagnosis is that after the reception of the blow there is a period of consciousness corresponding to the period of time necessary for the escape of a sufficient quantity of blood to produce unconsciousness from pressure. If a small branch of the middle meningeal is ruptured, the period of consciousness may be comparatively long, even several hours, occasionally a day or more; but if the main trunk is injured, the blood pours out so rapidly that only a few minutes may pass before unconsciousness supervenes.

If caused by fracture or foreign bodies, the symptoms of compression usually follow immediately upon the reception of the injury, but occasionally they may be delayed for some hours. If caused by inflammation and the formation of pus, the symptoms of course will develop only when the pus accumulates in sufficient quantity to produce serious pressure. This development of pressure symptoms in these cases is usually gradual, the mental dulness deepening into coma, but sometimes it is, as it were, by a sudden explosion. If tumor is the cause, the brain may accommodate itself for some time to a slowly-growing tumor, but if it grows rapidly symptoms of compression will set in at an early date. Optic neuritis will generally develop at an earlier or later date.

Diagnosis.—The principal conditions which must be diagnosticated from injuries of the brain producing compression are *alcoholic intoxication*, *opium-poisoning*, *apoplexy*, and *uremia*. If a man is picked up in the street by the police and is carried to a hospital without any previous history, the surgeon must be on his guard lest he mistake any one of these four conditions for a serious injury to the brain. In *cerebral injuries* there will usually be an evidence of the accident in a bruise or cut, though of course the man may have fallen when intoxicated or have been suddenly attacked by apoplexy and in falling have received a more or less serious wound. In *intoxication* the accident will usually be comparatively slight. Possibly his appearance, giving evidence of intemperate habits, may be some guide to diagnosis, but this may easily mislead us. His breath may be alcoholic, but it must be remembered that alcohol may have been given to the man to revive him after serious brain injury. A drunken man, although stupid, is not unconscious, nor is he paralyzed or hemiplegic. His pupils are not dilated as in compression, but are more commonly contracted, dilating when any attempt is made to rouse him. The temperature is generally subnormal.

In *apoplexy* there are absolute unconsciousness, stertor, and hemiplegia or complete paralysis. In *opium-poisoning* the pupils are contracted to pin-points and will not dilate, and there is no paralysis. In *uremia* paralysis and stertor are absent, unless there is apoplexy, and there is apt to be œdema of the legs, and if the urine be examined there will be found undoubted evidences of albumin. The eye-ground should be examined in all cases, as it may throw considerable light on the nature of the case. If, after all, the case is doubtful, it should always be treated as one of cerebral injury.

Prognosis.—If the compression is caused by extravasated blood, the patient has a fair chance of recovery after trephining, evacuation of the clot, and arrest of the hemorrhage. If it is caused by depressed fracture, and the

proper operative relief is afforded, his chances of life will vary with the degree of severity of the injury. In cases of foreign body in the brain the prognosis, as a rule, must be unfavorable; and the same may be said of tumors and inflammation with internal hydrocephalus.

Treatment.—The diagnosis of compression having been established, the treatment will vary with the cause. If it is from hemorrhage, the treatment must be the speedy relief of the pressure by evacuation of the clot and arrest of further bleeding by ligature, as mentioned in the next section. If it is from depressed bone, trephining should be done at once with all the precautions heretofore described, and the bone elevated or removed as may be found necessary. If from foreign bodies, these should be removed, with the limitations stated in the section treating of that lesion. If from an abscess in the brain, trephining should be done and the abscess evacuated and drained. (See Abscess of the Brain.) If serum has accumulated either in the ventricles or in the subarachnoid space, trephining should be done and the exudate drained, even by puncture of the ventricles if necessary. If the compression is from tumor, the tumor should be removed if the case is suitable.

In all cases the utmost care must be observed as to the later treatment by rest, the most restricted liquid diet, attention to the bowels and bladder, and the general precautions mentioned in connection with Meningitis and Encephalitis.

VII. **Intracranial Hemorrhage.**—This may be either spontaneous or traumatic. Though there is at least one case of apparently spontaneous rupture of the middle meningeal arteries, yet as a rule spontaneous hemorrhage into the brain occurs in connection with the lenticulo-striate artery distributed to the ganglia at the base. The clot usually forms either in these ganglia or in the white substance of the centrum ovale, and produces the familiar forms of apoplexy, the consideration of which belongs to medicine rather than to surgery. Richardière has shown that one of the most frequent causes of the death of newborn children very shortly after delivery is meningeal hemorrhage from the rupture of the vessels at the moment of birth as a result of traumatism to the fœtal head in its passage through the pelvis.

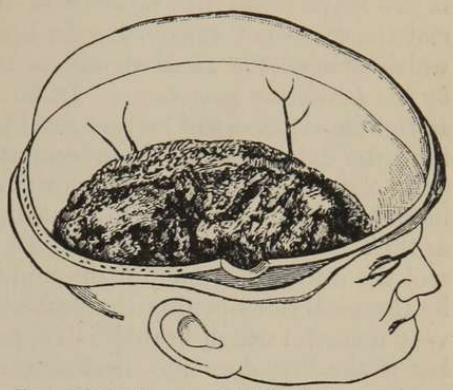
Hemorrhage from Traumatism may occur in three positions: it may be (*a*) extradural, that is, between the dura mater and the bones; (*b*) subdural, that is, between the dura and the brain; (*c*) cerebral, that is, into the brain tissue itself.

(*a*) **Extradural Hemorrhage.**—This is almost always caused by the rupture of the middle meningeal artery or its branches. The violence which may rupture this artery is, as a rule, considerable, although it may be so slight as to leave no bruise. Fracture will frequently exist, though in a considerable percentage of cases there may be no fracture whatever; but commonly it is present, and extends not only over the vault, but also to the base of the skull. It will be remembered that the middle meningeal arises from the internal maxillary and enters the cranium at the foramen spinosum, quickly dividing into an anterior and a posterior branch. The anterior branch, after running in the groove in the wing of the sphenoid, reaches the parietal bone at its anterior inferior angle, whence it passes upward toward the middle line. The posterior branch, after running over the posterior part of the squamous portion of the temporal bone, also reaches the parietal bone. The main trunk of the artery is rarely ruptured; the two branches are far more frequently the site of this lesion (Fig. 208).

The **symptoms** of such hemorrhage are of great importance, for while formerly in these cases the surgeon stood by with his arms folded and watched his patient die, the last few years have taught us that a large proportion of such

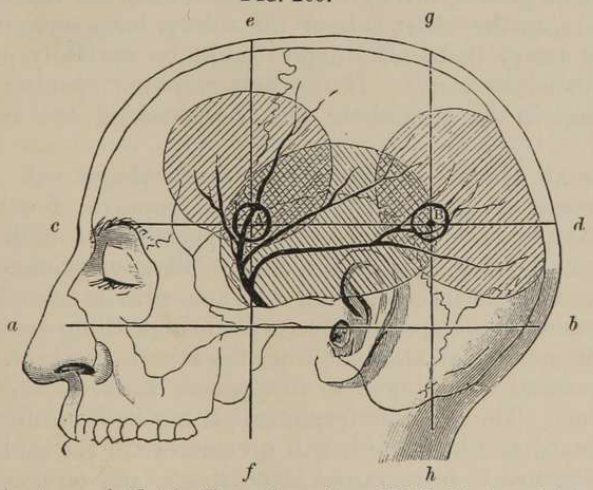
cases may be saved by prompt interference. The accident may stun the patient and may produce a brief period of unconsciousness. From this he recovers only to relapse anew into unconsciousness. This *period of consciousness* between the accident and the appearance of the persistent coma is of the greatest importance and worth all the other symptoms put together. It is due to the fact that a certain amount of time must elapse before the quantity of blood which escapes is sufficient to produce unconsciousness from pressure. If the main trunk or one of the larger branches is ruptured, the blood escapes rapidly, and this period of consciousness will be very brief; but if one of the smaller branches is ruptured the interval may be one of hours or even days before a sufficient clot accumulates to produce it. The possible existence of this interval of consciousness should therefore be inquired into in all cases, and if there be other signs of intracranial hemorrhage the diagnosis will be clear. These other signs may be, (1) Hemiplegia, on the side opposite to the hemorrhage. The hemorrhage, while usually on the same side as the injury, may take place upon the opposite side, in which case the hemiplegia and the wound will be on the same side. Moreover, the paralysis is apt to be progressive, extending from one part of the body to another, as the widening clot produces pressure on one cortical center after another. For instance, the clot may begin over the face center, producing paralysis of the face; then it extends upward to the arm center, and the arm

FIG. 208.



Hemorrhage from the Middle Meningeal Artery (Jacobson).

FIG. 209.



Site of Trephine Opening to reach Clot in Hemorrhage from Middle Meningeal Artery (Krönlein): *a*, *b*, horizontal line through the meatus; *c*, *d*, on a line with the eyebrows; *e*, *f*, vertical line 3 to 4 cm. behind the ext. ang. process; *g*, *h*, at the posterior border of the mastoid process. A, the point to reach the anterior, and B, the posterior branch (Esmarch and Kowalzig).

will be paralyzed; and finally, as it reaches the leg center, the leg will be paralyzed. Rarely the artery may be ruptured on both sides. (2) If the clot, instead of extending upward, gravitates toward the base, the pupil on the side of the clot will be dilated and immobile, and if on the left side aphasia

will appear. (3) The pulse becomes frequent. (4) Respiration is slow and stertorous. (5) The temperature will probably rise to 101° to 103°, or even 104° F., especially on the side opposite the clot. (6) In a compound (especially in a gunshot) fracture, with a perforation of the skull and the meninges, blood may escape in such quantity and with such rapidity as continually to force the brain-substance out of the wound.

Treatment.—As soon as the diagnosis is well established, operative treatment should be resorted to as quickly as possible. Wiesmann has best shown the importance of this, for of 147 cases treated expectantly, 131 (89.1 per cent.) died, while of 110 cases operated on, only 36 (32.7 per cent.) died, and in the majority of the fatal cases the extravasation was not reached and the clot therefore not removed. In operating we should determine the question which side of the skull should be trephined, *not by the site of the injury, but by the localizing symptoms.* In far the greater number of cases, as shown by Krönlein, the clot will be best reached by trephining one inch and a quarter behind the external angular process at the level of the upper border of the orbit. (Fig. 209, A). Should the clot not be revealed by this opening, we should immediately trephine again, just below the parietal boss, on the same level as the former opening (Fig. 209, B). By the anterior opening the main trunk and the anterior branch of the middle meningeal artery may be reached, and by the posterior opening the posterior branch. In many cases, of course, it is very doubtful which branch is ruptured; hence the need for the second opening if the first does not disclose the clot. The clot should now be removed, either opening being enlarged, if need be, by the rongeur forceps in order to gain access to it. If the pupil is dilated, and evidence given therefore that the clot is gravitating toward the base, the trephine opening should be made near the first point, but about half an inch lower. The clot should be scooped out very gently, and the cavity in which it has lain should be well washed out with sufficiently cooled boiled water. If the artery is still bleeding, a catgut ligature should be passed through the dura, under the artery, and out again through the dura on the other side of the artery, by a semicircular Hagedorn needle, and the artery tied. Drainage should be carefully provided, and the wound then treated as usual. If the first trephine opening does not answer well for drainage in the recumbent posture, a second one should be immediately made.

(*b*) **Subdural Hemorrhage.**—This hemorrhage will occur most frequently as a result of depressed fracture and rupture of a number of small vessels, or it may be of one large vessel (especially the middle cerebral), the contents of which pour out under the dura. The symptoms will be much the same as those mentioned in connection with hemorrhage from the middle meningeal, and at present there are no means of distinguishing between hemorrhage from the middle meningeal and that from the middle cerebral. It is, however, of no great practical importance to distinguish between them, for the treatment is the same. The anterior trephine opening before referred to, especially if enlarged upward and backward, will give access to the middle cerebral, and if the evidences point to intracranial hemorrhage, and on trephining no clot is found under the bone, the dura should be opened and the clot searched for on the surface of the brain itself, following the direction of the fissure of Sylvius, in which the middle cerebral lies. If this be the source of the hemorrhage, the bleeding point must be found and the artery ligated. More commonly, however, subdural hemorrhage is caused by the rupture of a number of vessels under a depressed fracture, and the consequences, unless the case is properly treated, are most deplorable. Not uncommonly the patient will die as a result

of the injury to the brain; but should he recover the course of events is usually as follows: The clot, having produced more or less extensive paralysis, is gradually absorbed, but the brain may not expand to its former position, being permanently depressed, for the site of the injury is sometimes occupied by spongy connective tissue the meshes of which are filled with cerebro-spinal fluid, resembling a series of cysts. The paralysis will gradually lessen and may almost entirely disappear. After a varying interval, from a few months up to two or three years, the patient may, however, become subject to epileptic or other cerebral disturbances, and if so he will lead a miserable existence so long as he may live. The importance, therefore, of evacuating the clot, removing the pressure, and thus preventing the disastrous later effects, is evident. Hence all cases of marked and localized depressed fracture should be trephined, the bone lifted, and the clot evacuated and treated as has been described.

Hemorrhage from Pachymeningitis Interna.—A few cases have been reported of subdural hemorrhage from pachymeningitis interna. These are amenable to the same treatment, by trephining, evacuation, and drainage. Even so long as two months after the accident Ceci has been able to rescue his patient from a condition of complete coma and palsy, with almost total restoration of function.

(*c*) **Hemorrhage into the Brain Substance.**—Severe traumatism may rupture the vessels in the interior of the cerebrum, and even produce hemorrhage into the ventricles. The symptoms in this case will resemble those of ordinary apoplexy in every respect except the cause. The diagnosis is based upon this resemblance and this difference. As a rule, little can be done in such cases, for the injury to the brain substance is generally so extensive that even if the clot be evacuated the patient will usually die from the injury.

(*d*) **Wounds of the Sinuses of the Brain.**—Occasionally in operations, but more commonly from severe and usually compound fracture, the superior longitudinal or the lateral sinuses of the brain may be injured. It is always a serious and often a fatal accident. The blood pours out so furiously that the patient may die in a few minutes from the shock of the injury; for undoubtedly rapid loss of blood from the brain itself is more fatal than the loss of an equal amount of blood from any other part of the body. Hence all operations in the neighborhood of the sinuses should be conducted with great care. If necessary to trephine in their neighborhood, the edge of the trephine should be at such a distance as to be perfectly safe. With the dural separator or a grooved director or probe, and then the finger, the dura may be separated and the sinus entirely detached from the skull; and then the original trephine opening can be safely enlarged at will by the rongeur forceps. If necessary, a portion of the sinus may be removed by first exposing it in the manner indicated, and then ligating it on both sides of the proposed incision. Should the sinus be ruptured either in an operation or by a fracture, the hemorrhage usually can be controlled by instant packing with iodoform gauze. Sometimes the margins can be seized by one or more pairs of hemostatic forceps, which may be removed on the second or third day. Of course great care should be taken lest they be displaced in the tossing of the head by the patient. Lateral ligature and suture of the sinuses have also been employed.

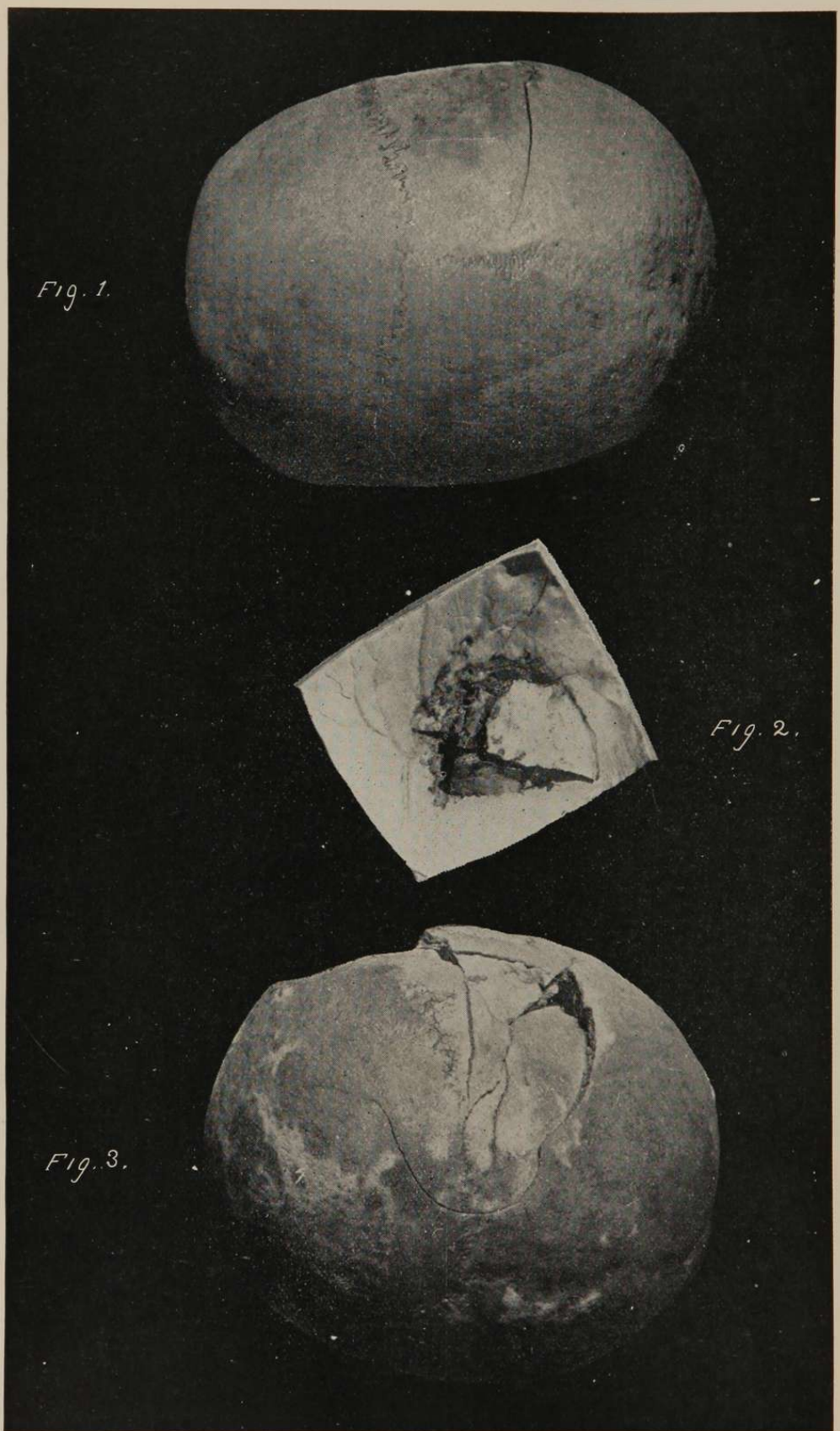
VIII.—FRACTURES OF THE SKULL

Fractures of the skull are considered with injuries of the head rather than with other fractures, for the reason that the fracture *per se* is of comparatively small moment. By far the most important factor in such injuries is the injury to the brain or to its membranes, or to both. A violence that will break the bones of the head is such that, even though there is no depression, very often the brain itself suffers serious injury; and if fragments are depressed or broken off and driven into the brain, the injury becomes even more severe and often fatal. The treatment of such fractures, therefore, is based on the injury, either actual or possible, to the brain itself, rather than on the injury to the skull. The history of such fractures and of their treatment is almost like that of abdominal diseases and injuries. The hesitation to interfere which prevailed in the past has been happily replaced by positive action of the most radical character, so that the treatment of such fractures has been almost entirely changed within the last ten years. The danger is now perhaps in the opposite direction—that surgeons may go too far and do harm rather than good by a rash interference instead of a wise conservatism.

Fractures of the skull are very frequent as a result of falls, blows, either from falling bodies or in personal encounters, and similar accidents. They are often extensive and involve wide areas of the skull in multiple fractures; or, on the contrary, they may be limited to a very small area, as in punctured fractures made, for instance, by a knife-blade or a nail, in which, as a rule, there lurks even more danger than in the more extensive fractures, because they are so apt to be improperly treated. The same varieties that are found in fractures elsewhere obtain in the skull. The fracture may be either simple or compound. If simple, the fracture in the bone does not communicate with the external air; if compound, it does, usually through the lacerated scalp. But attention is especially called to the fact that a fracture of the skull which extends into the nose, ear, or mouth is just as truly compound as a fracture of the vault, and even more dangerous, because the fact that it is a compound fracture, and therefore liable to infection, is so often overlooked. Such fractures, again, may be impacted. They may also be partial; that is, the outer table may not be broken, yet fragments may have been broken off from the inner table, wounding either the meninges or the brain itself.

Fractures of the skull are best discriminated by their position as fractures of the vault and fractures of the base of the skull. Fractures of the vault are usually the result of direct violence, while fractures of the base result either from the extension of fractures of the vault from the side to the base of the skull, or from indirect violence, such as a fall in which the person may alight upon the feet or the buttocks, in which case the blow is delivered through the spinal column, and sometimes even a fall on the vertex, in which, either with or without fracture of the vault, the base is fractured in a similar manner by the weight of the body. The base has also been fractured by violence received through the lower jawbone, the condyles having even been forced within the cavity of the skull.

Fracture of the skull sometimes, but very rarely, occurs at a point opposite that at which the blow is received. This is called fracture by *contre-coup*, or counter-stroke. Rupture of the meningeal vessels and of the brain itself certainly does take place at such a point not uncommonly, and its mechanism has already been explained (p. 498).



1. Linear fracture of vault of skull. 2. Depressed fracture of vault (from within). 3. Depressed fracture of vault (from without).

1. FRACTURE OF THE VAULT.

This may be a mere fissure, like a crack in a china plate (Pl. XIII, Fig. 1). The fissure may not be limited to one bone, but may cross a suture and extend quite widely. When compound, such a fracture may catch dirt or even a single hair, which, unless it is removed and the part disinfected, may become a source of serious or even fatal infection. Instead of a fissure the bones may be broken into several pieces, a comminuted fracture, either with or without depression of the fragments (Pl. XIII, Figs. 2 and 3). If depression takes place, there is usually a funnel-like hollow. There is no separation of the fragments, save what has been produced mechanically, for there are no muscles inserted on the skull to cause displacements similar to those which occur with most other fractures.

Symptoms.—If the fracture be a fissure, it can usually only be suspected, but may possibly be recognized in some cases by a "cracked-pot" sound. This may be elicited by percussion, best with, but sometimes even without, a stethoscope. It may be heard by the surgeon or by the bystanders, or may be perceived only by the patient himself. The same curious sound may be similarly elicited in hydrocephalus with beginning separation of the bones. If the fracture is much depressed, however, the depression, as a rule, may be easily felt by the finger. Care must be taken not to mistake for a fracture the circular effusion of blood which is so common after contusion. If there has been any destruction of the scalp, it is very possible to mistake an old depressed scar from this loss of tissue for an old depressed fracture of the skull. Occasionally there may be rupture of the dura even with simple fracture, and the cerebro-spinal fluid escaping under the scalp will cause a partially translucent, pulsating swelling, which becomes tense, especially with expiratory efforts such as sneezing, coughing, etc. It is a very rare but a positive sign of fracture. Still more rarely the fluid may come from the ventricles.

If the fracture be compound, its extent can be determined both by eye and by touch, but care must be taken not to mistake the ordinary sutures, and especially those of the Wormian bones or a slit in the pericranium, for linear fracture. The dark line of blood which marks a fissured fracture cannot be sponged or washed away, while the coagulated blood in an unbroken suture can be readily removed. This is a valuable means of differential diagnosis. The tooth-like character of the sutures is also a valuable aid. If cerebro-spinal fluid or brain tissue escape, the evidence of course will be positive.

Fracture of the inner table alone, which is very rare, can also only be suspected, but if there have been marked violence followed by symptoms of intracranial irritation or inflammation, the possibility that such an injury has occurred is increased; and if the symptoms be of localizing value—for instance, if there be a palsy of speech or of the right arm, or both of these symptoms, and if the blow have been received above and in front of the left ear—the possibility will become strong enough to warrant immediate operative interference.

The **prognosis** depends almost entirely on the amount of injury done to the brain rather than to the bone. As to the fracture itself, repair will take place, and the amount of callus thrown out in the skull is, fortunately, but little. Were it great, pressure on the brain would be the rule even in simple fissured fractures. If the fracture be compound, with loss of any fragments of bone, the loss will not usually be made good by new bone, but by fibrous tissue.

Treatment.—The conservative treatment of the last seventy-five years, which inculcated rest, antiphlogistics, sedatives, cold, and watching and waiting until the patient recovered or died, is curiously preceded and followed by a bold and active interference. Even pre-historic trephining, which was largely prac-

tised as a religious rite, must have been comparatively harmless, judging from the large number of skulls discovered with trephine openings healed before death. Prior to the earlier part of the nineteenth century the trephine was very frequently used: it is said that Chadborn trephined Philip of Nassau for epilepsy twenty-seven times, and instances of even a far larger number of operations on a single individual are known. The use of the trephine, however, was gradually abandoned, and for the last three-quarters of a century, almost disappeared until modern methods made the operative surgery of the brain so much safer that a return to frequent trephining and other similar operative interference has been a very notable fact within the last few years. Especially is this true since Macewen and Horsley have established the proper technique of such operations. At present, therefore, trephining with a view to the relief of immediate symptoms, and also quite as much for the prevention of later ill effects, is not only justifiable, but in many cases is demanded.

There are two forms of danger from such fractures: (1) the immediate dangers, which are first the injury to the brain, and secondly septic inflammation; and (2) the later dangers of severe continuous headache or of epilepsy and insanity, which are worse than death. For instance, even in a case of simple fracture there may have been a rupture of the dura and more or less laceration of the brain tissue, with effusion of a large or a small clot. If the clot be small, it will be absorbed before long, and healing of both the brain and the dura will take place by the ordinary cicatricial tissue of a lacerated wound. The skull, if it have been depressed, may even recover its vaulted contour (especially in children), but the scars which remain in the brain and dura are sometimes remotely the cause of epilepsy, insanity, and other complications of like character. Such a fracture, especially if compound and the result of a localized violence, may be attended with a clot, producing all the symptoms of compression of the brain. This clot and the brain tissue more or less intermingled with it may gradually be absorbed, but the brain is sometimes left permanently depressed, with spongy connective tissue, the meshes of which are filled with cerebro-spinal fluid; this sort of multiple cyst may keep up the palsy originally produced by the clot, and epilepsy, insanity, and other serious consequences may follow even if the patient recovers. The journals of the last few years have recorded a number of such cases, and the lesson to be derived from them is a most important and practical one. The doubt often expressed as to the wisdom of converting a closed fracture into an open one by an incision into the scalp has little weight, provided the surgeon observes the modern antiseptic precautions, without which methods no surgeon should touch a fracture of the skull.

Moreover, it is important to observe the great difference that should attend the treatment in cases in which a simple fracture occupies a limited area as a result of a localized violence—*e. g.* a blow from a hammer, and one in which the "bursting" force of a diffused injury produces long fissures in the bone and widespread injury to the brain. In the former such an exploratory incision may be entirely proper, in the latter in most instances it would be inadvisable.

If the fracture of the vault be simple, without depression and without cerebral symptoms, or if moderate cerebral symptoms have been present, but are abating, or if a fracture be only suspected, the case should be treated expectantly, but if any serious symptoms of intracranial mischief arise trephining should be done. In *simple fracture with marked depression* immediate preventive trephining should be done, even if there be no signs of encephalic mischief. Any violence sufficient to break a bone and depress it, there is good

reason to believe, may have lacerated the brain substance and probably the dura, and may be followed either by speedy inflammation or later in many cases by epilepsy, etc. if the depression remain. It is, however, but just to add that many surgeons still reject trephining until some symptoms of a lesion of the brain have manifested themselves.

In all *compound fractures of the skull* it is far better to shave the entire scalp rather than a small area, as is so often done. The removal of the hair even from a moderate area becomes very conspicuous, and it is better, even from an esthetic point of view, that the entire head should be shaved, so that the new crop of hair shall be of a uniform length all over the head. More than this, it is impossible to observe rigid asepsis without wide shaving, which thus becomes obligatory, even in women.

Compound fractures should always be explored by a large incision in the scalp. If the fracture be a mere linear fissure, it must be most carefully disinfected, and if it be impregnated with dirt or even if a single hair be caught in it, the outer table must be carefully chiselled away, turning the fissure into a V-shaped groove. The reason for this is that the danger lies far more in the probable infection than in the mere fissured fracture. If much depression exist even without symptoms showing that serious injury to the brain has been done, trephining should be done at once. It is still more strongly indicated if there be localizing symptoms which point to an injury of any of the cortical centers within easy reach, whether the fracture be simple or compound.

Punctured wounds of the brain are of course always compound fractures of the most fatal kind. In these the rule has long been absolute to trephine whether there be any brain symptoms or not.

If the surgeon sees that symptoms of intracranial mischief, such as local paralysis, epileptic seizures, beginning choked disks, etc., arise in any case of fracture of the skull, even after a considerable interval, his proper course is immediate operation. The longer the operation is delayed, the longer the "epileptic habit" has had a chance to form and the organic changes in the brain to become fixed, the less the probability of benefit from any operation. If, however, as in a case reported by Horsley, an old depressed compound comminuted fracture with laceration of the brain tissue, which caused in the first thirteen days of the patient's stay in hospital 2870 fits, could be cured by the removal of the scar tissue, we should not be deterred from attempting to relieve even the apparently most hopeless cases.

To sum up the matter, in any fracture of the vault, simple or compound, in which there are symptoms of intracranial mischief it is proper to incise the scalp and trephine. If there are no symptoms pointing to intracranial mischief, but there is marked localized depression from which we should infer the probability of either immediate or remote ill consequences, we should trephine. In all cases of punctured fracture the rule is absolute to trephine, open the dura, and disinfect. If, however, in a simple fracture there be no decided depression and no brain symptoms, the expectant plan may be pursued; but if the fracture be compound, it must be carefully disinfected, as has been described.

In giving these directions to operate it is of course understood that not only is the bone to be trephined, but if there is any reason whatever the dura must be incised and the brain inspected. Any further steps must depend on what is found. In 81 cases of compound fracture of the skull treated, as above described, by primary trephining the mortality was 1.23 per cent., while in 12 cases treated secondarily the mortality was 33.5 per cent. (Wagner). That is to say, later trephining, which should have been done at the time of the acci-

dent, caused an initial mortality nearly thirty times as great as simple primary trephining, to say nothing of later dangers.

2. FRACTURES OF THE BASE.

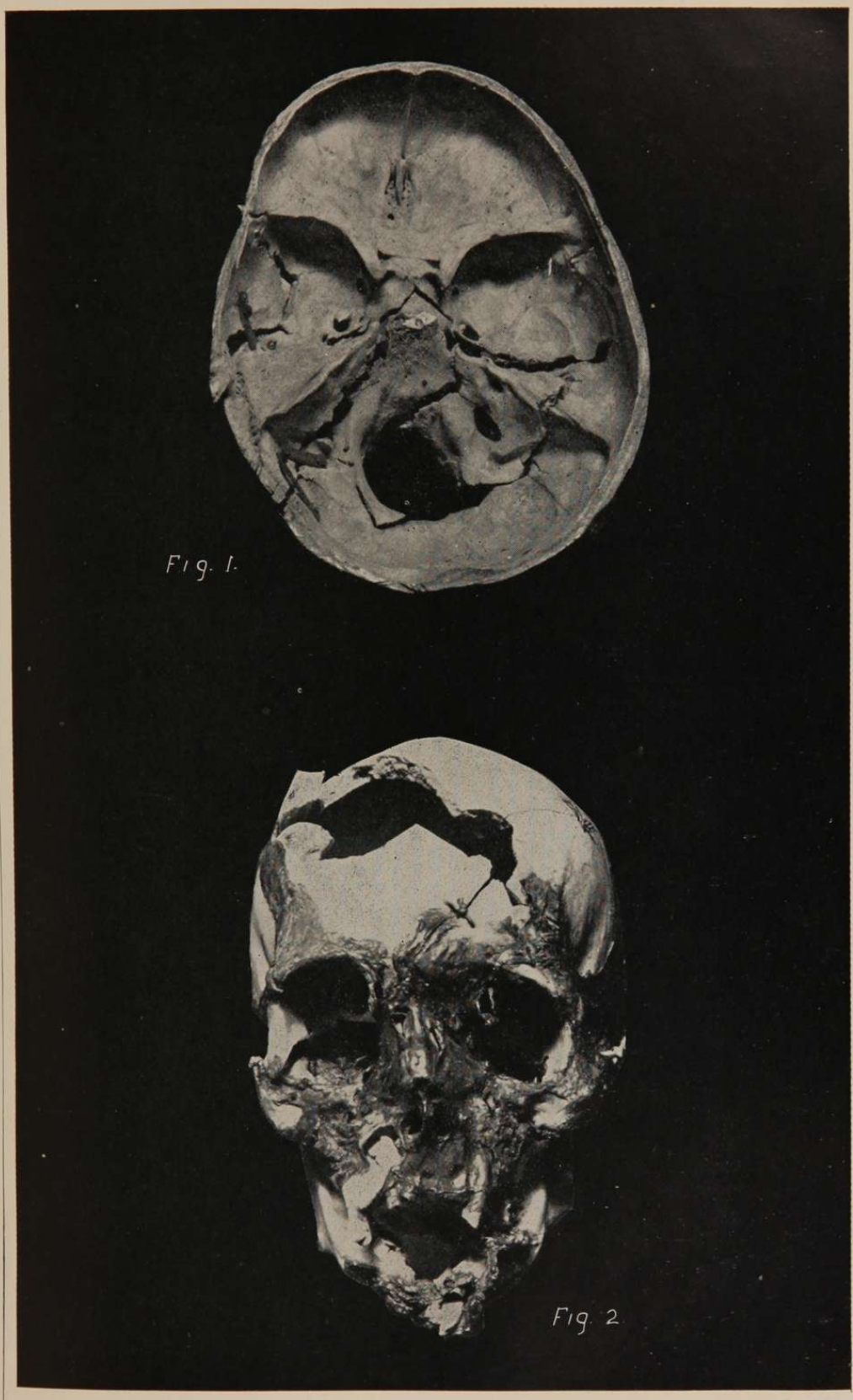
As has been already stated, fractures of the base (Pl. XIV, Fig. 1) either result from the extension of fractures of the vault to the base, or arise from indirect violence received through the spinal column or rarely through the lower jaw.

In addition to these cases a punctured fracture of the base may take place through three cavities at the base of the skull, the orbit, the nose, and the mouth. It is not very uncommon to see fractures of the base, with wound of the brain, caused by umbrellas, canes, knives, small sticks of wood, etc., which enter the orbit above the eyeball or gain access through the nose by piercing the cribriform plate of the ethmoid, while gunshot fractures are often the result of attempts at suicide by discharging a pistol into the mouth.

The fracture of the base may exist either in the anterior, middle, or posterior fossa of the base of the skull, the middle fossa suffering most frequently. Often more than one fossa is involved. Fracture of the posterior fossa has double the fatality of fracture of the other two.

The symptoms of fracture of the base are usually inferential, depending on the violence of the blow, and not uncommonly on our ability to detect extensive fracture of the vault probably extending to the base. In fractures through the orbit or other of the cavities just mentioned the evidence may be very clear, but, on the other hand, it may be very difficult to arrive at a positive conclusion. Not a few cases have occurred in which a thrust into the nose has produced severe bleeding, but in which the evidence of puncture of the base of the skull and injury to the brain has been very doubtful. This is equally true of the orbit, where a slight wound may be hidden in the folds of the upper lid. Large splinters of wood which have entered the cranial cavity either through the orbit or through the nose have been discovered at post-mortem examinations, their presence having been unsuspected during life. Of course the escape of brain substance through the ear, mouth, nose, or orbit is positive evidence. In fracture through the nose and mouth there may be vomiting of blood which has been swallowed.

The commonest sign of fracture of the base, especially in the middle fossa, is the escape of blood or cerebro-spinal fluid from the ear. Sometimes there will be bleeding from the ear, followed by the ordinary serous discharge from a wound, which may exist without any fracture of the base, but this bleeding will usually continue for only a short time. Long-continued bleeding, or, still more, the continuous discharge of a watery fluid, from the ear, if abundant, and especially if it is affected by the position of the head and is increased by any violent expiratory effort, such as sneezing, coughing, blowing the nose, etc., is almost positive evidence of such fracture, and especially if the watery fluid possess the chemical characteristics described below (p. 505). The patient may be directed to make these expiratory efforts with a view to testing the result. But in order that there shall be the escape of blood or cerebro-spinal fluid from the ear externally, the drumhead itself must also have been ruptured. The fact, therefore, must not be overlooked that there may exist fracture of the base without the escape of blood or cerebro-spinal fluid, on account of non-rupture of the drumhead. These fractures, however, are still compound, because they communicate with the external air through the Eustachian tube and the naso-pharynx, and their danger is all the greater



1. Fracture of base of skull. 2. Gunshot fracture of lower jaw and cranium.

because of their insidious character. Another evidence of fracture of the base is paralysis of the cranial nerves, especially of the optic, facial, and auditory nerves. Deafness and facial palsy, therefore, are very significant of fracture of the petrous bone, and if either or both of them accompany discharge of fluid from the ear and other evidences of fracture of the base, the diagnosis is assured. Optic neuritis also sometimes occurs, especially in fracture of the posterior fossa (Battle). Its advent is usually not till toward the end of the first week, and may be delayed even till three or four weeks have passed.

When the orbital plate of the frontal bone has been fractured, even without puncture, there is another symptom of considerable value—namely, after a day or two blood will appear first under the conjunctiva of the ball of the eye, and later in the lids. In fracture of the posterior fossa, which is especially fraught with danger, the mastoid region should be examined for ecchymosis. This is easily overlooked, as its existence is often hidden by the ear, the pillow, and the hair. As shown by Battle, it appears first anterior to the tip of the mastoid process, usually some time after the reception of the injury, and spreads chiefly upward and backward with a crescentic border. The reason for these peculiarities is that the blood cannot reach the skin below the occiput on account of the dense cervical fascia, but follows the muscular planes sidewise, first reaching the surface anterior to the tip of the mastoid by the loose tissue around the posterior auricular artery.

The temperature during the shock following the injury is subnormal. This is succeeded by a rise to 100° or 101° F., followed often by a second fall somewhat below the normal. It will then remain subnormal or rise to the normal. If the temperature rises to any notable degree, we may suspect suppuration and meningitis. If soon after the initial fall it rises quickly to 102° or in some cases 106°, 108°, or even 110°, we may be sure there has been some serious laceration of the brain, with almost certainly a fatal issue.

The **prognosis** in fracture of the base had always been an unfavorable one until of late years. The danger of infection was especially great, because the points through which septic infection may penetrate are hidden, and therefore were generally overlooked. These sources of infection are chiefly, as has been pointed out, the ear, mouth, nose, and orbit (if punctured); all of them are more or less inaccessible, difficult to disinfect, and likely to be overlooked. But the last few years have seen immense improvement in our methods of treating such fractures. The urgent necessity for disinfection of these dangerous cavities has been recognized, and as a result fractures of the base are much more amenable to treatment and their danger has been greatly reduced. A sudden, and especially a high, rise of temperature, as has just been stated, is a most unfavorable symptom.

Treatment.—In case of fracture of the base the fluid which escapes from the ear, nose, etc. ought to be collected, and examined to determine whether it be cerebro-spinal fluid. If it be, it will contain a small amount of albumin and a large amount of chlorides, and will sometimes give the reaction for sugar with Fehling's test. Next the cavity or cavities involved must be carefully disinfected. The ear should first be mechanically cleansed of wax, dirt, blood-clot, etc., and then should be most carefully disinfected by a stream of warm sublimate solution, 1 : 2000, or hydrogen peroxide, till it is absolutely clean. It may then be filled with sublimated cotton, iodoform gauze, or some similar disinfectant, and a sublimate dressing be applied externally. In the orbit the same rule must be carried out, and if the fracture be a punctured one, carrying infection into the brain, the wound must be enlarged and thoroughly disinfected; as a rule it is best to trephine or remove by the gouge and chisel

sufficient of the roof of the orbit to inspect the dura and brain itself if need be, and then after having disinfected the parts to drain them.

In the nose and mouth this proceeding must be modified, inasmuch as corrosive-sublimate solution would be dangerous from the possibility of its being swallowed. The parts, however, should be thoroughly washed with water as hot as can be borne, and then with a boric acid solution, which in the mouth must be frequently repeated by gargling, and in the nose by Thudichum's douche or by spraying. The nose should then be lightly packed with sublimate gauze or sublimate cotton, which will not only sterilize the air that may enter by the anterior nares, but also, by obstructing the passage of the air through the nose, tend to prevent infection by the posterior nares. Iodoform or boric acid may be insufflated into the naso-pharynx, and thus reach the orifice of the Eustachian tube. Of course it is recognized that the nose and mouth cannot be made absolutely aseptic, but only approximately so. But even this partial asepsis has resulted most hopefully in treatment. In rare cases drainage-tubes may be inserted into the cranial cavity through the nostrils, if need be by puncture of the cribriform plate. Similarly, for draining the middle fossa the skull may be trephined above and behind the auditory meatus. Thoroughness of disinfection and of drainage must be an absolute rule. To attain these ends the operative interference may have to be considerable, but they must be attained at whatever cost. If a fracture of the base is extensive, the head may be shaved and a plaster cap applied so as to immobilize the fragments. Of course the utmost quiet both physical and mental is necessary, with restricted diet, attention to bladder and bowels, and treatment by drugs to combat the symptoms as they arise.

IX. WOUNDS OF THE BRAIN.

These are produced by severe falls, by kicks, by the penetration of knives, nails, swords, bayonets, rifle-balls, etc., and may be received either on the vault or sides of the cranium or through the orbit, nose, or mouth. With the exception of such wounds in children through the open fontanelles, or possibly in adults through a large parietal foramen, they are necessarily accompanied by fracture of the skull. In many cases they are punctured fractures of the most dangerous kind. They must all be more or less septic in character, with laceration of the brain substance by the vulnerating instrument, with not uncommonly fragments of bone, hair, cap, etc. carried into the brain, and they are always attended by more or less severe hemorrhage. Recovery after a severe wound of the brain sometimes follows almost miraculously; as, for instance, in a recent case where a would-be suicide deliberately drove four nails through the skull into the brain, one being driven through the occipital bone. Knife wounds have been repeatedly recovered from, the blade of the knife having remained in the brain for many days or even years. Not uncommonly pistol-balls have remained in the brain for years before producing any serious symptoms, and sometimes the foreign body has been discovered only at the post-mortem, no symptoms whatever having arisen. The celebrated Vermont "tamping-iron case," in which a patient recovered after being wounded by a tamping-iron which passed entirely through the brain from below upward, is too well known to require repetition in detail. Loss of brain substance is by no means invariably fatal, although of course always serious.

The **symptoms** in such cases are occasionally surprisingly slight and long delayed, but more commonly are immediate and severe and in proportion to the extent of the injury received. Usually, even if the injury be moderate, head-

ache soon sets in, with all the symptoms of a developed encephalitis, followed, if not soon relieved, by coma and death. Very often there may be localizing symptoms of the greatest value which will enable us to discover an otherwise hidden injury. For instance, if a knife-blade have penetrated the speech center above and in front of the left ear, and have been broken off and hidden by the scalp and hair, the motor aphasia which follows will guide us to the region where we should search for the injury. If word-blindness or apraxia occur, the injury will be more apt to be above and behind the ear; if there be hemianopsia, the region of the cuneus should be examined; while palsy of the face, arm, or leg will point to their respective cortical centers as the probable site of the injury. In all such cases the entire head should be shaved, in order that the surface of the scalp may be examined with minute care. The vulnerating body also, if possible, should be examined, to see whether any part has been broken off and possibly left in the brain, and the evidence of eye-witnesses to the accident is always to be carefully weighed. In all cases which may involve a trial at court or a coroner's inquest careful notes should be made at the time. The question of foreign bodies in the brain will be treated presently.

Treatment.—The head should be shaved, and then with the greatest care the parts should be made as aseptic as possible, and all foreign bodies on the outside should be washed away or removed with forceps. Foreign bodies, fragments of bone, etc. which have been driven into the brain should all be removed and the depressed bone elevated; the cavity in the brain should also be disinfected. Hemorrhage should be arrested by ligature, by hot water, or by pressure. The dura, if not lacerated beyond repair, should be sutured, and possibly its place may be supplied by a bit of the pericranium. Drainage should be provided, best by rubber tubing, and then the flap of scalp should be replaced and sutured, and an ample sublimate dressing applied. The after-treatment before indicated should be carried out. Secondary abscess will be very apt to follow in many cases, and should be watched for, and the pus evacuated as soon as possible.

X. GUNSHOT WOUNDS OF THE HEAD.

These are frequently more serious than they appear to be at first. A glancing rifle-ball, and still more a larger shot, impinges with such force that while only the scalp may seem to have been injured, in reality the bone may have received sufficient injury to produce necrosis, and even the brain and its membranes may be or may become involved. The outer table may be only fissured, or, if it apparently have escaped, a fragment of the inner table may have been broken off. The scalp not uncommonly sloughs to a considerable extent. In other cases the most frightful and extensive injuries of the brain and the skull may be produced, as is shown on Plate XIV (Fig. 2).

Gunshot wounds directly involving the brain may be either perforating or penetrating. A penetrating wound is one in which the missile enters and does not emerge, and a perforating wound is one in which it passes entirely through the head. The injury to the skull or brain may vary from a comparatively slight wound to one which inflicts immense and widespread injury both to the skull and to its contents. The difference between the wound of entrance and the wound of exit is apt to be far more marked in the skull than in the soft parts. At the wound of entrance the aperture in the external table may be no larger than the ball itself, or may even have been reduced to a simple slit, whereas the inner table may be quite extensively fractured. At the wound of exit the reverse is true. The outer table will be more extensively

fractured than the inner, and in addition the entire aperture at the wound of exit, as the ball strikes on the concave surface of the skull, is apt to be much larger than the wound of entrance (Fig. 210).

Fig. 210.

Perforating Gunshot Wound of the Brain, involving the cuneus and producing hemianopsia. The wound of entrance is marked by a small linear scar below and to the right of the wound of exit, which produced the large excavated scar (Thomson and Keen).

The **symptoms** are very much the same as those in any other wound of the brain, with the exception that, owing to the widespread injury, there is less probability of limited localizing symptoms, though these may exist.

Treatment.—The recent advance in cerebral surgery again has materially changed our treatment of such wounds. The difference between the modern treatment of gunshot wounds of the brain and the older methods is due to the application of antiseptic methods and the consequent boldness with which we interfere, to the use of the aluminium gravity probe, and to our knowledge of the facts that drainage of the brain is not only feasible but essential, and that for the purpose both of searching for the bullet and of removing it we should often make a counter-opening by the trephine. The details of the treatment may be stated briefly as follows: (1) Shave and disinfect the entire scalp. (2) Disinfect the entire track of the wound from the wound of entrance to the wound of exit, if one be present, or to the certain or probable site of the ball if there be no wound of exit. (3) If there be any serious hemorrhage, the wound of entrance or the wound of exit or both must be freely enlarged by the rongeur forceps or the trephine, and the vessels secured by ligature, or occasionally the hemorrhage may be arrested by pressure or by hemostatic forceps. (4) The bullet or other missile must be removed if possible. For this purpose, if necessary, a counter trephine opening must be made. (5) Free drainage must be secured, again if need be by a counter-opening. For this purpose the drainage-tube may have to traverse the entire brain. (6) Apply antiseptic dressings, and continue the subsequent treatment on the principles already laid down. Most of the points above enunciated have already been considered, but some require a few words.

The *removal of the ball* has always been one of the principal difficulties in gunshot wounds. Fluhrer has introduced a probe of great value (Fig. 211), made

Fig. 211.

Fluhrer's Aluminium Gravity Probe (natural size, except the length, which is 12 inches).

of aluminium, with large conical ends of different sizes. The material is so light that if the head be so placed that the track of the ball is vertical, the probe if allowed to enter by its own weight will not produce a false passage, but will follow the track of the ball. If the ball is near the wound of entrance, it may be extracted through this wound, but if it has penetrated so far as to be more accessible from the opposite side of the skull, a counter-opening should be made at the point at which the probe would emerge if it

were carried through the head. It is important, therefore, in using the probe to measure its length, and when the probe has reached the ball to measure the protruding portion, which will give us the depth at which the ball lies from the wound of entrance. Then, pushing the probe farther on just to the counter-

FIG. 212.

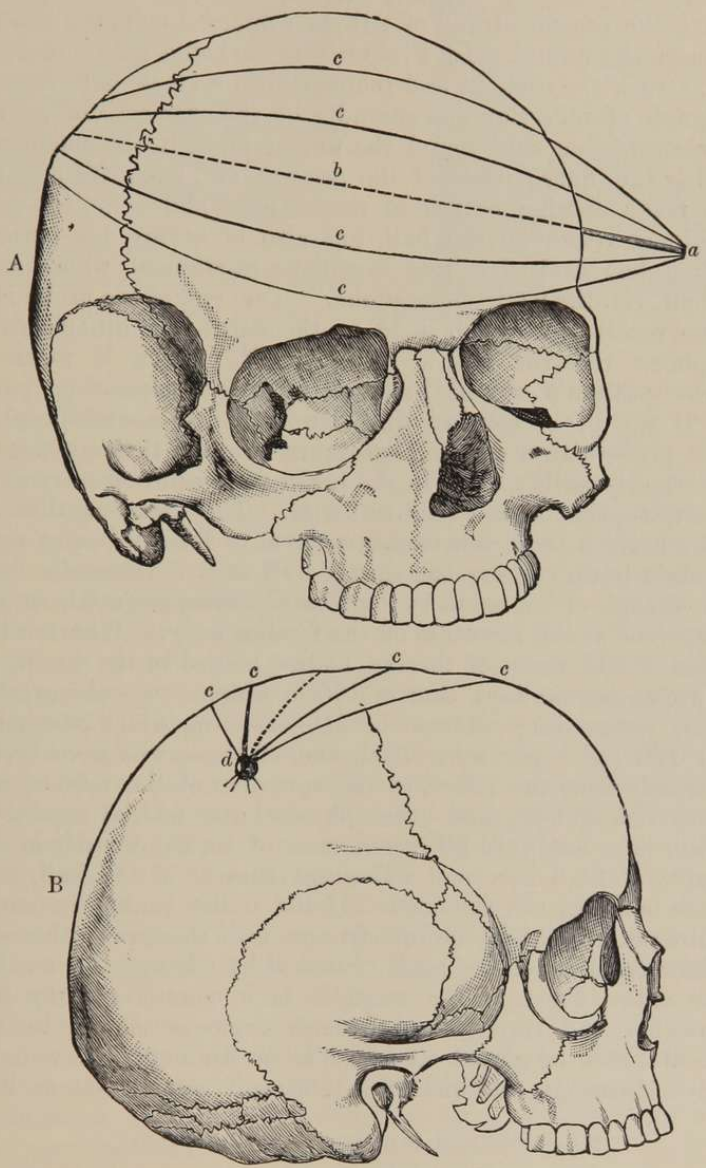


FIG. 212, A, B.—Method of Determining the Point for Counter-trephining: *a*, the protruding end of the probe; *b*, its axis continued to the counter-point *d*; *c*, similar lines all converging to *d*, the place for the counter-opening. These lines are fixed by regarding the skull in various planes: first from above, then in front, etc., and following the line of the protruding part of the probe to the opposite side of the skull (Bryant).

opening, and again measuring the part which protrudes from the wound of entrance, we ascertain the depth at which the ball lies from the counter-opening. Two strands of antiseptic silk are now attached to the extremities of the probe and are drawn through the wound by the withdrawal of the probe. To one of these strands a No. 9 (French) gum catheter is attached. This must be new and well disinfected, especially in the interior, and made rigid by a disin-

fected straight stylet. A pair of forceps is now tethered to the catheter by a loop of silk around one of its arms, and the ball is searched for at its known depth, first above, then below, to the right and to the left of the catheter guide. The forceps should not be swept around the catheter, but should be withdrawn and reintroduced for each search. The object of this is, of course, to avoid unnecessary injury of brain substance. The ball, if found, having been removed, the second strand of silk is utilized to draw a drainage-tube directly through the wound. In Fluhrer's remarkable case the ball entered the forehead, struck the occiput, and rebounded in a track determined first by the natural angle of reflection and secondly by the influence of gravity. He made a counter-opening, and found the wound made in the meninges by the ball on striking the inner surface of the occiput, and from this as a new point of departure made another search in the manner above indicated, with the result not only of removing the ball, but also of saving his patient.

Dr. Girdner has devised a very ingenious instrument which may aid in locating the ball, viz. the "telephone probe." One end of the probe is attached to a telephone receiver which is held to the ear. The other cord attached to the telephone receiver has a metal handle which is moistened and placed in the patient's closed hand or against some other part of his bare skin. If the probe touches the ball, a grating sound peculiar to the contact of the probe with a metallic substance is heard through the telephone receiver. Formerly balls lodged in the brain were allowed to remain unless they were quite superficial and readily found. The idea was that any meddling with the brain with a view to the removal of foreign bodies was unwarranted. Modern brain surgery has changed all this. Antiseptic disturbance of the brain, though of course to be deprecated unless essential, we now know is not so dangerous as the retention of the foreign body. Wharton has shown by an analysis of 316 cases of foreign bodies lodged in the brain, occurring even in the pre-antiseptic days, that in 106 in which removal was effected 34 (32 per cent.) were fatal; whereas in 210 cases in which the missile was not removed 122 (58.1 per cent.) died, and of those who recovered 10 succumbed ultimately from the effects of the retention of the missile, and many others suffered from epilepsy and other physical and mental troubles. Bradford and Smith have analyzed 89 recent cases of similar wounds of the brain, with a mortality of 33.3 per cent. following removal of the ball, and 54 per cent. when the ball was not removed. If the bullet cannot be found by the wound of entrance without undue interference with the brain, thorough disinfection of the wound should be made, followed by drainage by a rubber tube reaching the entire depth of the wound. If a counter-opening have been made, disinfection and through-and-through drainage should be employed. The head should then be placed so as to favor drainage, the wound covered with antiseptic dressings, and the after-treatment carried out as before.

XI.—FOREIGN BODIES IN THE BRAIN.

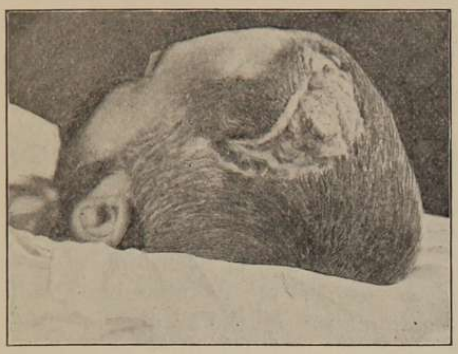
The treatment of foreign bodies in the brain has already been practically considered under the head of Compound Fracture and especially under that of Wounds and Gunshot Wounds, and the reader is referred to these subjects.

XII.—FUNGUS CEREBRI, OR HERNIA CEREBRI.

The former is the better term, as there is not commonly a true hernia of the brain. It is usually a growth from connective tissue (the neuroglia), and rarely contains much true brain substance (Fig. 213). Fungus cerebri, of course, cannot take place unless the dura has been opened, and in fact even in

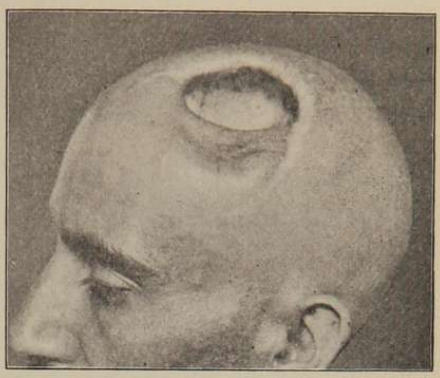
this case it is not likely to occur unless the brain substance itself has been wounded. Septic wounds by their failure to close early involve far greater

Fig. 213.



Removal of a Large Fibroma from the Brain (original): fungus cerebri soon after operation.

Fig. 214.



Depression in the Head, seven years after operation (Fig. 213).

danger of fungus cerebri than the aseptic wounds of modern surgery, which close by immediate union, because the neuroglia is softened and the intracranial pressure is markedly increased. Hence trephining if done with modern precautions involves but little danger of such a growth. Even if the dura has been opened, if it be closed either by interrupted or by continuous sutures there will be scarcely any risk, but the moment that any brain substance is removed the general risk of the operation, and the especial risk of fungus cerebri, are very much increased. If, therefore, in any operation it is necessary to remove any of the dura, and still more if any of the brain substance is removed, the suggestion made by Keen may be carried out, that a piece of the pericranium should be entirely detached from the under surface of the flap of scalp, turned upside down so that the osteogenetic surface shall be uppermost, and secured to the dura by a few interrupted sutures. Such a piece of the pericranium will retain its vitality and close the opening which otherwise would exist in the dura, and thus prevent a fungus cerebri. A fungus cerebri is usually more or less rounded and its surface lobulated, of a grayish dirty-white appearance, and soft to the touch; it produces no pain, and may pulsate with the heart. It is often the site of moderate or considerable discharge, and there may be escape of cerebro-spinal fluid even from the interior of the ventricles. It is apt also to bleed. The intelligence of the patient frequently remains good. The diagnosis, of course, is easy.

Treatment.—As a rule, the best treatment is to let the fungus alone or to dress it once or twice daily with simple antiseptic dressings. If it heals slowly, skin-grafting may be resorted to. Pressure by sponges or by dressing, though sometimes useful, is often followed by symptoms of intracranial pressure or by convulsions, and then has to be abandoned. If cut off by the knife or destroyed by the cautery, it almost always sprouts anew. It is a curious fact that as soon as such a fungus has cicatrized there is a sudden subsidence, so that instead of a bulging mass of tissue there is a marked depression, which is always permanent, and may be even one and a half inches deep. (See Figs. 210 and 214.) The latter shows the result seven years after removal of a large brain-tumor followed by the fungus cerebri shown in Fig. 213. An important lesson can be taught by such a depression in the brain. If the patient lies down, or even bends over, the hollow is immediately effaced. So too in violent expiratory efforts, such as sneezing and coughing,

the same effect will be produced. Such a case shows very clearly the rapid changes effected in the intracranial circulation and the cerebro-spinal fluid either by position or by violent expiratory efforts. This explains why when suffering from headache we walk on tiptoe in order to avoid any shock to the brain, and also why it is unwise to do any operation for cataract or other operation involving an incision into the ball of the eye when there exists cough from bronchitis or other similar cause.

XIII.—INFLAMMATION OF THE BRAIN AND MEMBRANES FROM TRAUMATISM.

Various terms are used to indicate inflammation of different parts of the brain and its membranes. The terms *encephalitis* and *cerebritis* are used indifferently for inflammation of the cerebrum, and *cerebellitis* is occasionally used for inflammation limited to the cerebellum. *Meningitis* means inflammation of the meninges of the brain, and *arachnitis* inflammation of the arachnoid itself. Two forms of meningitis also may be distinguished pathologically: *pachymeningitis*, or inflammation of the hard membrane or dura, and *leptomeningitis*, or inflammation of the arachnoid and pia considered as one. The differential diagnosis between these two forms can be made only on the post-mortem table; clinically they cannot be distinguished. Moreover, inflammation of the brain, of the pia and arachnoid, or of the dura is sure sooner or later to extend to either or both of the others, and the consequence in any form may be the production of suppuration, abscess, effusion into the ventricles, and softening of the cerebral tissue if the brain itself is involved.

Causes.—These are usually traumatic, such as contusions or lacerations of the brain, fracture of the skull, etc. Caries and necrosis of the bones of the skull, and occasionally pyemia, may also be the starting-point of such inflammation. Caries and necrosis of small portions of the skull not infrequently may cause a localized and limited meningitis, which is far less dangerous than the diffused form resulting from contusions or similar traumatisms which shake the brain as a whole and are followed by the most intense forms of diffused inflammation. Very often a piece of necrosed bone will lose its vitality, either from localized injury or from syphilis, and its removal will disclose a layer of granulation-tissue under it extending somewhat beyond the layer of necrotic bone; yet in this case the rest of the membranes and the brain itself may entirely escape.

Meningitis and encephalitis are either chronic or acute, and it is necessary to distinguish the two forms. Encephalitis will be used as a type of all these forms of inflammation.

1. **Acute Encephalitis.—Symptoms.**—These usually arise within a day or two after the injury, and with distinct symptoms, such as pain in the head, which is apt to be general, photophobia, intolerance of noise, and rapidly rising fever until the temperature is 103° or 104°, with flushed face, full, bounding pulse, contracted pupils, and a rise of surface temperature at the site of the injury. The bowels will be constipated and the patient sleepless and restless. Delirium is apt to set in early, with twitching and strabismus, followed by drowsiness which deepens into coma, and as the symptoms deepen there will be paralysis with involuntary evacuation of urine and feces, and the patient will die in a typhoid state. The ophthalmoscope will rarely show choked disk. At the post-mortem the dura will be found inflamed and reddened, the arachnoid usually whitish and opalescent, and if the inflammation have progressed far enough the hemispheres will be covered with a greenish-yellow layer of pus. The brain substance itself will be softened and vascular,

and very likely a layer of pus will lie at the base of the brain. The ventricles will be filled with turbid serum.

It is very important to distinguish between such inflammation of the brain and uremic coma. In uremia the fundus of the eye will probably show patches of albuminuric retinitis, while the urine will contain albumin and tube-casts, and there will be very likely coexisting œdema, especially about the ankles and the face. Not uncommonly also there may be chills at the beginning of the suppurative process in encephalitis, which are generally absent in uremia.

Treatment.—The patient should be placed in a quiet, dark room, with the head raised and the entire scalp shaved. The bowels should be quickly purged, but not immoderately, lest the patient be weakened by it as well as by the physical efforts necessitated by such purgation. The bladder should be carefully looked after, and retention of urine relieved by the catheter. Cold should be applied to the head, either by an ice-bag or by a coil of tubing for cold water. Occasionally, but not often, bleeding from the arm may be of value, but if so it will be only in the robust and at the beginning of the attack. Leeching or wet cups applied to the mastoid region and nape of the neck are better, as they directly withdraw venous blood from the lateral sinus through depletion of the radicles of the mastoid veins. Large doses of bromide, up to 100 grains, or even more, per diem, aconite, calomel guarded by opium up to the point of beginning ptyalism, and hypnotics, such as hydrobromate of hyoscine, chloral, paraldehyde, etc., should be given to procure sleep. In the early stages alcohol in any form is to be avoided, as an additional excitant, but in the later stages, when exhaustion and especially the typhoid state develop, it may be of value. In the stage of exudation, when pressure symptoms begin, blisters to the nape of the neck and occasionally to the scalp, with mercury and iodide of potassium, are the best remedies, if any remedies can be said to be best in a disease which is so often hopeless from the start. Should the patient recover, as he occasionally will, the most careful after-treatment is essential. Convalescence must be conducted very watchfully as to diet, exercise, and occupation. No physical exertion, even of the mildest character, should be allowed until the convalescence is well established. Absolutely no mental effort should be allowed, especially that involving any excitement, worry, or over-study, for many weeks, or, better still, months, after the attack.

2. **Chronic Encephalitis.**—The **causes** of chronic encephalitis are the same as those of acute, but usually the initial traumatism is less severe and the inflammation follows after a longer interval, but it is always much more apt to result in the formation of pus, either extradural, subdural, or cerebral. Distinct accumulations of pus will be considered under the head of Abscess.

Symptoms.—The patient has received probably a blow on the head, followed by the lighter symptoms already described under Contusion. From these he will recover more or less rapidly, and will apparently be again a well man; but days, weeks, or even months, after the injury he will begin to suffer with vague symptoms of cerebral trouble, especially headache, which very frequently will be localized at or about the site of the injury. He will be unable to attend to business or study for any length of time. There will be more or less mental dulness and irritability of temper. Without any change in his acuteness of vision, if the eyes are examined choked disk will be found. Not long afterward there will very likely be a chill, followed by a localized paresis or paralysis, and if the case terminate fatally the drowsiness will deepen into coma, and he will die with the same symptoms as those of acute encephalitis.

Treatment.—The same care should be given to the patient as before in the matter of mental quietude, physical rest, diet, moderate purgation, and watching the bladder if necessary. Blisters to the back of the neck and cold to the head are useful. Internally calomel and opium in the earlier stages, and mercury and iodide of potassium in the later, will be found most useful. Care must be taken not to confound the dulness caused by the opium with the coma which may arise in the course of the disease, and, conversely, the coma must not be mistaken for opium narcosis. If the patient recover, the same watchful after-treatment that has been above described must be stringently carried out. No one has better described the need for such rest after any concussion or inflammation of the brain than Mr. Hilton, in Lecture III. of his book *Rest and Pain.*

3. **Operative Interference in Meningitis and Encephalitis.**—Very naturally, in view of the boldness of modern cerebral surgery, the question will arise whether operative interference will not give a better chance for relief than the treatment above indicated. As yet, it is too early to be dogmatic on this point, for there is little experience to guide us. But as inflammation in the brain as in other parts of the body is followed by exudation and suppuration, and this exudate or pus, not being able to escape, produces rapid tissue-changes and symptoms of pressure, and as the bony skull cannot be perforated by the serum or pus, and so allow it to escape and relieve the pressure, as is the case in the soft parts, it seems reasonable that we should interfere surgically and afford a means of escape for the exudate by trephining, opening the dura, and draining. All surgeons would be agreed upon the propriety of this treatment when there is localized suppuration, but there is still a difference of opinion as to its propriety in the early stages when the exudate is only serous. It is, however, possible that just as when exudation or suppuration occurs under the dense periosteum, we incise it and give exit to the fluid; and when increased intraocular pressure occurs, an incision relieves it and saves the eye; or in an orchitis an incision relieves the pain and saves the testicle; so in inflammation of the brain future experience may show that it will be wise to trephine for drainage of the effused fluids before they have gone on to the stage of suppuration or abscess and done irreparable damage to the brain. In that case we shall be able hereafter to cope with the dangers of cerebral inflammation far better than we have been in the past, and our mortality records will be immensely improved. Very little has been done in this direction, however, and hence these views are put forward tentatively.

Mr. Horsley has already urged this course of treatment, and very properly his opinion carries great weight. In cases of chronic encephalitis probably such operative interference will be more likely to be followed by success than in the acute form, for in chronic encephalitis the symptoms often indicate localized pressure on a single cortical center or on more than one neighboring center. In this case the indications would be clearly in favor of trephining, incising the dura, or, it may be, puncturing it, with a view to the relief of the pressure. Whether acute or chronic, those cases afford the greatest probabilities of cure in which there is evidence of localized rather than diffused, and especially of basilar, inflammation, and in which there is a local production of serum or of pus. One remarkable acute case has been reported by Mr. A. E. Barker, in which there is reason to believe that he evacuated an ounce of odorless pus from the fissure of Sylvius, with good result. While a single case like this does not establish a rule, it at least suggests a possibility which must be taken into account and acted upon, especially in so fatal a disorder. In any such operation we must be guided absolutely by our present knowledge of the localizing

symptoms, which have already been stated and which are becoming more and more exact. Even in general encephalitis it is perhaps not too much to hope that operative interference may find some means of relief, although of course it is far less apt to do so than where the symptoms indicate localized pressure.

If the inflammation arises from a general shaking and laceration of the brain, it is often basilar, and the obtaining of good results from trephining is more doubtful.

XIV.—ABSCESS OF THE BRAIN.

Causes.—Nearly 50 per cent. of the cases of abscess of the brain arise from suppuration in the ear, especially the middle ear. This will be considered in connection with other cerebral disturbances having the same origin. The next most frequent cause is injury, such as compound fracture, or, rarely, simple fracture if a splinter is broken off from the inner table and driven into the brain. Not uncommonly, however, it may arise from simple contusion, which may not even have been very severe, and from which recovery apparently may have taken place. Weeks or months after such an injury, and in some cases even a number of years after it, abscess of the brain has been developed. Thus Mr. Damer Harrisson has reported the case of a boy fifteen years old who received a severe blow on the *left* side of his head at the age of four or five years. No serious symptoms followed, but at fourteen years of age a number of muscles in his right arm were the subjects of twitchings. Eight days before admission to hospital he had received a blow on the *right* side of his head from a pair of tongs. Three days after this last accident convulsions suddenly set in, beginning in the *right* arm and spreading to the face and leg on the same side, followed by complete right hemiplegia. Mr. Harrisson trephined him, not at the site of the second injury, but at the cicatrix of the first injury, received ten or eleven years before, and evacuated four drams of fetid pus; the boy recovered. This may serve as the type of a number of similar instances of late results from such an injury.

Besides such aural and traumatic cases, cerebral abscess sometimes follows septic disease of the lungs or ulcerative endocarditis, and in pyemia multiple abscesses of the brain not uncommonly exist. Occasionally tubercular abscesses are found.

Pathological Anatomy.—The site of the abscess may be between the dura and the skull, *extradural abscess;* or between the dura and the brain, *subdural abscess;* or in the substance of the brain, *cerebral* or *cerebellar abscess.* Except extradural abscess, which will be considered later, there are no means of accurately distinguishing these various forms.

If the cause of the abscess is traumatic, it is generally situated under the site of the injury, to which we may usually be guided by the scar, although, as already stated, sometimes no such mark exists. Occasionally it will occur on the opposite side of the head, being caused by the laceration of the brain, as already explained, by contre-coup. Its site must always be determined much more by the localizing symptoms than by the scar or the history, as, for instance, in a case reported by Macewen, in which the abscess was in Broca's convolution—that is, the third or inferior frontal at its posterior end—and the cicatrix was on the forehead. The size of the abscess will vary, from a cavity containing a dram or two of pus up to one involving a large portion of the hemisphere. It is commonly single, except in tubercular cases, where it is frequently multiple, although single tubercular abscesses have been reported. If large, they sometimes rupture into the ventricles, invariably with a fatal result.

Symptoms.—These may be divided into three classes: (1) those due to the suppurative process; (2) those due to pressure; (3) the focal or localizing symptoms.

(1) *Symptoms due to the Suppurative Process.*—Usually a rise of temperature is significant of suppuration in other parts of the body, but it is especially noteworthy that in cerebral abscess the temperature, as a rule, is either normal or subnormal, even when the other symptoms indicate the gravest peril. Occasionally there will be an initial rise, followed by a fall to normal or below it, and then toward the end of the disease there will be another rise, often accompanied by delirium, and the temperature again subsides, only to rise after an interval if life is sufficiently prolonged. The local temperature over the abscess, it is stated, rises, even if the general body temperature be subnormal. If, therefore, in any case following a traumatism symptoms of serious intracranial pressure set in, with the body temperature normal or subnormal while the local temperature rises and the pulse is slow, the first thought of the surgeon should be that he has to deal probably with abscess of the brain. A chill not uncommonly occurs, but may be absent. Of course anorexia, vomiting, general malaise, etc. are present. Somerville has stated that when there is pus in the brain the urinary chlorides will be below normal and the phosphates will be above.

(2) *Symptoms due to Pressure.*—Headache is one of the most important, and is almost always present, and not infrequently of a severe character, so that the patient will moan constantly. Should the temperature rise the headache is often aggravated, and sometimes is located distinctly over the lesion, but very commonly it is first general and then focal. The pulse is always slow, and may even fall to 30 or 40. Respiration is often of the Cheyne-Stokes type. The mind soon becomes clouded, and the dulness gradually deepens into coma, and the bowels and bladder are evacuated involuntarily. Epileptoid convulsions often occur, but if the abscess arises from ear disease and is situated in the temporo-sphenoidal lobe, the patient may be free from them. Sensation is not usually impaired to any extent. Choked disk may be present or absent, and may be unilateral or bilateral. If bilateral, it is commonly more marked on the same side as the abscess, though occasionally this is reversed. Sometimes ptosis may be present, and occasionally the entire third nerve is paralyzed, while the sixth escapes, though this is sometimes reversed. The pupil on the side of the lesion is usually dilated and more or less immobile. The patient's general condition fluctuates remarkably as to these symptoms of pressure, giving us hope sometimes of spontaneous recovery, and then becoming worse than before.

If the abscess is *cerebellar*, the diagnosis is even more obscure. There may be occipital headache and muscular rigidity of the neck. If it be in the middle lobe, there will be muscular incoördination, and especially a drunken, unsteady gait. Vertigo and vomiting are frequent and persistent. There will sometimes be tenderness on pressure and pain on percussion over the cerebellum. Choked disk is commonly absent.

(3) *Focal or Localizing Symptoms.*—If the abscess is situated in the left temporo-sphenoidal lobe, it may press on Broca's convolution, and this will produce motor aphasia. If it involve or press upon the lower part of the Rolandic motor region, it will produce paresis or paralysis of the opposite side of the face, followed by paresis or paralysis of the arm, and finally of the leg as the pus creeps upward in the motor region. Sometimes there will be distinct squint, from paralysis of the sixth nerve. Should the abscess arise in the frontal lobe from contusion or fracture of this region or from nasal disease, localizing symp-

toms are apt to be absent, since the frontal lobe is a latent region; and the same statement applies to the occipital lobe unless the abscess involves the cuneus, when hemianopsia of the same half—that is, right or left—of each retina will follow. If the angular or supramarginal gyrus is involved, there may be monocular Argyll-Robertson pupil,[1] as pointed out by Oliver. The local temperature of the two sides of the head should be taken, though it must be interpreted with care; and it must be remembered that the left side is normally of a slightly higher temperature than the right. Pressure on the skull and percussion, like the local temperature, may be of value, but must not be relied upon absolutely. Ferrier states that pain which is not spontaneously complained of, but is elicited by percussion, is of greater value than mere tenderness on pressure. As a means of diagnosis between cerebral and cerebellar abscess this is of some value so long as the mental condition of the patient is sufficiently clear.

Differential Diagnosis.—1. *Meningitis.*—Meningitis and abscess are very often extremely difficult to differentiate, but we may be helped in the diagnosis by the fact that meningitis is apt to develop within the first three or four days, whereas an abscess does not usually form earlier than the end of the first week. In meningitis also there are apt to be early dulness, deepening into coma and actual delirium, photophobia, and contraction of the pupils, with high general temperature and marked rigidity of the cervical muscles.

2. *Mastoid Disease*, following suppurative disease of the middle ear, sometimes occasions serious cerebral disorder without abscess. Trephining the mastoid, which should generally be done at an early stage, will eliminate this as a factor in the problem. Mastoid disease will ordinarily be accompanied with swelling, œdema, and pain in the mastoid region. It must be remembered also that a cerebral abscess and mastoid disease often coexist.

3. *Extradural Abscess* may be distinguished from cerebral abscess by the symptoms given later.

4. *Thrombosis of the Lateral Sinus and Pyemia.*—Commonly the internal jugular vein, as well as the lateral sinus, will be invaded by the thrombus, and will be hard and cord-like, and the veins of the face are apt to be swollen. Pressure and percussion over the lateral sinus will be painful. The temperature will fluctuate violently, rising far above the normal, and there will be rigors, sweating, and general prostration, and eventually suppuration in the joints, with pyemic symptoms referable to the lungs and liver. Usually also the intellect is much clearer than in abscess, at least in the early stages.

5. *Tumor.*—A tumor is ordinarily slow in its growth, and often attended with distinct localizing symptoms at a comparatively early stage, while abscess usually pursues a much more rapid course. There are in abscess commonly the history and often the evidence of distinct injury or of disease of the ear or nose. Choked disk is almost always present in tumor, and is generally double and much more frequent than in abscess. Moreover, abscess is far more common in the temporo-sphenoidal lobe or in the cerebellum, especially from ear disease, while tumor is rare in these situations. In other parts of the brain, on the contrary, tumor is more common than abscess. The temperature is not apt to rise in tumor, but should there be any marked and rapid fluctuation, and especially any prolonged subnormal temperature, it would be strong evidence of abscess; if the patient is syphilitic, he is more apt to have tumor than abscess.

[1] The Argyll-Robertson pupil is one which is more or less contracted, but the iris does not contract when light is thrown upon the retina, although it varies with accommodation and convergence. If this peculiarity exists in one eye only, it is called monocular Argyll-Robertson pupil.

Treatment.—A few early attempts to evacuate an abscess of the brain, by Dupuytren, Detmold, and others, are on record, but it is only since cerebral localization has enabled us to diagnosticate with comparative accuracy the location of an abscess, and within the last few years, since cerebral surgery has advanced with such rapid strides, that surgeons have been emboldened to interfere in an operative way in cases of such abscess, and in very many instances with the happiest results. When the abscess is located, the head should be shaved and disinfected, as already described. If the localizing symptoms point to the region of the scar, we should trephine at that point, but if they indicate another region we should always trephine in accordance with the doctrines of cerebral localization rather than by the indication or the history of the lesion. Of course if there be a fistula discharging pus, we should trephine at the mouth of the fistula and follow it up to the abscess.

The dura having been opened, if there be an abscess the brain substance will probably bulge markedly through the opening. The normal pulsations of the brain will be absent. For exploration the grooved director is the best instrument to use. The hypodermatic needle and the knife have been used, but there is considerable danger of wounding the vessels, whereas the grooved director is safe in this respect, and as soon as the abscess is reached it will allow the pus to flow through its groove. The director should be forced gently and carefully straight forward into the brain in the probable direction of the abscess, and may be safely introduced to the depth of two to two and a half inches if the abscess be not reached more superficially. If the abscess be not reached, the director should be withdrawn exactly in the line in which it entered, and the brain similarly punctured in another direction. As soon as the abscess-cavity is reached, the knife should be used to open the abscess, and the opening may be enlarged by a pair of hemostatic forceps, introduced closed and drawn out expanded to a reasonable degree, so as to afford a free opening for the pus. The granulation-tissue lining the walls of the abscess-cavity should then be removed by the sharp spoon, care being taken not to do unnecessary damage to the neighboring parts of the brain. The cavity should next be very gently washed out, best with a boric acid solution, and a drainage tube inserted. This should be either of rubber or of silver. A buttonhole opening should be made in the scalp through which the tube may emerge, and the tube should be secured to the scalp by a silk thread. The bone should not be replaced. If the abscess is large and the first trephine opening does not drain it well in the recumbent posture, a second opening should be made, and the tube may pass through this or through both openings. An abundant sublimate dressing should then be applied. After two or three days the drainage tube may be gradually shortened until it can be dispensed with. Should there be reaccumulation of pus after apparent healing, the wound must be reopened, the pus evacuated, and the cavity washed out and treated as before. Sometimes such reaccumulation will occur two or three years after the first abscess.

If the first trephine opening does not disclose any abscess, and it is possible that one may exist at another point, a second, and if need be a third, trephine opening should be made at the possible point of suppuration. The dangers of additional trephining are nothing as compared with the dangers of an abscess, which is necessarily fatal unless evacuated.

In cerebellar abscess the upper edge of the trephine should be well below a line from the inion to the external auditory meatus (the line of the lateral sinus), and midway between the tip of the mastoid and the inion. The gouge may often replace the trephine to advantage, especially in children. It must be remembered that the skull is thin and quickly penetrated in this region.

The rongeur may be used to enlarge the opening if need be. The flap in the dura should have its base upward, to guard the sinus. The grooved director may be used again to penetrate the cerebellum, and even should the abscess exist on the opposite side of the cerebellum, it may be reached by an oblique puncture, care being taken not to injure the superior vermiform process.

XV.—DISEASES OF THE BRAIN ARISING FROM SUPPURATIVE DISEASE OF THE EAR.

If we look at the base of the skull on the inside, we will be struck by the position of the petrous bone as a boundary-line between the middle and posterior fossæ of the skull. The upper edge forms a sort of watershed, with a moderate declivity in front toward the middle fossa, in which lies the temporo-sphenoidal lobe, and a sheer declivity at the back toward the posterior fossa, in which lies the cerebellum. The wall of bone between the tympanum and the middle fossa especially is very thin, and we can easily understand, on noting the anatomical relation of the temporo-sphenoidal lobe and the cerebellum to the petrous bone, how disease of the ear may readily break through the thin osseous barrier and produce inflammation of the meninges, thrombosis of the petrosal or lateral sinus, and involvement of either the temporo-sphenoidal lobe or the cerebellum itself. This explains the frequency of cerebral disease as a result of disease of the ear.

Barker estimates that there are not far from 2000 deaths annually from ear disease in Great Britain, with a population of but little more than one-half that of the United States. Of all these a very large proportion are caused by cerebral disorder resulting from ear disease. Of 43,730 cases of ear disease tabulated by Bürkner, 66.9 per cent. were disease of the middle ear, and 29 per cent. were suppurative middle-ear disease. Four-fifths of these were chronic, among which are to be sought the greater number of brain lesions. We are very apt to imagine that the excessively fetid discharges which often accompany ear disease are far more dangerous than those without such odor; but Röhrer has shown that the non-fetid discharges are the causes of the most dangerous cerebral sequels, since fetor is due to bacilli which are not pathogenic, but merely saphrophytic. Therefore the presence or absence of odor in the discharge is no test of its danger. Of all the discharges, the inspissated pus that is found in the ear in many cases is the most dangerous, being filled with pathogenic micro-organisms.

Primary acute inflammation of the ear rarely causes cerebral trouble: it is in the chronic cases that the danger lurks. In these, the mucous membrane being destroyed, the bone is bare and often carious and the seat of septic discharges and also of septic foci. Hence if we attack an ear the seat of such chronic discharge, and possibly of such inspissated pus and septic foci, we should be very careful to do it thoroughly and with the strictest antisepsis, or we may light up new and dangerous septic processes, giving to the inactive micro-organisms new life by the moisture supplied to them by opening the vessels and lymph-channels, and spreading them by breaking down the barriers to their introduction into the system.

It is a curious fact that aural disease may produce an abscess an inch or more from the inferior surface of the brain, the intervening cortex remaining perfectly normal. This may occur, according to Barker, in one of two ways: either a thrombus may extend into the lateral or the petrosal sinus, and from this through the veins that empty into the interior of the brain, especially as these veins have no valves; or, secondly, the blood-current may be reversed in these veins by reason of the thrombus.

Aural disease may cause meningitis, phlebitis, thrombosis of the lateral and petrosal sinuses, extradural abscess, or cerebral or cerebellar abscess. Of these, meningitis, pyemia, and abscess are the most frequent.

I. The **Meningitis** from aural disease differs in no respect from that arising from other causes, except that it is more likely to be localized and may be more frequently relieved by operation, as has already been indicated under that head.

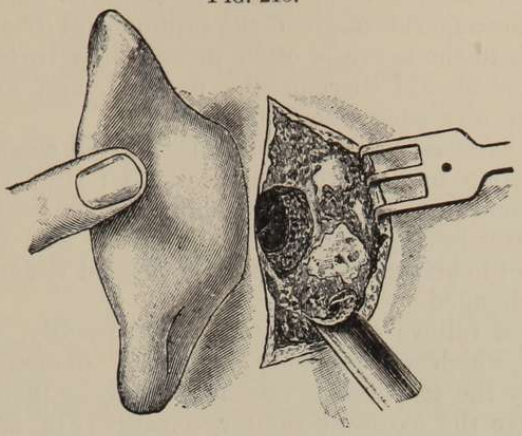
II. **Cerebral Abscesses from Ear Disease** are almost always situated in the temporo-sphenoidal lobe between two vertical lines, of which the anterior is drawn through the tragus, and the posterior two inches back of the tragus. Nine-tenths of them lie in a region covered by a circle of one inch and a quarter radius, the center of which is one inch and a quarter above and behind the meatus. This is well named by Barker the "dangerous region." They may be encapsulated or diffused. In other respects they do not differ from the cerebral abscesses already described.

Diagnosis.—The ear discharge from which they arise is almost always chronic, and may have existed for years. While the general health is good, there may be a sudden cessation of the discharge, with a rise of temperature, nausea and vomiting, and a dull ache in the mastoid region, the temples, and the neck; the pulse becomes frequent, the tongue foul, and very often there is diarrhea; that is to say, the symptoms of acute septic infection are engrafted on the existing chronic saprogenic suppuration. The headache and tenderness are often general or frontal, and not located at the site of the lesion. The temperature after the initial rise is again subnormal, and is in especial contrast to that of pyemia, with its acute fluctuations, which bear no relation to the ordinary morning fall and evening rise, or to the presence or absence of discharge, and may be accompanied with rigors. It is again in contrast to the high temperature of meningitis, which has not the abrupt oscillations of pyemic temperature. The intellect is dull and sluggish and deepens into coma. The bowels are apt to be constipated, the breath fetid, and the skin muddy, and there is marked emaciation. Optic neuritis, if present, is of value, but is often absent. Convulsive twitchings or paralysis are of great value, if present, by their localizing indications. The state of the pupil is not commonly to be relied upon.

Treatment of Abscess from Ear Disease.—The treatment of abscess arising from ear disease is the same in principle as that of cerebral abscess in any other region or from any other cause. Prevention of the cerebral disease is vastly better than treatment after its onset. Hence if after chronic ear disease persistent headache, vomiting, and mental dulness, without rise of temperature, occur, the mastoid should be opened as indicated below. Not seldom this will avoid the later necessity for graver operations. If, however, when first seen the intracranial symptoms have already arisen and the mastoid process has not already been opened, with few if any exceptions the first step should be to open the mastoid and thoroughly wash it out. In doing this as practised by Horsley and Barker a vertical curved incision should be made a quarter of an inch behind the meatus in the axis of the mastoid from its base to its tip, about two inches in length, the ear being drawn well forward. The mastoid antrum and cells should then all be thoroughly laid open by the gouge and chisel, and the posterior wall of the meatus be chiselled away to the cavity of the middle ear (Fig. 215). All the inspissated pus which is often found both in the mastoid antrum and in the mastoid cells, and which cannot be got rid of by simple syringing, should be removed by a small sharp spoon or a gouge and chisel, care being taken not to wound the lateral sinus. In order to reach the antrum the opening is best made from one-third to one-half of an

inch behind and the same distance above the center of the meatus (Fig. 216, ×). To find the mastoid antrum Macewen has directed attention to the value of

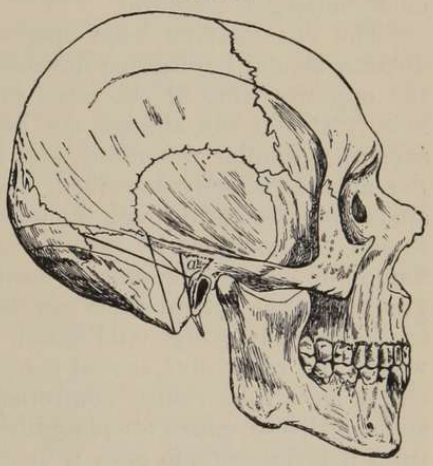
Fig. 215.



Opening the Mastoid Antrum (Esmarch and Kowalzig).

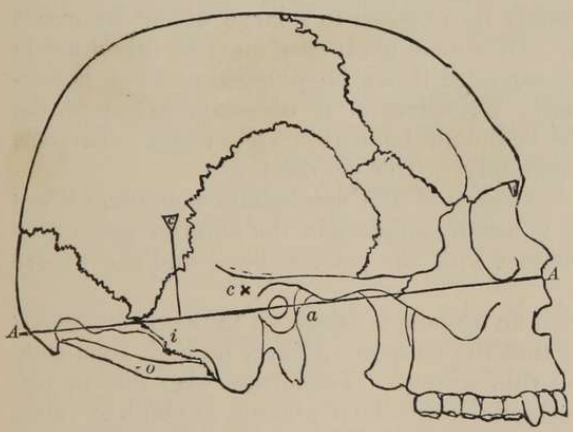
the "suprameatal triangle" which is formed by the posterior root of the zygoma above (dotted line, Fig. 217), the upper and posterior segment of the osseous external meatus in front (broken line, Fig. 217), and an imaginary nearly perpendicular line uniting these two (short nearly vertical line, Fig. 217). Within this triangle and toward its base the opening into the mastoid antrum may be made with safety. The

Fig. 217.



Surface Guides for the Sigmoid Sinus and the Suprameatal Triangle (Macewen): artificial lines drawn upon the skull indicating the following: (1) The short vertical line from the posterior border of the external auditory meatus to the posterior root of the zygoma marks the base of the suprameatal triangle (*a*); the *broken* line indicates the anterior border of the suprameatal triangle, its base being the *dotted* line marking a part of the root of the zygoma. This broken line also indicates the course of the facial nerve. (2) The second vertical line, extending from parieto-squamo-mastoid junction to tip of mastoid; the upper two-thirds of its length indicates the position of the sigmoid sinus. (3) The oblique line passing from asterion to upper limit of external auditory meatus indicates the posterior two-thirds of the sigmoid sinus from its commencement to its knee.

Fig. 216.



A, *A*, Reid's Base Line: *a*, the meatus; *c*, the point for trephining to reach an abscess in the temporo-sphenoidal lobe or to puncture the lateral ventricle 1¼ inches back of the meatus and 1¼ inches above Reid's base line; *i*, the mastoid vein; *o*, the point for trephining to reach an abscess in the cerebellum; ×, the point for trephining the mastoid antrum (Barker).

perforation is made slightly forward to avoid opening the sigmoid sinus (the curved part of the lateral sinus in the mastoid portion of the temporal bone,

Fig. 215). When the surgeon has penetrated to the depth of half an inch, he must be careful not to injure the facial nerve, the course of which is indicated by the broken line in Fig. 217. To avoid this he should "keep close to the floor of the middle fossa and nearer the posterior border of the opening, toward the posterior superior angle of the suprameatal triangle" (Macewen). The near approach to the nerve is often preceded by twitching of the facial muscles. The face should therefore be exposed, and an assistant be requested to observe any such phenomenon.

Of course the external meatus should also be well cleansed antiseptically. There is no objection here to the use of the 1 : 1000 sublimate solution, which, however, should not be used in washing out the cavity of the cerebral abscess itself. After having cleansed the ear it is well to inject the cavity with an emulsion of iodoform and to apply boric-acid fomentations, which are to be frequently changed.

Should this not relieve the symptoms very speedily, we must search for the abscess itself, which will probably lie in the "dangerous region." The best point to apply the trephine is one and a quarter inches behind and the same distance above the external auditory meatus (Fig. 216, *c*). One great advantage of this position is that it is far enough away from the ear to avoid septic infection from any aural discharge in case no abscess is present. It is better to use for the exploratory operation a small trephine, one-quarter or one-half inch, enlarging the opening, if need be, with the rongeur forceps or by a larger trephine.

The dura having been opened by a simple crucial incision, the grooved director should be inserted downward, forward, and inward in the direction of the opposite wing of the nose, as this is the axis of the temporo-sphenoidal lobe. Should the abscess not be reached, punctures may be made in other somewhat similar directions, and the cavity when found should be treated in the manner already described. Sometimes pus in the groove for the lateral sinus will ooze out through the opening for the mastoid vein (Fig. 216, *i*), which should be examined by turning back the scalp sufficiently to expose it. If found, of course the groove must be opened and the pus evacuated. The groove for the lateral sinus can safely be exposed to a large extent by means of the rongeur, gouge, and chisel. Of course great care must be taken not to wound the sinus, but should it be wounded it can be plugged and the hemorrhage, as a rule, readily controlled. Whenever it is necessary to expose the sinus, strips of gauze for plugging it should be within easy reach. In some cases it is desirable to open it deliberately. (See p. 528.)

III. **Cerebellar Abscess.**—Abscess of the cerebellum sometimes arises in connection with ear disease. It is usually situated in the anterior part of the lateral lobes where these are in contact with the petrous bone and the groove for the lateral sinus.

The general **diagnosis** for such an abscess is based on the same symptoms as that of cerebral abscess, except that the temperature may be high from complications, and choked disk is, as a rule, absent. Tenderness over the cerebellum, especially on percussion, and occipital headache if present, are both of value, but our means of positive diagnosis for cerebellar abscess are at present lamentably deficient. The point at which to trephine, as already indicated (Fig. 216, *o*), is midway between the tip of the mastoid and the inion, and well below a line drawn from the meatus to the inion, which line corresponds to the lateral sinus; or, in general terms, an inch and a half behind the meatus and one inch below Reid's base line—a line drawn from the lower border of the orbit through the middle of the external auditory meatus (Fig. 216, *a*, *a*). The surgeon

must remember that the occipital bone is very thin. A gouge may often replace the trephine.

The **treatment** of the abscess when once found is the same as that of cerebral abscess. In puncturing the cerebellum care must be taken not to injure the superior vermiform process.

IV. **Extradural Abscess** is an abscess forming between the dura and the bone. These abscesses almost always arise from disease of the ear which has produced caries of the petrous bone. The abscess may be diffused over the dura or accumulated at one point.

The **diagnosis** from cerebral or cerebellar abscess or meningitis or thrombosis of the lateral sinus is not easy. The eye symptoms and the headache will be the same, but the temperature is in marked contrast to that of cerebral abscess, and will rise to 102° or 104°. The pain is usually above and behind the ear and is fixed, and the same point is markedly tender to percussion and pressure, the tenderness extending both back of the mastoid and above it. Not uncommonly there is œdema of the scalp. Extradural abscess should be suspected if the mastoid have already been opened without improvement and there be no signs of the cerebral irritation of leptomeningitis or the focal symptoms and low temperature of cerebral abscess, or of pyemia arising from thrombosis of the lateral sinus or the internal jugular. Symptoms of cerebral pressure are sometimes seen in extradural abscess.

Treatment.—If the mastoid has not already been opened, it should be done immediately and the cavity cleansed as before indicated. If a fistula exists from which pus escapes, it will lead us to the abscess. The dura should be laid bare, care being taken, of course, not to wound the lateral sinus. If a thrombus exists in the sinus, it should be opened and the clot evacuated and the sinus disinfected, either with or without ligation of the sinus as is thought best. The abscess having been reached, it should be cleansed with an antiseptic solution, the granulation-tissue lining its cavity curetted, any necrosed or carious bone removed, and free drainage provided.

Hoffman gives a table of 102 fatal cases in which the diagnosis was only made post-mortem. Ten other cases were diagnosticated during life, of which 8 recovered after operation. It is hardly necessary to comment upon such statistics.

V. **Pyemia and Thrombosis of the Lateral Sinus.**—Until recently these cases have been very rarely recognized, and when recognized they have been left without operative treatment, with the absolute certainty of a fatal result. It is not a common sequel of ear disease, but it is sufficiently frequent to demand that surgeons shall be acquainted with its symptoms and with its treatment, especially since Lane, Ballance, and others have placed the latter on a rational foundation. Sometimes pyemia may exist without thrombosis of the sinus, but commonly they coexist.

The **symptoms** will be a preceding history of chronic otorrhea, followed by headache and pain in the region of the sinus, vomiting, distinct and repeated rigors, violent oscillations of temperature, tenderness and local œdema over or behind the mastoid, and all the ordinary symptoms of pyemia. As the clot usually extends both in the course of the lateral sinus and soon into the internal jugular vein, there will be tenderness over the course of the lateral sinus—that is, in a line from the external auditory meatus to the inion—and also in the neck over the course of the internal jugular vein, which may feel like a tense, tender cord or may even have been destroyed. Choked disk will very likely be present.

The **treatment** should be prompt and positive. First the mastoid should

be opened and cleansed. Next the sinus should be exposed, and if there be any pus in the groove for the sinus, it should be washed away. If the sinus be thrombosed, it must be opened and thoroughly cleansed even to the torcular Herophili. Should it not be closed by the clot, and hemorrhage be very free, this may be controlled by instantaneous plugging with strips of iodoform gauze, which should be ready at hand. The internal jugular vein should then be exposed in the neck, and the vein should be followed down until a point *below* the thrombus is reached, which can usually be determined by touch with comparative ease. The vein should next be ligated, to prevent the extension of the septic thrombus downward to the heart and lungs, and it should then be washed out and made as aseptic as possible. Although in the nature of the case perfect asepsis cannot be obtained, yet the results have been such as to highly commend the treatment. Recovery has taken place in 56 out of 84 cases—66.7 per cent.—that have been operated on and reported. Without operation death is almost inevitable. Hence every case should be submitted to operation the moment the diagnosis is established.

The *petrosal sinuses* may also be thrombosed, but without local symptoms to guide us.

Sometimes the *cavernous sinus* is thrombosed, rarely from disease of the ear, but more frequently from infective inflammation about the orbit, the jaws, or the throat. If so, there will be hyperemia of the retinal veins and œdema in the region of the frontal vein and in the eyelids, with exophthalmos from retrobulbar œdema. The opposite eye is often in turn affected from extension of the thrombus to the opposite side. There may also be neuralgia of the first division of the fifth nerve and paresis or paralysis of the muscles supplied by the motor oculi (third), the abducens (sixth), or the pathetic (fourth) nerve, all of which run in the sinus.

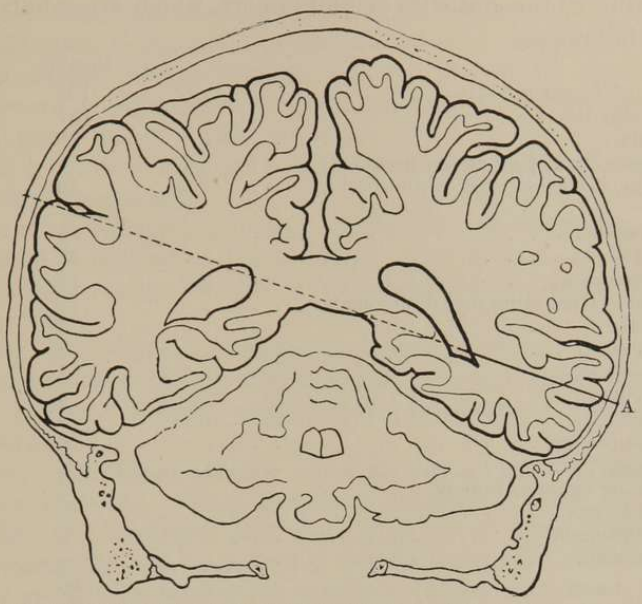
The treatment of these latter forms of sinus-thrombosis and of pyemia from ear disease, without thrombosis, must unfortunately be limited to the general treatment of pyemia.

XVI.—SURGERY OF THE LATERAL VENTRICLES.

Until of late it was supposed that any injury involving the lateral ventricles was necessarily fatal. This, however, is disproved by a number of cases in which the lateral ventricles have been opened by injury, such as simple fracture of the skull, of which there are at least 5 cases reported in children, of whom 3 recovered. In addition to these there are also recorded 7 cases of compound fracture with secondary implication of the ventricles, 4 of which recovered, and 2 of primary rupture of the ventricles by compound fracture, both of which recovered. Sometimes also in cases of fungus cerebri a communication is established with the lateral ventricles, followed by continuous discharge of cerebro-spinal fluid from the ventricles, in which recovery has taken place. Besides this, Keen has shown that puncture of the lateral ventricles through the brain substance can be done accurately, and that a drainage-tube may be introduced into the ventricles and remain several weeks without inflammation of the brain or its membranes, and that even irrigation of the ventricular cavities from side to side after bilateral trephining can be done without discomfort to the patient. Therefore in fracture involving the ventricles we should not infer that the patient must die and that we must do nothing, but should treat the case on the same antiseptic principles and by the same methods that we should employ had the ventricle not been invaded, and with a very reasonable hope of recovery.

If the ventricles are to be tapped, the lateral route is the best. A half-inch trephine opening should be made one and a quarter inches behind the external

Fig. 218.



Puncture of the Lateral Ventricle by the Lateral Route at A (Keen).

auditory meatus and the same distance above Reid's base line (Fig. 218, A). Then the grooved director or a small tube (caliber No. 5 of the French catheter scale or a little larger) should be thrust carefully and steadily into the brain in the direction of a point H vertically two and a half to three inches above the opposite meatus. If the lateral ventricle be of normal dimensions, it will be reached at a depth of two to two and a quarter inches, but if distended it will be reached at a less depth. The entry into the ventricle will be recognized by the instant diminution of resistance and by the escape of cerebro-spinal fluid. Drainage may then be effected, either by inserting a small bundle of horsehair doubled like a hairpin, with the rounded ends inserted first, and passed through the tube, or by carrying a rubber drainage-tube of the same size into the ventricle.

The operation has been done several times for chronic hydrocephalus, without, however, up to the present time, a single cure; but in acute hydrocephalus the result has been slightly more promising. Mr. Mayo Robinson has reported one case in which undoubtedly life was saved. Dennis has reported one case of evacuation of a clot in the lateral ventricles, but the laceration of the brain was such that the patient died soon afterward. A number of successful cases of operation for increased intracranial pressure have been reported.

Of course if the ventricles are tapped the asepsis should be absolute, or the result will necessarily be fatal.

XVII.—INTRACRANIAL TUMORS.

I. Their **cause** cannot, as a rule, be determined. Occasionally they arise from injury; in which case they are apt to be sarcomata, although they may be

fibromata or other varieties of tumor. Sometimes they are parasitic in origin, from the echinococcus or from the ray fungus (actinomycosis), and tumors of both of these varieties have been operated on successfully. Much more frequently, however, they arise from no assignable cause. Hale White and Bernhardt have gathered the statistics of 580 tumors, which are tabulated by Seguin and Weir, as follows:

	Number.	Per cent.
Nature of tumor not stated	133	22.9
Tubercular tumors	137	23.0
Gliomata	76	13.0
Sarcomata (including cysto-sarcomata)	75	13.0
Hydatids, cysticerci, and echinococci	30	5.0
Cysts	27	4.6
Carcinomata	24	4.0
Gummata	21	3.6
Glio-sarcomata	14	2.2
Myxomata (including myxo-sarcomata)	12	2.0
Osteomata	6	+1.0
Neuromata	4	—1.0
Psammomata	4	—1.0
Papillomata	4	—1.0
Fibromata	3	
Cholesteatomata	2	
Lipomata	2	
Erectile or vascular tumors	2	
Dermoid cysts	2	
Enchondromata	1	
Lymphomata	1	
Cases	580	

On looking at this table we see that the number of tubercular tumors exceeds twofold that of tumors produced by any other one cause. The sarcomata and gliomata, which are practically all sarcomata, taken together slightly exceed tubercular tumors. Of the 580 tumors in this table, the nature of 447 was known. The tubercular and these two kinds of sarcomata numbered 288, leaving, therefore, only 159 for all the other known kinds of tumor. Tubercular tumors are most frequent in early life. Three-fourths of them occur before the twentieth year, and one-half before the tenth, according to Gowers. On the contrary, the various forms of cancer, including sarcoma, are more common from twenty to forty years of age.

II. **Location.**—Of 637 intracranial tumors tabulated by Gowers, 297 were situated in the cerebral hemispheres, excluding the central ganglia, 179 in the cerebellum, 59 in the pons, 48 in the central ganglia, 31 in the medulla, 13 in the corpora quadrigemina, and 10 in the crura cerebri. Starr found 96 tumors of the cerebellum in 300 cases of intracranial tumors in children only.

III. **Infiltration.**—Some tumors are definitely limited either by a distinct wall, as in a well-defined cyst; in others, as in a fibroma or an osteoma, the limits of the tumor, though without any such wall, are definite and abrupt; but malignant, and to a less extent tubercular, growths of the brain, as of other parts of the body, are more apt to infiltrate the surrounding tissues without any well-defined margins. This, however, is not always the case. When infiltration exists, the need for removal of more tissue than that which constitutes the tumor itself is very apparent. The probability of recurrence is also much greater in such cases.

IV. The **symptoms** of tumor are in many respects similar to those of other lesions. They may be caused either by irritation or destruction of the cerebral substance or by pressure upon the brain. They are either diffused or localized.

1. *Headache* is, as a rule, early, constant, and severe. When the tumor is superficial the headache is apt to correspond to the site of the disease. While, like all the other symptoms of tumor, it may be absent, yet in the great majority of cases it is present, and is usually one of the most annoying and painful symptoms. As a rule it is diffused, but even if it is localized we must not depend upon it too much as an indication of the site of the tumor.

2. *Pain* is almost always present, and may either be spontaneous or be evoked by pressure or percussion. As a localizing symptom, pain, like headache, is not of great value. Pain, however, which is not spontaneously complained of, but is produced by percussion, is of more value than spontaneous pain or pain upon pressure.

3. *Vertigo* is a common symptom, although not constant, but is more marked probably in cerebellar tumors than in cerebral. If the tumor is in the cerebellum, the vertigo is apt to be present in the recumbent posture as well as in the erect.

4. *Vomiting*, if cerebral in origin, is of considerable value. By cerebral vomiting is meant that variety which has no relation either to the ingestion of food or to a furred tongue, constipation, diarrhea, or other evidences of disturbed digestion.

5. *Epileptic convulsions* usually set in as soon as the tumor is of sufficient size to produce pressure. They are often general in their distribution, but occasionally they are localized, and if so they are of great value; for if the attack begins always in the same arm or on the same side of the face or in the same leg, they point with reasonable accuracy to the location of the tumor.

6. Another of the pressure symptoms is *choked disk*, which in tumor is nearly always double. It sets in probably as soon as the tumor has reached any size, but while its existence is of value, as indicating the presence of a tumor, it gives no indication of the position, character, or size of the tumor. If it be monocular—that is, in one eye only—the tumor is most likely to be in the opposite hemisphere, but if optic neuritis and choked disk exist in both eyes, as is almost always the case, the site of the lesion is probably the side on which the least swelling occurs; and this may be especially inferred if the other symptoms point in the same direction. Strange to say, it does not interfere with the acuity of vision until secondary atrophy of the nerve has taken place.

7. *Other Eye-symptoms.*—Paresis of any single muscle or any group of muscles generally indicates either pressure from a coarse lesion in the cortex which supplies this muscle, or true infiltration of pathogenic material into the meshes of the nerves themselves. Unless, however, associated with other symptoms, it is of little value. Spasm of any of the muscles is of more value than paresis or paralysis, and indicates more positively a lesion in the motor centers of such muscles. Homonymous hemianopsia is of great value, since it generally indicates a lesion of the cuneus on the same side. The term hemianopsia denotes a condition in which, each retina being divided by a vertical line into two halves, the right half of each retina is insensible to vision, and therefore objects in the left half of the visual field are not seen; or, *vice versâ*, the left half of each retina is blind, and then the right half of each visual field is not seen. If the right cuneus is involved, the right halves of the retinæ will be blind and the left halves of the visual fields not be seen, and *vice versâ*.

The pupils are not uncommonly unequally dilated or contracted. Their condition is of little value in pointing out tumor in contrast with any other intracranial disease.

Focal Symptoms.—1. *Hemianopsia* has already been mentioned.

2. *Aphasia.*—If the tumor be located in the third frontal convolution, on

the left side in right-handed persons, and on the right side in left-handed persons, as a rule, motor aphasia will be marked.

3. *Paresis or Paralysis.*—If the tumor be located so as to press directly upon the face center, arm center, or leg center, or if it be even some distance from these and yet large enough to exercise distant pressure upon them, there may be paresis of the arm or leg or even a partial or complete hemiplegia.

4. *Anesthesia.*—Unless the internal capsule is involved, anesthesia is rare; yet it sometimes does occur. Tumors pressing upon the olfactory or any other nerve or involving the nucleus of any nerve or nerves will produce at first irritation and afterward destruction of the function of such nerve or nerves.

Mental Disturbances.—As a tumor increases in size, stupor, and finally coma, almost always precede death. Earlier in the history of the disease, however, there are mental disturbances, such as hallucinations and delusions, and in most cases there is a general loss of mental acuteness, with loss of memory and more or less childishness. Resemblance of the symptoms to hysteria should not lead the surgeon to overlook a possible organic disease. Among other mental disturbances, the following should be mentioned:

1. *Word-deafness*, or, as it is often called, sensory or amnesic aphasia, is the loss of memory of the sound of a word. For instance, a spoken word, such as "cat," would not convey its proper meaning to the patient. Word-deafness generally indicates a lesion in the posterior half of the first temporal convolution on the left side.

2. *Word-blindness*, *alexia*, is the loss of memory of the appearance of a written or printed word. For instance, again, a written or printed word "cat" would be unintelligible to the patient. This defect usually indicates disease of the lower posterior portion of the parietal lobe on the left side, and especially the angular and supramarginal gyri.

3. *Agraphia* is the loss of memory of the muscular movements made in writing, so that the patient has lost the faculty of writing, though he still retains control of the muscles involved in this act. It usually indicates a lesion beneath the motor speech center (Broca's convolution), or possibly of the posterior part of the second frontal convolution.

4. Again, there may be loss of perception of the use, odor, color, or taste of any object presented to the mind. This general symptom is often termed *apraxia*, and of course has as many varieties as there are avenues by which the mind may be reached; for instance, sight, touch, smell, taste, hearing for language, hearing for music, etc., any of which may be lost, producing mind-blindness, mind-deafness, etc. The patient in mind-blindness will be unable to recognize an object by sight, but may still be able to recognize it by touch. All these various conditions should therefore be examined. Apraxia will generally indicate a lesion in the supramarginal or angular gyrus in the left hemisphere in right-handed persons, and *vice versâ*.

V. **Diagnosis.**—That there is need for more exact means of diagnosis is very evident when we remember that in a number of cases an operation has been undertaken for a tumor supposed to be located at a certain point, without finding the tumor, and the post-mortem has shown either that the tumor existed elsewhere or that there was no tumor whatever. Time is enabling us, however, gradually to become more accurate in our diagnosis. There are six questions (Weir and Seguin) to which, if possible, we must obtain answers in any suspicious case:

1. *Does a Tumor exist?*—The symptoms, briefly stated, will be headache, pain, possibly vertigo, cerebral vomiting, convulsions either general or localized, and paresis or paralysis to a greater or less extent, choked disk, possibly

stupor toward the end of certain cases, hemianopsia, and apraxia or aphasia, with or without anesthesia. While all these will not be present in any one case, if there be a reasonable number of them the probabilities of tumor will be very strong. The differential diagnosis between tumor and abscess has already been given on page 523. In Bright's disease, and sometimes in lead-poisoning, there may be headache, vomiting, convulsions, and choked disk, but the examination of the urine and the usual dropsy in Bright's disease, and the wrist-drop and condition of the gums in lead-poisoning, together with other symptoms of both disorders, should put us on the right track.

2. *What is the Location of the Tumor?*—This question must be answered by the localizing symptoms above given, if they exist; for it must be remembered that in certain parts of the brain a tumor may exist without any localizing symptoms, but with only the general symptoms of headache, vomiting, choked disk, and convulsions. These latent zones are especially the anterior portion of the frontal lobes, the temporo-sphenoidal lobe except on the left side in part, a considerable part of the parietal and occipital lobes, and to some extent the cerebellum. Sometimes even a very large tumor may exist and give no signs of its presence, but if it be in certain localities where the centers for the special senses are located, or in the cortical centers for motion, or in the paths of distribution of the nerves from these centers, we may be able in most cases to locate it with reasonable accuracy. If in the history a number of centers have been successively involved, this fact is very important, as the history of the march of the paralysis or the irritation is of the greatest value in enabling us to locate the tumor. Rapidly-produced blindness is usually due to tumors, especially in the cerebellum or pons, which obstruct the veins of Galen or the straight sinus or the iter e tertio ad quartum ventriculum, and so produce an internal hydrocephalus, pressure on the optic tract, choked disk, and later blindness.

3. *At what Depth does the Tumor lie—that is, is it cortical or subcortical?*—A tumor in the cortex may be diagnosticated possibly by tenderness to pressure over the area of the tumor, possibly by a local rise of temperature, and also by considering the number and relations of the centers involved by the tumor and the absence of anesthesia.

4. *Is the Tumor Single or Multiple?*—As a rule, if multiple, operation will be contraindicated; but if single, its removal may be attempted unless specially contraindicated. If single, the localizing symptoms should be referred either to one center if the tumor be small, or to several adjacent centers if it be large. If the centers involved are multiple and far apart, the probabilities are against a single tumor and in favor of a multiple; or if single, the tumor will be very large.

5. *What is the Size of the Tumor?*—In a few cases this has been diagnosticated. The tumor is probably small if only a restricted area of the brain is involved, as shown by a limited paresis or paralysis, if with time no adjacent centers have become involved, and if the symptoms of intracranial pressure are either slight or absent. A large tumor can be diagnosticated by the involvement of a large number of neighboring centers and marked symptoms of pressure. Often this diagnosis, however, cannot be made before operation. Even if the tumor be large it may be removed successfully. Thus Horsley has removed a tumor weighing over four ounces, and Weir and Keen have removed two others but little short of this weight; and two of these three patients recovered. We should therefore hesitate before refusing to operate, even if the tumor be probably of large size. Refusal means with practical certainty a fatal termination. Operation, it is true, may be followed by death,

but this would only be anticipating by a little time the natural termination of the disease, and it gives the only hope. If the tumor is found to be too large for removal, the surgeon will of course terminate the operation, and, as shown by a number of cases, the patient may be decidedly the better by reason of the interference, especially from the relief to the headache, blindness, vertigo, and vomiting. In one of Horsley's cases, in which for inoperable cerebellar tumor he removed half of the occipital bone, the relief to the dyspnea, headache, and rotary convulsions was so great that the patient requested the removal of the other half, and his life was prolonged for two years in relative comfort.

6. *What is the Nature of the Tumor?*—If the patient has suffered from cancer, tubercle, or syphilis and the symptoms of intracranial tumor are present, it is most likely that the cerebral tumor is of the same nature as the disease already existing elsewhere. We can always make a guess based upon the facts that before twenty years of age tubercle is much more frequent than any other disease, and that between twenty and forty glioma and sarcoma are more frequent than other tumors; but such a guess is hardly one upon which we should act. Hale White and Von Bergmann have both opposed operation in syphilitic tumors, but the view of Seguin is that if the antisyphilitic treatment has been inefficient, including the administration of increasing doses of the iodides up to half an ounce a day, operation should be attempted. Horsley limits such trial of internal remedies to six weeks, after which he would proceed to operation. A gumma which has undergone a fibrous change and has resisted such vigorous specific treatment is practically a permanent tumor, and whether it shall be attacked or not must be determined on precisely the same grounds as any other tumor. Tubercular tumors are more apt to be multiple than any other variety, and we should therefore hesitate somewhat more as to them.

VI. **Prognosis.**—If an intracranial tumor be not operated upon, it is almost necessarily a fatal disease, with the exception of those syphilitic growths which yield to the iodides. It is possible that life may be very much prolonged in some few cases, but in the majority a few months or a year or two is all that can be expected. Hence, as it is so almost uniformly fatal, and as operation has given such good results, it is proper that we should operate, unless the multiplicity, depth, size, etc. present positive contraindications. If we operate, the prognosis varies much, first as to immediate recovery, and secondly as to ultimate recovery.

1. *As to Immediate Recovery.*—Chipault's statistics (1894) include 67 operations for intracranial tumors, of which 47 recovered and 20 died. In addition to this, 47 cases of exploratory operations in which the tumor was not found gave 35 deaths and 12 recoveries. The chief reason for the fatality of this last condition has been probably too extensive exploration in search of the tumor or for its removal. If no tumor is found after cautious search by knife, grooved director, and the gentlest use of the little finger, or if, being found, it is not removable, the operation should be terminated at once, especially if there is much bulging, indicating a large tumor. In 7 cases in which trephining was done for the relief of the increased intracranial pressure caused by the tumor, recovery followed in all. Probably time, by perfecting both the diagnosis and the operative methods, will enable us to improve upon these results. At the same time, it must always be recognized that an operation for cerebral tumor is a very serious one, not to be undertaken lightly nor without explaining the entire matter carefully at least to the family: the mental condition of the patient may be such that it would be unwise or useless to explain it to him.

Another important reason for the mortality has been the delay in operating.

Physicians, who almost always see these cases first, postpone consulting a surgeon for an unreasonably long time, in the vain hope of improvement. It cannot be too strongly insisted on that we should treat tumors of the brain just as we treat tumors in other parts of the body—as a rule, remove them at the earliest possible moment. In the brain the reasons for early operation are even more cogent, for the soft tissue here is more easily injured, it cannot escape from pressure as do the soft parts not enclosed in such a bony case, and the growth of the tumor is insidious and not easily discovered, as it is when accessible to the eye and the finger. We can only infer its growth from the symptoms. When a tumor is diagnosticated and located with reasonable certainty, if it be probably amenable to operation, its removal by operation should be attempted as soon as drugs have been fairly tried and proved of no avail. The limit for this "fair trial" Horsley, as stated above, puts at six weeks, and certainly this is enough. After that it is but wasting time and imperilling life to wait longer. Further time only allows of increase in the size of the tumor, with wider infiltration of brain tissue or wider destruction by pressure, and the operative dangers and difficulties increase with each week or month of delay. If the tumor is not removable, the opening in the skull should not be closed by replacing the bone. This partial operation will often be an immense comfort. In tumors of the cerebellum operation for their removal has been followed by a fatal result in three cases out of five. Their proximity to the fourth ventricle, the tubercula quadrigemina, and the pons, with the important and vital centers lying there, makes operations in such cases peculiarly hazardous. But great relief can be given by wide removal of the bone, as already stated.

2. *As to Ultimate Result.*—If the tumor be malignant, it will return, as a rule. In tubercular or syphilitic tumors the probability of a permanent cure is good. In benign growths recurrence is not to be expected. In estimating the future of such patients it must be remembered that the tumor during its growth has done a certain amount of damage, just as a bullet that has lodged has inflicted a certain amount of injury in its pathway to its resting-place. The removal of the bullet or of the tumor will not affect the damage already done. Hence if an optic neuritis, for instance, has continued long enough to be followed by atrophy of the optic nerve, it is hopeless to expect that the blindness will disappear, though vision may improve greatly even if the tumor has existed for years. So also the paralysis of an arm or a leg from pressure on its center may remain, though in the majority of cases the motor function has been to a great extent restored. If the epileptic habit has been formed, the removal of the tumor will probably modify and may possibly cure the attacks, but they will often persist, though they may be less frequent and milder.

VII. **Treatment.**—When it has been decided that the tumor exists in a given locality, and that it is amenable to operation, the operative procedure may be very briefly described.

1. A large semilunar flap is made, with the center corresponding to the site of the tumor. 2. An opening not less than an inch and a half in diameter is made in the skull, by the trephine, the chisel, or otherwise, as may be deemed best. 3. The dura should be opened. 4. The tumor, having been recognized, should be enucleated, if possible, by the finger. This will very rarely be practicable. If not, the knife, the scissors, the sharp spoon, or the handle of an ordinary teaspoon may be used to remove it, either as an entire mass or piecemeal. 5. If the tumor be subcortical, an incision should be made in the brain and the little finger inserted with great gentleness to recognize the resistance, size, etc. of the tumor. When found it is to be removed as before described. 6. If the tumor be so large that it would be

unwise to remove it, the operation should be immediately terminated and the dura and flap secured, the bone not being replaced. 7. The operation is often best done in two stages (p. 489). 8. The method of dealing with hemorrhage and the other steps of the operation differ in no wise from those described under the head of Technique.

XVIII.—EPILEPSY.

From a surgical point of view cases of epilepsy are either traumatic or non-traumatic.

I. **Epilepsy following Traumatism.**—As a rule, the epileptic attacks do not make their appearance until some months or even years after the accident, and the earlier attacks are not only less frequent than the later ones, but are often unattended at first by loss of consciousness (petit mal), and only after a time become fully-developed epileptic attacks. There is reason to believe that even slight accidents may sometimes produce epilepsy, presumably through the agency of a cicatrix in the dura or in the brain. Very often in such cases there will be lesions of motion and sometimes of sensibility, perhaps dating back to the time of the accident. It is probable also that if after compound fracture any portion of bone remains depressed, it may irritate the underlying cortex and cause epilepsy. Similarly, in some cases apparently by reason simply of the presence of the resulting cicatrix, epilepsy may follow. Hence one argument for the radical treatment of such injuries at the time they are received, as has been advocated in preceding pages. The numerous cases reported in the periodical literature of the last few years constitute a very strong reason for the propriety of thus interfering in the way of prevention of the epilepsy, rather than allowing it to set in and then trying to remedy it.

Sometimes the cicatrix in the scalp is tender or is the seat of radiating pains and sometimes of the aura. Pressure on it may produce a fit, although most frequently it will not. Very rarely there will arise from a traumatism a sarcoma, fibroma, or other form of tumor which itself will cause epilepsy. Apparently mere alteration in the texture of the cortical tissue from fatty or other degenerative changes following traumatism may itself give rise to the epilepsy. Mr. Horsley especially has shown not only that such brain scars, scars in the dura, cysts, fragments of bone, etc., are presumably the cause of such epileptic attacks, but also that their removal has resulted in relief and even in cure.

In cases of epilepsy arising from traumatism, if the trauma is shown by a scar or by evidence of injury to the bone without a scar, the injury may be, first, over well-known centers, motor or otherwise; or, secondly, it may lie over the so-called latent zones of the brain.

In those cases in which *the lesion lies over well-known centers and the epileptic fit is limited to the muscles corresponding to these motor centers*, the inference is that they stand in the relation of cause and effect. But it must always be remembered that the irritation of the scar in the scalp is sometimes sufficient to cause the epileptic attacks, and hence, as a rule, the proper course of procedure is to prepare for a complete trephining with the same minute care that has heretofore been described as necessary in cerebral operations; but if an exploratory incision exposing the bone under the scar shows no injury sufficient to make us think the brain is certainly injured, we should limit the operation to the excision of the scar. Especially will this be proper if the scar be the site of tenderness on pressure and of the epileptic aura, or if pressure on the scar produce a distinct fit. In a moderate number of cases now reported in which there existed no fracture of the bone, but only a scar in the scalp, the excision of the scar has been followed by cure.

Moreover, we must remember such cases as the one related by Briggs, in which a girl had both an old depressed fracture of the skull and necrosis of the tibia. He very wisely first operated on the tibia, and after five years the fits had not recurred, showing that their origin was not in the depressed fracture of the skull, which *prima facie* was the probable cause, but in the irritation of the tibial disease. We should not, however, be too hopeful if the fits cease immediately after the excision of the scar or after any other operation. It is a strange fact, to which White has recently called renewed and especial attention, that any operation, even though trivial, is apt to cause the cessation of the fits for weeks or months; and hence after removal of the scar we cannot be certain that the epilepsy is cured until at least three years have elapsed without the return of the attacks. The surgeons of the largest experience are probably the most cautious in drawing too favorable conclusions.

If excision of the scar does not cure the patient, and the scar lies over the motor center which corresponds to the initial muscular spasm, and still more if there is evidence of any depression of the skull or of an old compound fracture, a second operation should be done and the patient be trephined. The lesion rarely will be a splintering of the inner table, sometimes with a depressed fragment of bone; sometimes a cyst following a blood-clot, or not uncommonly simply a brain scar, with generally a corresponding cicatrix in the dura. Occasionally, however, nothing more than thickening and eburnation of the bones of the skull will be found.

After trephining the skull, the dura should always be opened, even though it be sound, in order to inspect the brain. If there be a scar in the dura, it must be excised, and if there be one in the brain, it should also be excised down to the white tissue. In such cases it is of the utmost importance to remember that *all* the damaged brain tissue must be removed. It is better even to trench somewhat upon apparently healthy brain tissue, for the removal of a little more tissue than is necessary is preferable to the opposite error of removing less than is necessary, with possible retention of the epileptic fits. In effecting this removal it is important also to remember that we can extend our incisions in the antero-posterior direction much more freely than we can in the vertical direction, for extension in the vertical direction means involvement of other motor centers, whereas extension antero-posteriorly will probably merely add to the completeness of the removal of the injured center. It is not, as a rule, necessary to go deeper than the gray substance, unless we find evidence of a scar or other lesion at a greater depth. Care must be taken to arrest the hemorrhage, as has been already mentioned in the section on Technique, the ligature being the chief reliance, and pressure and hot water coming next in efficiency. Large veins should be ligated before division, or, better still, should be avoided, as is often possible, by going around them or by lifting them and working under them. If any of the dura has been removed, its place should be supplied, as has been suggested, by a bit of the pericranium. This is especially important in cases where the brain has been incised, so as to avoid a fungus cerebri. Drainage, as a rule, may be omitted. The bone should not be replaced if it would probably produce pressure on the brain. Otherwise it may be put back, not only the large piece removed by the trephine, but a number of the small pieces as well. All these should have had the care described in the section on Technique, in order to preserve their vitality. If the bone is diseased, of course it should not be replaced, nor if it is irregular and would produce irritation or pressure. Possibly experience may show that it is best not to replace it at all; this is yet an open question.

In those cases in which *the lesion does not lie over well-known centers of motion, special senses, language, etc., but over the latent zones*, the scar should still be excised as above advised, but the surgeon should always be prepared to do a complete brain operation as well as simple excision of the scar, for he can never tell how far it may be wise to extend the operation until after he has lifted the scalp and inspected the bone. If excision of the scar, as before, does not effect a cure, and there is distinct evidence, as above stated, either of fracture or of irregularity of the bone, or if the scar is tender or the seat of an aura, or if a fit follows pressure upon it, trephining should be done. Once the bone has been removed, the dura should be opened, and then what is to be done either to the dura or to the brain must depend on what is found. Any dural scar, brain scar, altered brain tissue, or cyst should be treated by excision. Sometimes in cases of compound fracture trephining will have been done at the time of the accident and yet epilepsy will develop later. In such cases, whether the lesion be over the motor or other well-known centers or over the latent zones, as a rule it will be proper to lift a flap of scalp, enlarge the bony opening if necessary, and examine the brain. Trimming the thickened bone away from the edges of the opening left by a compound fracture or a former trephining, or the removal of any of scar tissue, will often effect a great improvement, and in some cases even a cure. Secondary operations of this kind have sometimes proved very successful. In all such operations as this it must be remembered that if we undertake an operation at all it must be done thoroughly. A large trephine may be used, one and a half inches in diameter, or else several small trephine openings should be made, and enough of the bone between them be removed to enable us to see the brain tissue well. Timidity in this respect will often result in a fruitless operation where a bolder course might have achieved success. In operations on the brain it is always important to have plenty of room for inspection of the brain, for determination as to what should be done, and for facility in dealing with hemorrhage.

In all cases of epilepsy it is important that the operation should be done at an early date, in order to prevent secondary sclerosis and the formation of the epileptic habit, a point on which Sachs has laid especial stress.

II. NON-TRAUMATIC EPILEPSY.

1. Jacksonian Epilepsy.—This term is applied to those cases of epilepsy in which there is spasm of a certain limited group of muscles *without loss of consciousness*, and in which, therefore, the discharging lesion seems clearly to be limited to the center corresponding to the muscles involved. In a number of such cases these centers have been exposed, then recognized by the battery as already described, and the entire area excised. The time has not yet come when a definite opinion can be expressed as to the value of these operations. The danger to life is not very great. A large number of the cases have not been bettered, but in many great relief has followed both in diminished severity and diminished frequency of the attacks.

Some cases have been reported in which momentary faradization of the cortical centers which are evidently diseased has produced a fit entirely analogous to the typical epileptic fits to which the patient has been a victim. Such momentary faradization of a normal cortex should produce only a single movement of the part supplied by that portion of the cortex. Whether this will be of value in determining that a cortical centre which appears to the eye and touch to be healthy is really diseased, is a matter to be decided by a larger experience.

The question naturally arises whether this excision will not produce palsy of the muscles supplied by this center. Complete primary paralysis of these muscles always follows such removal, and not uncommonly the pressure of the clot or of the exudate formed after the operation will paralyze neighboring centers, so that there may be complete hemiplegia in many cases resulting from simple excision, for instance, of the arm center. But it is an invariable rule that this hemiplegia is but temporary. After a few weeks the patient will begin to regain control over the muscles, and eventually he will regain motion in its entire range, but usually with some lessened muscular strength; that is, there is a certain paresis remaining. Whether this regain of muscular control is due to the cortical center on the opposite side of the brain taking up the work of the lost center (as the left hand may take up the work of the right after amputation), or to a regeneration of brain tissue, is at present in doubt, with perhaps a preponderance of testimony against regeneration of the cerebral tissue. Experimental transplantation of brain tissue itself from one animal to another has been done with good results from an operative point of view. Whether this can ever be applied to man is unknown.

One precaution is very essential in these cases. Many patients will describe a fit of the Jacksonian type (without of course using this term), which description a closer observation will show to be wholly erroneous. In fact, so absorbed are the relatives of an epileptic in seeing that he does not injure himself, and in sympathetic care for him, that in most cases they are the worst possible witnesses as to the character of the attacks. Hence no patient should be operated on for epilepsy unless his attacks have been seen either by the surgeon himself or by a competent and trained nurse—if possible, one who has been accustomed to observe such fits. Members of the family, moreover, are not trained observers, and for scientific accuracy such training is essential. It is essential that the nurse should be instructed by the surgeon to do absolutely nothing but observe and immediately record the phenomena observed in each fit. Cold, hard, scientific facts are what we want, not sympathetic statements. In true Jacksonian epilepsy the patient himself, if a reasonably careful observer, can give much help, because he does not lose his consciousness.

The observations above referred to should cover, first, what muscles are first involved, and, secondly, the march of the fit; that is to say, the fit having started at such and such a point, whether it extends to other points in any definite order, and whether this order is the same in different fits. Thirdly, the state of the pupils should be very carefully observed, whether dilated or contracted, whether equally so, whether responsive to light stimulus, etc. Lastly, as soon after an attack as the patient is capable of using the dynamometer it should be employed to determine the comparative strength of the muscles, especially of those first involved, which in such cases are apt to be paretic in consequence of exhaustion from the spasmodic motion.

2. **Focal Epilepsy.**—In a certain number of cases in which there has been no lesion of which there was evidence by scar, depressed bone, or other signs, in which there were unconsciousness and general epileptic spasm instead of monospasm (*e. g.* of an arm or a leg), but the attacks always began in a certain set of muscles, as if they always had their origin from the cerebral center dominating these muscles as a focus, from which they radiated to other centers, an attempt has been made to prevent their recurrence or extension by removing the center corresponding to the muscles in which the fits start. In these cases, even more possibly than in those of the Jacksonian type, it is necessary to have reliable and repeated observation of the attacks before deciding to operate. Even with the diminished dangers of modern cerebral surgery, exposing the

brain, and especially excising a cortical center, is not a trifling operation, but a serious one, which must not be undertaken without the best evidence of its necessity. No member of the family, no friend, no one but a trained observer, must be trusted to determine these facts. The testimony of the family may be taken as a corroboration, but not as a foundation. Moreover, it has been well pointed out by Putnam that the value of spasms starting in the hands is not so great as where the spasm begins in a less easily disturbed part, as the elbow or the shoulder. The finger motions are highly specialized, and therefore their equilibrium is much more easily disturbed than, so to speak, the more phlegmatic, coarser, better-balanced muscles of the larger joints like the shoulder. If, therefore, in focal epilepsy the muscles of the shoulder are those first involved, the spasm extending from the shoulder finally over the whole body, such a case is far better suited to operation than one in which the more easily unbalanced muscles of the hand, thumb, etc. are the site of the initial spasmodic movement. In other words, the equilibrium of the hand is more easily disturbed than that of the shoulder, and is therefore of less value as a factor in determining us in favor of operation. Results seem thus far to indicate that in a small percentage of cases, which can scarcely as yet be stated numerically, a cure may possibly be effected. In a number of cases, much larger than in the last class, considerable improvement will follow; in an equal or still larger number no betterment will follow. The operation, however, does not seem ever to produce an increase in the number of attacks. The percentage of deaths in the reported cases is not large, yet danger is a factor in the decision of the question whether an operation shall be done or not, which must on no account be omitted in the statement of the case to the patient and the family. Epilepsy is so direful a disease that there are few parents or patients who would not be willing to face a large risk to life for the reasonable probability of betterment, and still more if there be a chance of cure, however small; and they are all the more willing when there is but slight chance of death and none of being made worse.

In these cases it is especially important always to make a large opening in the bone, in order, if possible, to recognize the convolutions. When the brain is exposed, no antiseptics should touch it until the battery has well defined the center which is to be identified and removed. In faradizing the brain the current required is about that which is necessary to call the muscles of the thumb into action, and stronger currents should be avoided: although no serious injury to the brain has thus far been reported as a result of such faradization, yet its possibility should lead us to use as gentle a current as will effect our object. The faradization should not be repeated any oftener than is necessary.

Horsley has especially insisted here on thoroughness of excision. If any of the center be left, the operation will probably prove a failure. When the center sought for has been found and its limits determined, any large veins involved in its excision should first be tied, and then the center limited by incisions made with a sharp knife held vertically to the surface. This should penetrate to the white substance. The cortex may then be removed either by scissors or by knife. Sometimes we can strip off or push away the pia and its vessels from the underlying convolutions, and so avoid wounding any large vessels. It will rarely, if ever, be necessary in cases of focal epilepsy to remove any of the dura. After the excision, therefore, this should be carefully replaced and secured by sutures, and the operation terminated as heretofore described.

Unfortunately, the large majority of cases of epilepsy belong rather to so-called general epilepsy than to focal, Jacksonian, or traumatic. Such cases are evidently unsuited to any operation, and in our new-born boldness,

begotten of success in cerebral surgery, we should not overstep the limits of prudence and operate indiscriminately and unwisely. Each case of epilepsy must be studied by itself for days, and sometimes even for weeks, before we reach a definite conclusion that it is wise to operate. The surest way to discredit cerebral surgery is to practise unwise cerebral surgery. Hence, while advocating a more radical treatment than that formerly thought to be wise, we must be careful not to proceed to the opposite extreme of indiscriminate operative interference. A progressive conservatism, if the term is allowable, should be our rule.

XIX.—TREPHINING FOR INVETERATE HEADACHE, INSANITY, AND ARRESTED DEVELOPMENT.

I. **Inveterate Headache.**—Occasionally headache will be fixed in its locality and of an excessively severe type, so that it will interfere seriously with the patient's health and happiness, and may even make any occupation impossible. The cause of such a headache is often traumatism, resulting in disease of the bones. The possible existence of hysteria, gout, or syphilis should always first be considered, and the family and personal history therefore should be investigated with great care. As a rule, especially in the case of a hysterical woman, we should refuse to undertake an operation until a thorough trial of all the remedial means at our command for such diseases has been carefully made by a competent neurologist. If then no relief has been afforded, in view of the very small risk to life involved in simple trephining it is proper that it should be done. Trephining having been done, it is better, usually, to open the dura and inspect the brain, even if nothing further be attempted. It is not wise, as a rule, to go so far as to trephine a patient and then neglect the information which may be derived from the simple opening of the dura. Properly done, this adds practically little to the risk and may add immensely to our knowledge. If nothing is found, the dura should be sutured in place, without replacement of the button of bone.

II. **Insanity and other Mental Disturbances.**—The most remarkable case in which a psychical disturbance has given a clue to the diagnosis is reported by Macewen. The man had been injured, and a year later suffered from melancholia and a tendency to homicide. There were no motor phenomena whatever, but it was discovered that for two weeks after the accident he had suffered from the form of apraxia called mind-blindness. Vision was perfect, but what he saw conveyed no impression to him. His New Testament was recognized by touch, but on opening it the printed words had no meaning for him. A lesion in the angular gyrus was diagnosticated, and on operating it was found that a portion of the inner table had been detached and was pressing on the supramarginal and angular convolutions. The man made a good recovery. This case is cited especially as an indication of how a minute, painstaking investigation of the history of an injury and its sequels may prove to be of the greatest value in locating, and therefore in relieving, the disorder. The number of cases of insanity after injury is very considerable, and operation is certainly justifiable in such cases if in any, provided there be reasonable indications not only of an injury, but also of such connection between the injury and the insanity as would show that the injury stood in a causal relation to the mental disturbance. It would be folly, for instance, to trephine for an injury received after the insanity began unless there were independent reasons for doing so, such as paralysis, etc., as a direct result of the injury. Mr. Claye Shaw has recently trephined also in cases of general

paralysis of the insane, but the number of cases is too small and the time since the operations too brief to give any data for an opinion whether the operation is wise and will do any good.

III. **Arrested Development.**—If the cause of the arrest of development be traumatic, something may be done with a hope of relief, as in a remarkable case of Dr. Felkin and Mr. Hare in which a girl of seventeen had sustained fracture of the skull at the age of ten months, followed by paralysis and imperfect development of the right arm and leg. A cyst was found two inches in depth, with an osteophyte half an inch long. This existed outside the dura, which was not opened. The operation was followed by marked improvement.

Where, however, the arrest of development is congenital, the cause has undoubtedly arisen during intra-uterine life, and there is serious doubt whether any good will follow operation in such cases. As has already been indicated under the head of Microcephalus, it is possible that a certain number of cases of general arrest of development of the brain itself in size may be benefited by a linear craniotomy. As a rule, however, in cases of arrested development of intra-uterine origin, with the exception perhaps of microcephalus, it is undoubtedly wiser not to operate, as operation simply exposes the patient to danger without any reasonable hope of improvement.

CHAPTER II.

SURGERY OF THE SPINE.

THE general **anatomical considerations** in relation to the spine which influence the diagnosis and treatment of its various diseases and injuries may be briefly summarized as follows:

It supports the weight of the head, connects the bones of the thorax with those of the pelvis, forms a bony canal for the reception of the spinal cord, gives a basis of support and attachment for the ribs, and, owing partly to its curves and partly to the fact that it is made up of so large a number of bones with the intervertebral disks interposed between them, it lessens in a very remarkable manner the effects of shock transmitted to it from various parts of the body.

The normal curves of the column are three in number, and are all antero-posterior. In the cervical region the normal curve is convex in front; in the dorsal, the convexity is posterior; in the lumbar, the convexity is again anterior. These curves are maintained largely by the varying thicknesses of the intervertebral disks and partly by the differences in the vertical thicknesses of the bodies of the vertebræ.

On each side of the spine are powerful muscles which run longitudinally, the tendons of which are inserted into the processes of the vertebræ. These muscles maintain the body in an erect position, and when in a condition of health preserve the vertical position of the spine by preventing it from inclining to one side or the other. The spinal cord, which is usually about seventeen or eighteen inches in length, does not fill the spinal canal, but is separated from the walls of the latter first by its investing membranes, and then by some loose connective tissue containing a plexus of large veins. It extends in the adult from the upper border of the first cervical vertebra to the

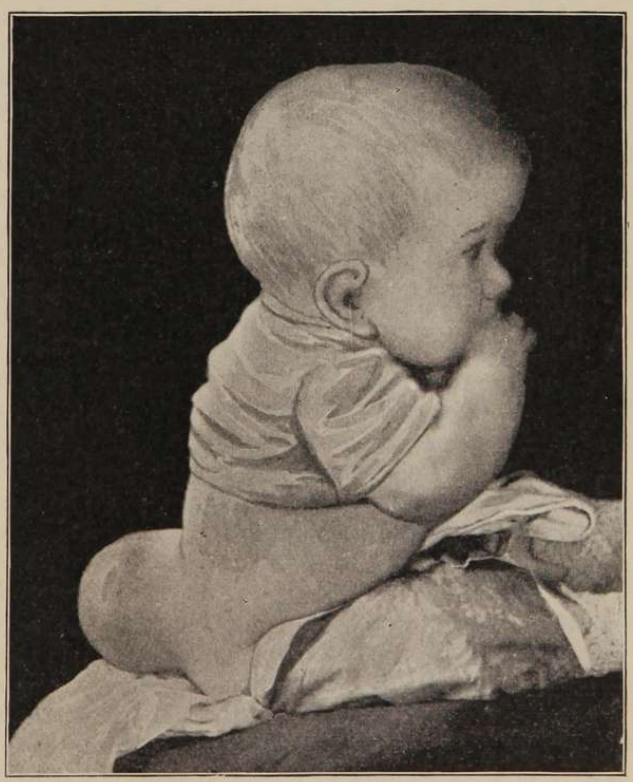
lower border of the first lumbar vertebra, where it ends as a slender prolongation of gray substance extending into the filum terminale.

The membranes of the cord consist of the pia mater, or vascular membrane closely embracing the surface of the cord itself, the arachnoid, separated from the pia mater by an interval known as the subarachnoid space, and the outermost membrane, the dura mater, separated from the arachnoid by an interval known as the subdural space. The arachnoid and dura mater are here and there connected by areolar tissue, but for the most part are simply in contact, the cerebro-spinal fluid keeping the arachnoid in close relation to the under surface of the dura. The cord is steadied in the spinal canal largely by means of the nerves which find exit through the intervertebral foramina on each side of the spinal column. The anterior or motor roots are the smaller of the two; the posterior roots, which are sensory, are composed of finer filaments, and each root bears a ganglion which is situated in the intervertebral foramen just external to the point where the nerve perforates the dura. The roots of the spinal nerves on leaving the cord do not pass out directly at the same level, but run obliquely downward, so that the point at which a particular nerve emerges from the cord is considerably higher than the point at which it emerges from the spinal column, this difference of level increasing from above downward. For example, the eighth dorsal nerve emerges from the spinal *cord* opposite the seventh dorsal vertebra, but from the spinal *column* between the eighth and ninth dorsal vertebræ. These anatomical and physiological facts will serve to make somewhat clearer the descriptions of the various diseases and injuries of the spine and of spinal operations.

CONGENITAL DEFORMITIES.

Spina Bifida.—The chief congenital deformity associated with the spine is due to an arrest of development, owing to which the symmetrical halves of the spinal column fail to unite, leaving a more or less considerable space between them. The gap may extend completely through the bodies of the vertebræ, or may be limited to the arches and the spinous processes; the latter is the more common. The lumbar portion is the part chiefly affected, 50 per cent. of all cases occurring in this region, 12 per cent. in the lumbo-sacral, and 27 per cent. in the sacral. As the result of this deficiency the membranes of the cord are pressed through the opening, forming a tumor known as **spina bifida** (Fig. 219), on account of the condition

Fig. 219.



Spina Bifida (original).

of the spine which gives rise to the deformity, and as **hydrorhachis**, on account of the fluid contained in this tumor. The latter varies in size from that of a walnut or of a closed fist to that of a child's head. It is sometimes covered with skin normal in color and appearance, but oftener the skin is thin and translucent, or it may be entirely absent, in which case the tumor will have a raw, florid appearance. The true sac of the tumor consists of the membranes of the cord blended together and enclosing a liquid which is ordinarily the cerebro-spinal fluid. It usually communicates directly with the brain, as in the normal condition, through the opening in the pia mater at the lower border of the fourth ventricle. Pressure on a tumor of this variety will therefore sometimes cause stupor by increasing the pressure upon the brain. The cord is variously situated as regards the sac, being sometimes in front, sometimes behind, and sometimes spread out as a thin layer upon its internal surface. When the protrusion consists only of membranes and fluid, it is called a **spinal meningocele**; when it contains a portion of the cord also, it is called a **meningo-myelocele.** When the central canal of the spinal cord is dilated, forming the cavity of the sac, the tumor is called a **syringo-myelocele** or **syringo-myelia.** The second of these is by far the more common.

The **diagnosis** of this condition may be made by observing the following points: 1. The tumor is congenital. 2. It occupies a central position, a peculiarity which characterizes most tumors of intraspinal origin. 3. It may probably be reduced by gentle pressure, or at least greatly diminished in size, the diminution being attended with increased tension of the fontanelle, and sometimes with stupor, convulsions, or other nervous symptoms. 4. The bony margin of the gap in the spine can often be felt at the base of the tumor. 5. The tumor becomes more tense when the child cries or coughs. 6. It is often translucent, and when so an opaque band or bands, consisting of the spinal cord and nerves, may sometimes be seen upon the inner surface of its wall. 7. It is apt to be associated with other deformities, such as hydrocephalus or talipes, or with paraplegia, vesical or rectal paralysis, etc. 8. The cutaneous covering of the tumor is often absent.

Occasionally some of these symptoms may exist and not others. We may have a congenital tumor situated over the middle of the spine, fluctuating and with thin and translucent walls, but not perceptibly affected by the coughing or crying or straining of the patient, and not associated with hydrocephalus or club-foot or paraplegia. In this case the tumor is probably a meningocele, in which the communication with the spinal canal has been shut off. The usual course of such cases is toward death, which commonly occurs within six or eight months; spontaneous cure occasionally, but rarely, happens, the vertebral arches growing and developing, and the neck of the sac correspondingly contracting, and finally becoming shut off from its communication with the canal. Oftener, however, the integuments and membranes over the tumor ulcerate, the contents of the sac escape, and frequently the child dies in convulsions or will perish soon afterward from a septic meningitis following infection through the ulcerated tract.

Treatment.—If the tumor is small, covered with sound skin, and not growing rapidly, it should be enveloped in raw cotton and supported by a very loosely-fitting elastic bandage; or gutta-percha may be used as a binder; or a layer of cotton brushed over with collodion may be applied to its surface. There is a chance by this method that the tumor may shrink and disappear. The outlook is seldom encouraging, as even in the most favorable cases the child is small, poorly nourished, and, as has been said, is apt to have paralytic complications.

As to operative measures, while various successes have been reported by other methods, such as simple tapping and drainage, and more recently in a limited number of cases by excision of the sac, yet on the whole the method of injection of the sac seems at present to offer the greatest prospect of ultimate recovery with the least immediate danger. The sac being cleaned, a syringe which will hold about 2 drams of an iodo-glycerin solution (iodine, 10 grains; iodide of potassium, 1 dram; glycerin, 1 ounce) is chosen, and a moderately fine trocar. The puncture in the swelling should be made well to one side, obliquely through healthy skin, and not through the membranous sac-wall, the objects being to avoid wounding the cord or nerves and to diminish the risk of leakage of the cerebro-spinal fluid. Unless the sac is very large, it is probably better not to draw off much, if any, of the fluid on the first occasion. The child should be laid upon its side. About a dram is the quantity recommended to be injected. Care must be taken to prevent escape of the cerebro-spinal fluid, because any leakage may lead to septic meningitis and death. When the needle is withdrawn the tissues should be pressed around it and the little aperture immediately painted with collodion and iodoform and covered by a dressing of dry gauze secured with collodion. A little chloroform may be given, to prevent any crying and straining at the time. The child should be kept as quiet as possible afterward, on its side, and an assistant should make sure, for the first hour at least, that no leakage is going on. Shrinking of the cyst, setting in rapidly and continuing steadily, shows that all is well. If the injection fail altogether or cause only partial obliteration of the sac, it should be repeated at intervals of a week or ten days (Jacobson).

A number of successful cases of *excision* have been reported, and recently Bayer has reviewed the whole subject, and rejects the use of the seton, the injection of iodine, and the excision of a part of the sac, as being at the same time unsatisfactory and dangerous. He urges that the condition is one analogous to hernia and should be treated in a somewhat similar manner; that the danger of meningitis in the one case is no greater than the danger of peritonitis in the other; and that, as compared with the operation above mentioned, it is both safer and more radical. In one case he operated in the following manner: Two lateral flaps were made from the skin covering the tumor and were dissected down to its pedicle, and the sac of the meningocele was opened. The cauda equina was seen flattened out on the posterior wall of the sac. It was loosened after dilatation of the incision, and was replaced in the spinal canal. The sac of the meningocele was then removed, leaving only two lateral flaps of the dura, which were sewed together after thorough antiseptic cleansing of the wound. The muscles and skin were afterward brought together separately. The case was successful. Bayer suggests that possibly in the future, through a greater development of the technique of the operation, a bony roof over the sewed sac may be produced by forming two lateral periosteal flaps from the canal of the sacrum.

Hildebrand has collected 87 cases of excision with 23 deaths, a mortality of 26.4 per cent. Unquestionably, operative measures, especially in meningocele, are gaining ground in the estimation of surgeons.

SPINAL TUMORS.

Congenital tumors other than spina bifida are found chiefly in the sacral region, and may be of various kinds. **Lipomata** sometimes here attain a very large size, and occasionally spring from the interior of the spinal canal. **Dermoid cysts,** containing the usual contents, hair, sebaceous matter, etc., are not infrequent, and may communicate with the rectum or the bladder. The

so-called **congenital sacral tumor** is a large mass occurring in the region of the coccyx, sometimes pedunculated and made up of cysts of various sizes, often lined with columnar epithelium and filled with a viscid, gelatinous material. **Fœtal tumors** of all sizes may be found in the same region, and may contain merely masses of the different tissues or a considerable and well-developed portion, a limb or a trunk, of the fœtus incorporated with the individual who bears it.

All these growths may be treated by excision, although, as their extent is often uncertain before operation, great caution should be exercised.

Tumors of the spinal cord itself may be either intra-medullary or extra-medullary, and are of great variety. The diagnosis will usually be made by the neurologist rather than by the surgeon, but it is proper to give a brief outline of the general diagnostic points which it will be necessary to bear in mind before deciding upon or rejecting operative interference. In the first place, it will be requisite to determine whether the symptoms are due to pressure on the cord or to inflammatory or other changes involving primarily the structure of the cord itself. If, in a case of paraplegia, there is the history of a very gradual onset beginning with pain and followed first by motor paralysis and then by sensory paralysis; if the symptoms are irregularly unilateral; if the pain has first seemed to be neuralgic or rheumatic and burning and shooting in character; if the anesthesia and pain in the lower limbs ascend gradually from the soles of the feet toward the trunk; and if at the same time there is a constant dull ache in a distinct segment of the spinal column, accompanied by a feeling of weakness at that point, much heightened by fatigue,—we have a group of symptoms pointing strongly in the direction of a neoplasm. In addition, it would be found that at first the reflexes,[1] both deep and superficial, were much exaggerated, becoming gradually lost as destruction of the cord with descending degeneration and wasting grew more marked, the abolition of the reflexes beginning, as in the case of the pain and anesthesia, in the plantar region and passing gradually upward.

Later in the disease we have the development of spasms with clonus, which are most marked in the intradural cases, as is also the symptom of rigidity. Local nutrition is not usually impaired; tenderness of the spine on percussion when it occurs in the dorsal region appears to be lower than the tumor producing it; in the cervical region this generalization does not seem to hold so closely. The feeling of stiffness and weakness will usually be found to correspond to the position of the tumor. Lateral curvature of the spine is a secondary result of the tonic spasm of the spinal muscles, and therefore the concavity of the bend is on the same side as the growth. The pupils are not affected, except when the cord is pressed upon above the level of the second dorsal nerve.

The age of the patient, judging from Mr. Horsley's tables, throws but little light upon the diagnosis of tumor, as we find lipomata occurring at an average age of two and a half years, sarcomata at eighteen years, echinococcus at thirty-four years, tubercle at thirty-nine years, scirrhus and myxoma at forty-eight and fifty-three years. These figures apply to extradural growths. In the case of intradural growths we have tubercle at eighteen and a half years, myxoma at forty-three years, fibroma at forty-four years, sarcoma at forty-one, psam-

[1] By a "reflex" is meant an involuntary muscular response to certain irritations of the skin (superficial reflex) or of the muscles (deep reflex), or, as it is often called, "tendon-reflex." The commonest example of a superficial reflex is the movement of the leg upon tickling the foot-sole; the best instance of a deep reflex is the "knee jerk," or sudden extension of the leg following a tap on the ligamentum patellæ.

moma at fifty-one years. It will be seen, therefore, that while age may be of use in excluding certain forms of growth, as, for example, tubercle in intra-dural growths in persons beyond thirty years, it is of but little value in deciding the general question as to the presence or absence of a neoplasm.

This sketch of the principal symptoms makes a tolerably distinct clinical picture, but one which is, nevertheless, liable to great variation, and therefore difficult to differentiate from that of certain conditions of the cord, some of which are due to causes quite beyond the reach of operation. The chief of these are—spinal hemorrhage, extra-medullary or intra-medullary; pachymeningitis externa, from caries; chronic transverse myelitis; primary lateral sclerosis or spastic paraplegia; hypertrophic cervical meningitis.

Having decided in any given case that the symptoms are probably due to tumor, the interesting question, whether it is within or outside the membranes, will still remain to be settled. The best general guide will be found in the fact that the symptoms of intra-medullary growths are chiefly those of motor and sensory impairment, while the extra-medullary growths produce much more markedly irritative effects, as, for example, pain, spasms, etc. In the presence of a paralysis of gradual development, preceded by long-continued signs of nerve-irritation and with a distinct unilateral element, the transference of paralysis from one to the opposite limb having been effected slowly and after a considerable interval, the diagnosis of compression of the cord by some cause outside of its own structure would seem warranted. Aneurysm might be excluded in the absence of the characteristic physical signs and of evidence of erosion of the spinal column; gumma would be accompanied by a history of syphilis, would often be associated with other and recognizable specific lesions, and would possibly yield to the use of iodide of potassium: a new growth (cancer or tubercle) in the bodies of the vertebræ themselves generally causes a perceptible deformity. By attention to the points which have been mentioned a tolerably correct opinion may be arrived at.

Prognosis.—All the evidence which we now have points to extraordinary reparative power on the part of a cord which has simply been suffering from compression, and to an almost equally remarkable tolerance to operative interference. The material for finely differentiated prognosis can hardly yet be said to exist, but in a general way it is safe to say that the diagnosis of tumor (if it be non-malignant) carries with it a reasonably favorable prognosis, which is strengthened if, in addition, the tumor is thought to be extra-medullary.

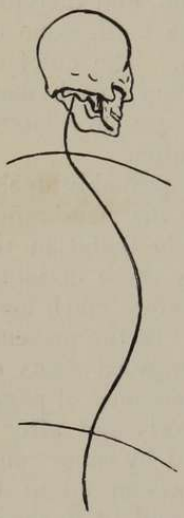
As a result of these considerations it seems proper that every case of focal spinal lesion thought to depend on a tumor, and not distinctly a malignant and generalized disease, should be regarded as amenable to operative interference, at least of an exploratory character, no matter how marked or how long continued the symptoms of pressure may have been. The operation is practically identical with that of resection of the laminæ. (See p. 572.)

Neuralgia.—In some cases of intractable brachial neuralgia, and in others of spasms with violent neuralgic pains in the region supplied by the lumbar and sacral nerves, intraspinal section of the posterior roots has been performed. The operation has been done in five cases, in two of them with some improvement, in the others without much success. It should certainly for the present be reserved for cases in which it is desired to verify a doubtful diagnosis, or for those in which the pain is so great and so little affected by other treatment as to justify so serious an operation. It may be performed by following the directions for resecting the arches and opening the dura in the manner described on page 572.

SPINAL CURVATURES.

The more common pathological curvatures of the spinal column are three in number: *Scoliosis*, or lateral curvature; *Kyphosis*, or *Excurvation*, an antero-posterior curve with the convexity backward; and *Lordosis*, or *Incurvation*, an antero-posterior curvature with the convexity forward.

Fig. 220.



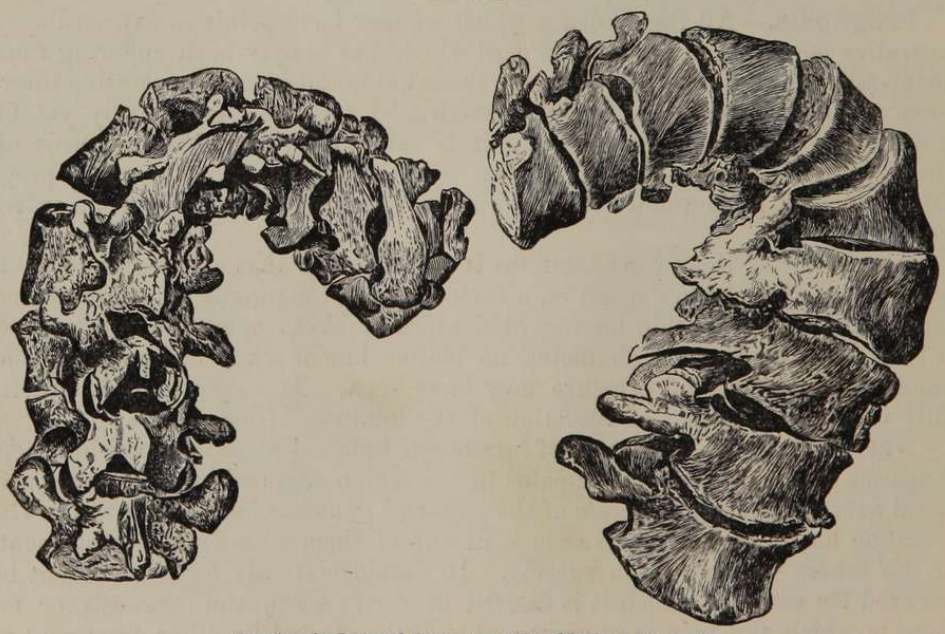
Primary and Secondary Lateral Curvatures (Agnew).

Lateral Curvature.—In scoliosis the spine describes two or more lateral curves with their convexities on opposite sides of the longitudinal axis of the back (Fig. 220). The vertebræ of the region involved are also otherwise changed in their relations to the same axis, being rotated so that their spinous processes point toward the concavities of the lateral curves (Pl. XV, Figs. 3 and 4).

Varieties.—The most common curvatures are those in the upper part of the dorsal region with the convexity to the right side. The second or compensatory curve is in the lumbar region with its convexity toward the left (Pl. XV, Figs. 1 and 2). In marked cases a third, also compensatory, may form in the cervical region, and will also have its convexity on the opposite side from the original curve. Occasionally four or five curves may exist, reciprocally compensating one another.

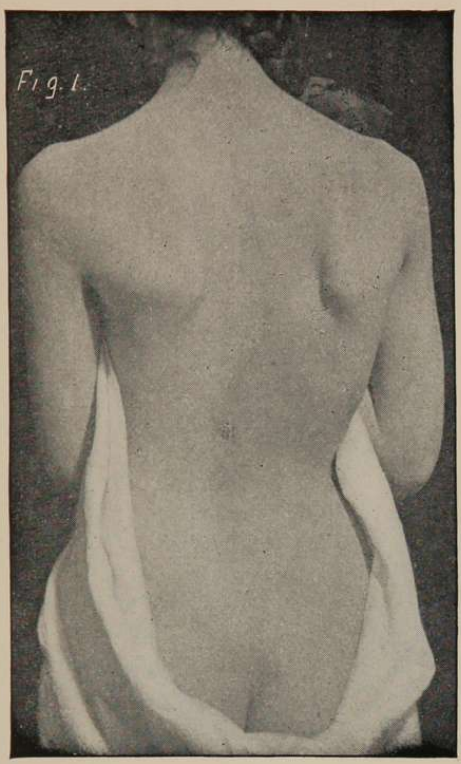
The intervertebral disks in the region of the curve are unequally compressed, becoming wedge-shaped, with the base of the wedge toward the convexity of the curve. The rotation of the bodies of the vertebræ (Fig. 221) is often so extreme that their anterior surfaces point directly toward the convexity and the spines

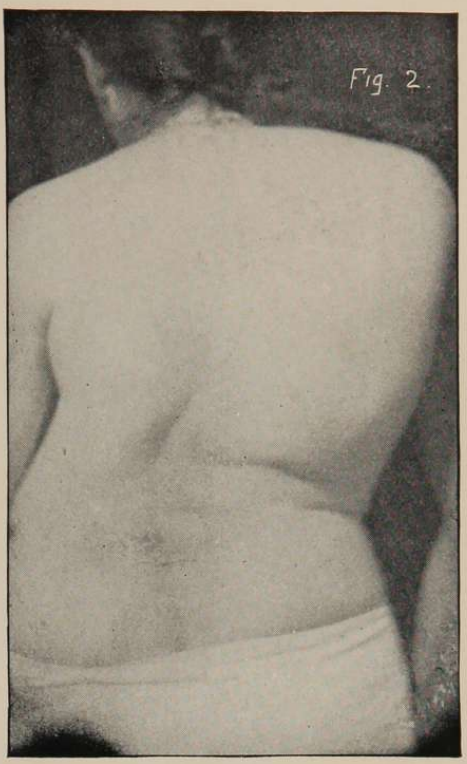
Fig. 221.

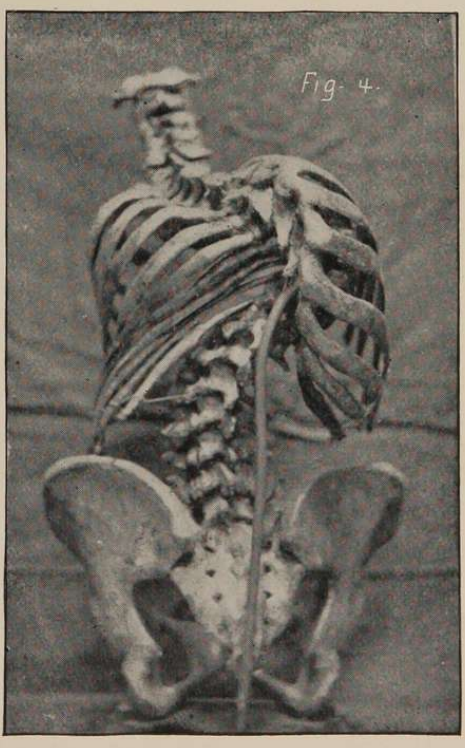


Torsion in Lateral Curvature (Bradford and Lovett).

toward the concavity of the curve. This tends to bring the spines back again into the median line, although sometimes in these cases the twist is so great







Lateral curvature of the spine (scoliosis).

that the angles of the ribs and the transverse processes of the vertebræ occupy exactly the position of the spinous processes.

The ribs on the convex side are widely separated, and are more horizontal than they normally should be; their angles become prominent, and the scapula is carried forward with them, making a large "hump" in the dorsal region. On the concave side the obliquity of the ribs is exaggerated, and in bad cases they may even touch the crest of the ilium. The thorax is therefore generally distorted, and viewed anteriorly will present an abnormal prominence of the left breast (Pl. XV, Figs. 3 and 4).

Causes.—*Predisposing* causes are general weakness, prolonged ill health, rickets, rapid growth, struma, etc. The *exciting* causes are all those conditions which in such a subject produce for long periods an undue inclination of the spine to one side or the other. The typical cases are accordingly seen in delicate girls between twelve and twenty, whose muscular strength and development do not keep pace with their growth, who sit for hours at a desk with no support for their backs, and who carry a heavy weight in the shape of school-books to and from school, and usually on the same side of the body. Any habitual *one-sided position of the body* will have the same effect. Other causes are *obliquity of the pelvis*, produced by unequal length of the lower limbs; *unilateral muscular atrophy* due to central changes when the seat of the trouble is in the spinal cord; *unilateral muscular hypertrophy*, from over-use of one side; or *spasm* from central disease will draw the column toward the side of the enlarged or contracting muscles. *Sacro-iliac* disease, by causing the patient to lean away from the affected side to relieve pressure, *empyema*, through the resulting contraction of the thorax, and *morbid growths* of the sides of the trunk or pelvis, by their weight, may produce the same result.

Symptoms.—The earliest development of this trouble is often insidious. The first complaint of the patient, if a boy, may be that the suspenders on one side slip off his shoulder, or in the case of a girl it may be first noticed by the dressmaker, who may wish to pad out one of her shoulders. Examination will show a slight prominence of one scapula, and perhaps of the opposite iliac crest, and if the spinous processes are followed down the back by one finger with firm pressure, the resulting red line on the skin will show the curve unmistakably.

In severe cases the "hump" on one side, usually the right, the elevation of the right shoulder, the projection of the ilium on the left side, the prominence of the left breast, and the easily recognized curves of the spine, constitute an unmistakable group of symptoms, the majority of which are always present.

In hysterical distortion of the spine the curvatures disappear on making the patient bend forward until the fingers touch the ground. In caries of the vertebræ with lateral instead of antero-posterior curvation the characteristic symptoms of Pott's disease will be present. (See p. 554.)

Treatment.—Perhaps the most important advice to be given to the general practitioner in relation to the treatment of this condition is a caution against the use of braces, corsets, jackets, and other mechanical appliances which, by confining the movements of the chest and supplying an artificial support in place of the muscles which it is most desirable to develop, actually do great harm to many patients instead of good.

Careful attention to the general health, a rigid observance of all hygienic rules, properly directed exercise both active and passive, and massage, constitute the essentials of the only treatment likely to be of service.

The exercise should be prescribed by the physician. The patient should walk a certain time daily carrying a light weight balanced on the head; should several times daily swing for a few minutes by the hands from a cross-bar; and

should sit on a seat raised some inches on the side corresponding to the convexity of the lumbar curve, so that the spine may be strengthened during the efforts to produce a curve compensatory to the obliquity of the pelvis produced by the slanting seat. A high sole on the shoe on the same side has a similar effect.

The patient should be taught to hold the back in the position in which the surgeon finds the curves to be least perceptible, as in that position the weak muscles must act most vigorously and will gradually be strengthened. A form of exercise which has been advocated by excellent authorities consists in placing the patient face downward on a table, bringing the shoulders and trunk over the end, and then, while he is held on the table by an assistant who embraces the legs and thighs, causing him alternately to flex and extend the body at the hips while the surgeon or masseur resists his efforts. Massage of the weak muscles, electricity, "muscle-beating," etc. are valuable adjuncts. In very severe and long-standing cases with marked deformity and great weakness, the use of a spinal jacket (Fig. 222), preferably of leather, but it may be of plaster or steel, may be absolutely necessary. Carefully directed gymnastics with the use of special apparatus are often beneficial.

Fig. 222.

Leather jacket and jury-mast (Sayre).

Posterior Curvature, or Kyphosis, as a distinct disease, is met with in *infants* as a result of rickets, or of having been nursed in a sitting posture, or encouraged to sit up straight at a very early age: at *puberty* it is usually found in the same class of patients as the subjects of scoliosis, and arises from the same cause; *i. e.* it develops in weakly girls from long continuance in a bad position, such as they often assume in practice on the pianoforte or at a school-desk: in *adults* it may also be caused by employment that necessitates constant stooping over, especially if this is associated with poor food and bad hygienic surroundings. It is accordingly seen in rag-pickers, miners, cobblers, tailors, etc. Oftener it is symptomatic of some other disease, as spondylitis deformans, or is caused by an unconscious effort to relieve certain symptoms, as dyspnea in asthma and emphysema, tenderness in metritis and chronic peritonitis, pain in muscular rheumatism or in chronic rheumatic arthritis.

Pathology.—In the slighter forms of the disease there is merely relaxation of the vertebral ligaments, with separation of the laminæ and spinous processes. In others there is absorption of the anterior portions of the intervertebral disks and of the bodies of the vertebræ.

Diagnosis.—It requires to be diagnosticated only from the deformity of Pott's disease, which may be easily done by noting the absence of muscular rigidity, of pain or tenderness, of abscess, of complications of the spinal cord, etc. The curve of kyphosis is extensive and is a true curve, not an angular projection of one portion of the spine. The disease occurs more frequently in the aged than in children.

The **treatment** consists in removing the cause and in developing the weak spinal muscles by appropriate exercise and massage. In young persons abandonment of the vicious posture, with the use of proper exercise, will generally effect a cure. In adults, and especially in the aged, the condition is apt to be permanent, and if very pronounced may require the use of some form of spinal brace.

ANTERIOR CURVATURE, OR LORDOSIS, is often congenital, and may be due to rickets or to disease affecting the posterior portions of the vertebral bodies, but is commonly compensatory and secondary to the deformity of Pott's disease. It may be produced by ankylosis of the hip-joints in partial flexion.

It is usually found in the lumbo-dorsal region, and consists in a marked forward curvation of the lumbar spine, throwing in the loins so that a deep concavity exists in the lumbar region, making the sacrum and the hips prominent, depressing the pubes, and causing a protuberance of the abdomen.

Treatment.—As a rule, it requires no surgical interference, but occasionally, when it depends upon caries of the vertebræ, some artificial appliance will be needed.

SPONDYLITIS DEFORMANS is a term which, though etymologically applicable to an inflammatory disease of the vertebræ producing deformity, such as Pott's disease, is employed clinically to denote chronic rheumatic arthritis of the vertebral column (Treves). It is a disease of old persons, as a rule, though occasionally it is seen in middle life. It is attended with the same changes that characterize arthritis deformans everywhere (see section on Diseases of Joints), and is marked by absorption of the intervertebral disks, by the formation of osteophytes upon the bodies of the vertebræ, and finally by firm bony ankylosis of several vertebræ. The disease begins with pain in the back, followed by rigidity and the development of kyphosis. The curve increases, the ribs become fixed and the thorax immobile, so that respiration is abdominal. When it comes on in middle-aged or elderly persons, and is moderate in extent, it does not seem greatly to influence the expectation of life.

Treatment is of little or no avail, but may be conducted on the general principles applicable to chronic rheumatic arthritis elsewhere.

TUBERCULOSIS OF THE SPINE.

POTT'S DISEASE, SPONDYLITIS.—**Cause.**—Tubercular inflammation of the bodies of the vertebræ is a disease usually found in childhood, affecting more frequently delicate children between the ages of three and ten years, of poor parents, and especially those of tubercular families. No age or class is exempt, however, and occasionally no family history of struma or of tubercle can be elicited. Usually the affection is ascribed to some slight traumatism; this may be the exciting cause in many instances, but the tubercular diathesis or soil is essential to the production of the typical disease.

Pathology.—The inflammation begins in the cancellated structure of the vertebral bodies, which undergoes the changes characteristic of tubercular ostitis elsewhere, the extent and rapidity of the process being proportionate to the number and activity of the bacilli on the one hand and to the vitality of the tissues and of the individual on the other. The results of the rarefying ostitis thus set up may accordingly be threefold: 1. Resolution; 2. Caseation; 3. Liquefaction.

1. When resolution takes place, after a certain stage has been reached, the normal cells get the mastery, the bacilli disappear, the inflammation slowly subsides, the exudation is reabsorbed, and the parts return to their original condition. This result is rare.

2. Far oftener the process of disintegration and caseation advances, the body of the vertebra breaks down, usually at the anterior border first, and masses of fungous granulations replace the osseous cancelli and invade the intervertebral spaces, causing absorption of the disks. Even at this stage, however, repair may begin; ankylosis may follow the transformation of the granulations into

sound fibrous tissue, and a return to health with little or no deformity or functional disability may ensue. This is the result aimed at by the surgeon, and as a rule his successful cases belong to this group.

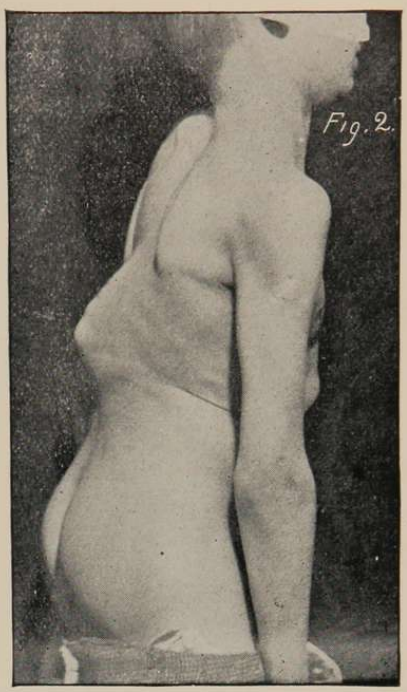
3. In the third class the destructive process is of greater activity: the caseous masses formed in and between the bodies of the vertebræ liquefy and become collections of so-called "tubercular pus;" the anterior surfaces and adjoining edges of the affected vertebræ disappear, as do the intervertebral disks; the whole vertebral body may be absorbed, or more rarely may practically become converted into a large sequestrum lying in a caseous abscess filled with a serous exudation mixed with minute particles of bone, necrotic fragments of connective tissue, and cheesy débris, which together give its contents a milky appearance.

Still later, this collection of fluid finds its way toward the surface by one of several channels and becomes a so-called *spinal abscess*, often, if it breaks spontaneously or is opened carelessly, undergoing infection with pyogenic germs or with germs of putrefaction or with both. During this time the disappearance of the bodies of the diseased vertebræ, permitting the undue approximation of those above and below them, has caused a change in the shape of the spinal column, a falling forward of the segment above the diseased area, a backward projection of the spinous process of the vertebra nearest the area of disease, and the formation of a distinct prominence, which is known by the unscientific name of "angular curvature" (Pl. XVI). This most commonly occurs in the dorsal region. A compensatory *lordosis* often follows in the lumbo-dorsal region. This occurs, though very rarely, as a primary deformity resulting from disease of the posterior portion of the vertebræ. It is, as has been said, more often congenital and hereditary or associated with rickets. Caries in the cervical or lumbar region first causes the disappearance of the normal backward concavities of the spine in these regions, so that straightness of the spine in the neck and in the loins has the same significance as a moderate projection in the dorsal region. During this time a slow thickening of the connective tissue between the dura and the walls of the canal is going on, a so-called external pachymeningitis, which is the chief cause of the paralysis occasionally seen in this disease. This inflammatory growth is oftenest anterior, and by its pressure produces motor paralysis; frequently, however, it is also posterior, and then there is paralysis of both motion and sensation. Occasionally, but rarely, the bodies of the displaced vertebræ impinge upon the cord. Still more rarely there occurs a transverse myelitis of the cord itself. In both these latter cases there would, of course, be paralytic symptoms.

Symptoms of Pott's Disease.—These vary with the stage and extent and situation of the inflammatory process, but observe approximately the following order in their development:

1. The child will complain of *pain* in the region supplied by the nerves arising from the affected segment of the cord. If the disease is lumbar, the pains are abdominal and are apt to be associated with vesical irritability; if dorsal, the pains are epigastric or intercostal, and respiration is sometimes irregular and hurried from the failure of the respiratory muscles to take their full share in the work; if cervical, neuralgic pain or numbness in the arms and hands, a tickling cough, and difficult deglutition are the prominent symptoms. It is to be noted that the pains are apt to be symmetrical.

2. *Increase of pain upon movement*, and especially upon jumping or upon flexing or rotating the spine, is extremely significant. If the child can jump painlessly from a chair to the floor, it is almost certain that no inflammation of the body of a vertebra exists. If the vertebræ be crowded together by

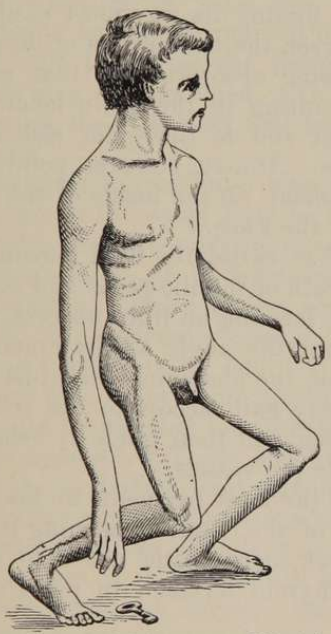


Pott's disease of the spine (spondylitis).

pressure on the head or shoulders while the patient sits or stands or while he lies face downward across the knees of the surgeon, the pain will be much increased. Conversely, if while erect the patient be gently lifted by the hands under the chin and occiput, or if in the prone position on the surgeon's lap the latter's knees be separated so that the spine is elongated, pain will be relieved. Pain may be increased by percussion of the spinous processes, and sometimes the skin over the spinal gutter and the neighboring muscles is tender to the touch; but these signs are of slight value if present, and are by no means constant.

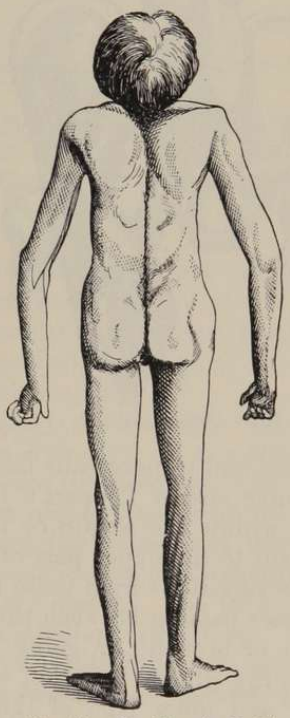
3. *Involuntary immobilization of the spine*, a result of this pain upon movement, is a very characteristic symptom. If the child is asked to look at something behind him, he turns the whole trunk. If he is requested to pick up something from the floor, he stoops by bending the thighs upon the trunk and the knees upon the thighs, never by flexing the spinal column in the usual way (Fig. 223). In walking he moves as though on ice, sliding or shuffling along so as to avoid the jar of successive steps. In standing he fixes the upper portion of the column by the aid of the trapezii and the other scapular muscles,

FIG. 223.



Manner of Picking up an Object in Pott's Disease (Agnew).

FIG. 224.



Standing Position in Pott's Disease (Agnew).

the action of which at the same time raises the shoulders and throws the arms out from the side (Fig. 224).

4. In standing or sitting there is also an *involuntary transference of the weight* of the head and shoulders and parts above the diseased area to the pelvis by means of the upper extremities. The hands are often placed upon the hips and the arm muscles are tense. In walking about a room the little patient will support himself upon articles of furniture, going from one to another with great care, losing no opportunity to lay hold of a chair or a couch.

5. The *deformity* will usually be characteristic, and has already been described. As a rule, the diagnosis by means of the above symptoms should be possible before any material change in the contour of the spine occurs.

6. *Spinal abscess* occurs later, and will vary in its position according to the seat of the caries. *a.* In disease of the cervical vertebræ the abscess is apt to be **retro-pharyngeal.** A fluctuating swelling appears in the pharynx, usually to one side of the median line. If it shows externally, it does so behind the angle of the jaw. Sometimes it follows the œsophagus into the mediastinum, or it may pass between the longus colli and scalene muscles and point on the neck in front of or behind the sterno-mastoid.

b. In dorsal caries the fluid collects along the front and sides of the dorsal vertebræ in the posterior mediastinum. Thence it may pass between the transverse processes to the back, constituting **dorsal** abscess; or may descend to the diaphragm, pass under the outer arcuate ligament, and point in the ilio-costal space as a **lumbar** abscess; or go under the inner arcuate ligament to form a **psoas** abscess (Fig. 225). The latter, being prevented from spreading inward or backward by the spine and the last rib, and having its progress forward checked by the ligament, is impelled downward by gravity and by its increase in size, finding its way most easily into the space between the two origins of the psoas, gradually causing absorption of that muscle, and usually pointing in the groin below Poupart's ligament and to the outer side of the femoral vessels. It may, however, point above Poupart's ligament, on the inside of the thigh, or even below the knee.

Fig. 225.

Psoas Abscess (Albert).

c. In lumbar caries the fluid remains outside of the sheath of the ilio-psoas and occupies the iliac fossa, forming an **iliac** abscess, which is apt to occupy the angle at the junction of the iliac and transversalis fascia and to point on the abdominal wall just above the outer end of Poupart's ligament; or it may gain access to the true iliac space within the sheath of the ilio-psoas, which will then guide it below the ligament to the upper part of the thigh outside the vessels.

As variations from these routes, which are the most frequent, we may have abscesses passing between the ribs to the side of the chest, or opening into the pleura or bronchi, or going through the great sacro-sciatic notch to appear under the gluteal muscles, or through the thyroid foramen to point on the upper and inner part of the thigh.

7. *Paralysis*, always motor at first and often not affecting sensation at all, is the result chiefly of the external pachymeningitis which has been described.

Diagnosis.—The above symptoms will usually enable the disease to be recognized and easily differentiated from thoracic or abdominal aneurysm, hysteria, renal disease, rheumatism and neuralgia, empyema with subdiaphragmatic abscess, etc. The most important symptom in the early stages is, perhaps, the rigidity of the spine; later the deformity is easily recognizable.

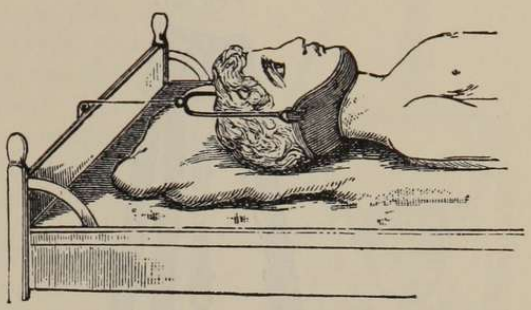
Treatment.—The indications for treatment in Pott's disease are, 1. To endeavor to secure resolution of the tuberculous ostitis; 2. To limit the destruction of tissue and the resulting deformity as much as possible; 3. To promote

ankylosis; 4. To evacuate pus; 5. To remove a sequestrum or the focus of carious bone; 6. To relieve the cord from pressure by pus, bone, or, most commonly, by the products of an external pachymeningitis.

The first three may be considered together, and are equally met by the application of the same principles.

Rest is always the most important consideration. In very young children, in patients of all ages where there is very active and progressive disease, and in all cases in which the ostitis or caries is situated in the cervical or upper dorsal region, confinement to bed in the *recumbent position* is almost imperative. In cervical caries the head and neck should also be fixed by sandbags laid one on each side, secured in position by tapes, and extending from the vertex to the shoulder. Extension in bad cases with beginning pressure symptoms may be applied from the chin and occiput, the head of the bed being sufficiently elevated, or from the lower limbs by raising the foot of the bed and applying adhesive strips with weight and pulley, as for fracture of the femur, to both legs; or the two methods may be combined. To prevent excoriation of the skin by the adhesive strips, the legs may first be bandaged and the plasters applied over the bandages.

FIG. 226.



Extension in the Recumbent Position (Reeves).

Whenever the patient's circumstances make it practicable and the general health can at the same time be maintained, recumbency with limitation of all but slight and necessary movements should be continued until all symptoms have disappeared, or, if the disease has already reached the stage of caseation or liquefaction, until complete consolidation has taken place.

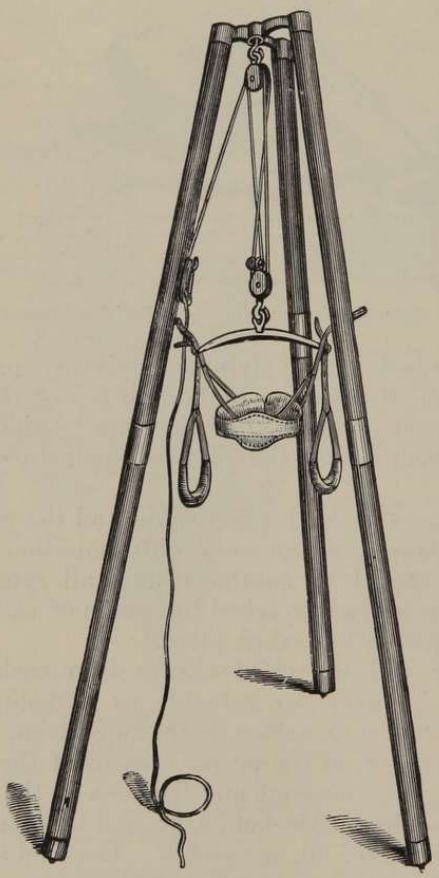
This is not always possible, nor will the child always bear such prolonged confinement to bed. It is, however, so valuable as a method of treatment that every effort should be made to secure its thorough trial. The bed should be wheeled into the sunlight, or, at the proper seasons of the year, into the open air. There should be gentle massage and frictions of the limbs and of the abdominal and pectoral muscles. Alcohol baths, and sometimes in very young children inunctions with cod-liver oil, are useful. The food should be nutritious and as abundant as digestion and assimilation will permit. Much of the success of treatment will depend upon the care and judgment shown in the feeding, and the surgeon cannot too closely scrutinize the details of diet. A large variety of tonics have been employed in these cases, but three are to be especially recommended: viz. a well-made and digestible emulsion of cod-liver oil; the phosphates, which may often be contained in the same emulsion; and iodide of iron in doses to suit the age and the stomach of the patient.

When consolidation has occurred, which will be after a period represented by months rather than weeks, and is accompanied by a disappearance of symptoms and an increase in the general strength and well-being, the patient should be allowed to sit up, cautiously at first, and if the deformity has been marked should wear some light form of spinal jacket. The higher the caries in the vertebral column, the greater should be the caution in permitting the erect position.

Rest of the affected region when the disease is below the mid-dorsal vertebræ and is not too acute or extensive, and where the patient is old enough, may be satisfactorily obtained by the use of some form of spinal jacket, by means of which the weight of the parts above the disease may be transferred from the spinal column to the curves and bony prominences of the pelvis and hips.

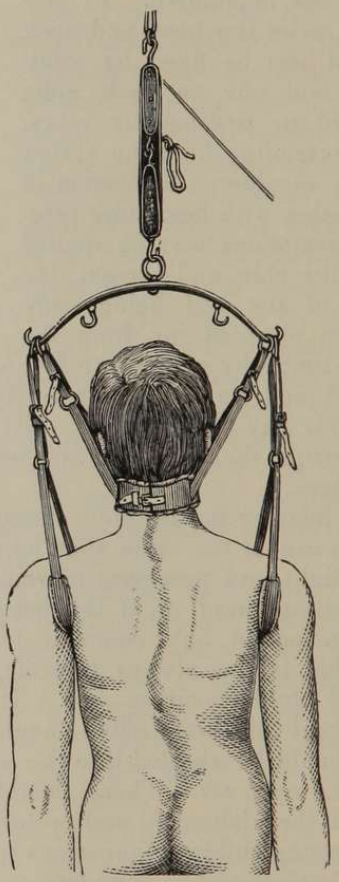
The simplest of these jackets is that known by the name of Dr. Sayre, who devised it. It may be applied as follows: The patient is stripped, and a closely-fitting woollen undershirt, reaching below the nates and provided with shoulder-straps, is put on. He is then placed beneath a tripod, and a leather headgear

FIG. 227.



Tripod for the suspension of the patient (Sayre).

FIG. 228.



Patient in position for the application of the plaster jacket (Sayre).

embracing the occiput and chin is adjusted, and in older children or adults axillary bands are added (Figs. 227, 228).

By means of pulleys the patient is then elevated (*a*) so that the toes just touch the floor; (*b*) or so that the heels are about two inches from the ground, the "fore-pads" of the feet being in contact with the floor; (*c*) or so that the heels are merely raised from the ground. These various degrees of extension are to be applied according to the age and weight of the patient and the extent of the disease, the first mentioned being suitable for the youngest and lightest children and the least extensive disease, the last applying to adults and to more severe forms of the trouble.

While the patient is held in this position the woollen shirt is kept drawn well down, pads of cotton wool are applied over the iliac spines and other bony

prominences, the space between the breasts in women is filled with a temporary pad, and a wedge-shaped pad is placed over the lower part of the abdomen under the shirt, with the base of the wedge upward, enclosed in a towel to admit of its ready removal. This is the so-called "dinner-pad," intended to leave a space after its withdrawal which will allow for the physiological distention of the abdomen after eating. Plaster bandages are then applied, rollers $2\frac{1}{2}$ to 3 inches in width and 6 yards in length being used. The first turns are made midway between the trochanter and the crest of the ilium, and they are then carried regularly and smoothly up to the axilla, each turn overlapping the preceding turn about one-third (Fig. 229). About three layers are required. An assistant with a basin of dry plaster and a wet sponge may strengthen the dressing here and there if required, and can keep it smooth. The jacket should be left on until the plaster has set, usually about fifteen or twenty minutes, and the patient should then be taken under the arms and carefully laid upon a hard mattress, where he should remain about an hour. He may then be allowed to dress and go about. The temporary pads should be removed.

Fig. 229.

Plaster applied, and slit up in order to prepare plaster cast.

If the jacket has been well applied it will usually give relief or comfort. It should never be worn continuously longer than ten or twelve weeks. When removed, the parts can be inspected and abrasions or excoriations treated while the patient is recumbent. A new jacket may then be put on in the same manner as before. The advantages of the plaster jacket are its cheapness and the readiness with which it can be applied. Its disadvantages are its weight, its liability to exert uneven pressure, and its concealment of the parts beneath it for so long a time. Some of these may be removed by cutting it down the front after it has hardened, springing it off the patient, and making holes at a short distance from its two edges, after "binding" them with a broad strip of adhesive plaster, so that it may be laced. It should not be used in very young children, in early and acute disease, in the presence of cardiac or pulmonary complications, over abscess which is pointing, or in extremely feeble and anemic patients. In all these cases recumbency, with proper attention to diet and hygiene, is preferable. A jacket of half-tanned leather (Fig. 222), such as has been recommended by Agnew, can be made by a good surgical cutler from a mould taken in plaster as just described, and is much lighter and more comfortable. A jacket of poro-plastic felt is also recommended, and can be readily applied. Corsets of various sizes are made of this material. The patient is suspended, wet cloths are wrapped around the body, and a corset of the proper dimensions is momentarily dipped in scalding water and is then moulded to the figure. After it "sets," it can be made to lace down the front, and is easily removed and reapplied.

In cases of disease above the mid-dorsal region the "jury-mast" (Fig. 222)

must be applied in addition. It consists of a vertical bar fitted to the curve of the back and neck, extending above the head, and carrying the occipito-mental leather apparatus. The jury-mast removes injurious pressure on the softened vertebral bodies by supporting the weight of the head and of the portion of the trunk above the diseased vertebræ on the chin and occiput. The lower end of the bar is held in the plaster by a cross-piece or is riveted to the poro-plastic or leather jacket. In cases where the jury-mast is thought unsafe, a breast-plate and collar for the same cases have been made by Edmund Owen; but such cases are far better treated by recumbency.

The Treatment of Spinal Abscesses varies somewhat with their situation, but the rule should be to open them freely as soon as they are accessible. Aspiration is usually a failure. Tapping and irrigation with antiseptic fluids, or the injection of an emulsion of iodoform, or the swabbing out of the cavity, followed by the use of iodoform and the treatment of the cavity as a simple wound, have all been tried with more or less success. The results from any of them are vastly better than were obtained by any of the older methods, but their precise comparative value is as yet uncertain.

Retro-pharyngeal abscess if pointing in the pharynx should be opened promptly, to avoid the danger of suffocation which attends its spontaneous and unexpected evacuation. Of late, the tendency of surgeons is toward reaching these abscesses by external incision, instead of through the mouth, in order to secure asepsis. The incision is made at either border of the sterno-cleido-mastoid muscle and the abscess reached by a careful dissection, especially in the neighborhood of the vessels.

Psoas abscess may be opened either in the loin or in the groin or in both localities. If only one is selected, the former is beyond all doubt to be preferred. A vertical incision at the outer edge of the erector spinæ should be carried down through the external oblique, internal oblique, and transversalis muscles and the lumbar fascia until the edge of the quadratus lumborum is seen. Then a transverse division of the fibers of that muscle and of the transversalis fascia on the level of the tip of the second or third lumbar transverse process avoids the lumbar arteries, which are above and below the process, and gives access to the finger, which in lumbar abscess will go at once into the abscess-cavity, and in psoas abscess will easily pass through the attenuated sheath and the few remaining fibers of the psoas into the collection of pus (Treves).

A second opening made below Poupart's ligament by cutting on the end of a long probe introduced through the loin will permit of through-and-through irrigation by means of a large drainage-tube, which later may be replaced by two tubes, to be gradually shortened so that the abscess-cavity may contract in the middle.

With proper antiseptic precautions the opening of a spinal abscess should not be attended by the development of the hectic fever, the emaciation, and the rapid failure which so commonly followed this operation in earlier days. It was then thought to be due to the removal of the internal pressure of the pus from the vessels in the walls of the "pyogenic membrane," but undoubtedly it was the result of infection of a tubercular cavity with pyogenic organisms.

The lumbar operation is also to be preferred, as enabling us in a certain number of cases to meet another indication—namely, the removal of the focus of carious bone. In so-called "posterior vertebral disease," *i. e.* in cases in which the osseous lesions are localized in the transverse or spinous processes or the laminæ, operation is of course both easy and satisfactory, and seven out of eight recorded cases have given excellent results. Posterior vertebral disease is, however, extremely rare. When the bodies of the vertebræ are diseased, as is

usually the case, above the twelfth dorsal they are practically inaccessible, except in very unusual cases associated with extensive caries of the ribs. At and below that point, however, an operation such as the one described above may be of great use. Fourteen such operations have been followed by eight cures, five cases improved, and one death which had no relation to the operation itself. They have shown that the solidity of the spine is not affected by either the curetting or the removal of a sequestrum, and have demonstrated that the costo-iliac space in proper cases (*i. e.* in those where only one or two vertebræ are affected and there is but slight angular projection with a curve of large radius) is ample for the work to be done. For these reasons it is safe to say that the search for the focus of bone disease in caries of the lumbar vertebræ is indicated with sufficient frequency to give the matter a real surgical interest. The seat of disease may be sought in exceptional cases even before the appearance of an abscess, and in the presence of an abscess may often be reached with great ease and certainty. The bodies of the lumbar vertebræ are accessible by Treves's operation even when no abscess which is appreciable clinically is found. If an abscess exists, therefore, even when it points anteriorly it is proper to open it by the lumbar route and seek the focus of disease. This permits us, if the abscess depends on vertebral disease, to reach the twelfth dorsal vertebra without wounding the pleura. The benefit to the patient in successful cases is as definite and unmistakable as that following the removal of a focus of tubercular ostitis and caries in any other region.

The last indication for operative interference, viz. the existence of paralysis thought to be due to pressure upon the cord, is to be met in various ways.

It should be clearly recognized that such cases, especially in children, frequently recover under careful hygienic treatment, when the abscess, if any exists, can be evacuated and the treatment by extension and a spinal jacket employed. It has been shown conclusively by Weir Mitchell that no case of Pott's paralysis ought to be considered desperate without the trial of suspension, which has succeeded after the failure of other accepted methods, such as continued rest in bed, with the administration of tonics and frequent cauterization with the hot iron; that the pull probably acts more or less directly on the cord itself, and the gain is not explicable merely by the obvious effects on the bony curve; that the methods of extension to be used in these cases may be various, provided only that we do get active extension; and that the plan and the length of time of extension must be made to conform to the needs, endurance, and sensation of each individual case.

Extension may be employed by making the bed an inclined plane, or more forcibly with the patient in a sitting position. In either case the stretching is done through traction from the chin and occiput by means of a collar resembling that used in swinging the patient for the application of a plaster jacket (Fig. 226). When this form of extension can be borne (and it generally can be) it is very effective. It must be the method used in high dorsal and cervical caries. In other cases the extension may be made either from the upper portion of a spinal jacket applied in the usual way or from both the jacket and the occipito-mental collar. This distributes the pull and renders it a little less severe, although if suspension from the head is done gently and the amount of the pull is increased slowly, very few patients complain of it. If the extension is to be made from a spinal jacket, loops of bandage, like the straps of a girl's dress, should be carried up over the shoulders during its application, their loose ends being imbedded in the plaster. In all cases the extending force is the weight of the patient's body.

The apparatus may be improvised by having the collar made of quilted

canton flannel, the foot of the bed being raised if the use of an inclined plane is indicated, and the cord attached to the cross-bar, or, if vertical suspension is desired, a gallows can be made by a carpenter to straddle the bed and to carry the cord and pulley. The pulley may be fixed at the end of an iron support resembling that used in the "jury-mast" extension for Pott's disease. This may be fastened to the back of a reclining chair, so that it curves out over the head of the patient, who can then, if he is old enough, regulate for himself the amount of pull which he can sustain with comfort. This admits of very delicate graduation of the extending force, by suspending the patient from a spring balance attached to the jury-mast.

This method of treatment should be persevered in for weeks or months if there is the least indication of improvement, and will sometimes produce remarkable results in apparently hopeless cases. Of course the most careful attention to hygiene must be combined with this as with any other form of treatment employed. Electricity and massage to keep up muscular nutrition, good food, iron, and cod-liver oil, pure air and sunlight, are as important as they always are in tubercular disease.

In cases in which all this has been tried unsuccessfully, or in those in which the disease is slowly but steadily progressing to an unfavorable termination, when with more or less complete loss of motion and sensation below the level of the lesion there are incontinence of urine and feces and the development of bed-sores, and especially when acute symptoms threaten life, resection of the arches and laminæ of the affected region becomes justifiable.

When the tubercular process affects the arches and there is paraplegia, we may sometimes operate in the hope, not only of freeing the cord, but also of removing at the same time the focus of disease. This double indication may also be fulfilled in those cases in which, without bone disease, there is a posterior pachymeningitis or a tuberculoma occupying the canal. Here again, however, time and careful attention to hygiene, including change to sea- or mountain-air, often work wonders. If the lesion of the bodies of the vertebræ is in the lumbar region at a point where these bodies are accessible, it may be possible in certain cases to expose the cord from the back by removal of the laminæ, with the object not only of removing pressure, but also of reaching and taking away the diseased bone and tubercular granulations. In tuberculosis of the body of a vertebra and compression of the cord by *anterior* pachymeningitis we can fulfil only one indication, *i. e.* liberate the cord from pressure. We should operate only in grave cases in which acute compression, the appearance of respiratory complications, and the rapid development of degenerative processes force us to interfere, or in which the course of a chronic case is steadily toward a fatal termination, although no advanced visceral tubercular lesions are present.

Operation having been decided upon for any or all of the above reasons, the prognosis will be favorable in proportion to the youth and strength of the patient, the absence of generalized tuberculosis, and the nearness of the lesion to the base of the spine.

INJURIES OF THE BACK.

Sprains.—Sprains of the spine are of all degrees of severity. The structure of the vertebral column is so complex and its relations are so numerous and varied that a great variety of symptoms may follow a sprain according to the extent of the damage which is inflicted. In the mildest degree of sprain the muscles alone are involved, and we then have merely a temporary stiffness and a little local tenderness over a limited area. In more serious accidents, as those occurring during railway collisions, the ligaments may also be involved

and are sometimes actually torn. When this happens in the case of the ligamenta subflava, there may be immediate and severe extradural hemorrhage, followed by temporary paraplegia. The symptoms which are never absent are pain and stiffness. Occasionally there is a little local swelling, but this is not constant. The pain is referred to the extremities of the injured nerves, sometimes shooting down the limbs, occasionally, when the injury is at the lumbo-dorsal junction, being referred to the pubic region. The skin over the injured part is apt to be exceedingly tender. The stiffness produces a degree of rigidity of the spine which resembles very much that seen in Pott's disease, the patient involuntarily immobilizing the vertebral column and avoiding rotation and flexion as carefully as possible. When the injury is unilateral this muscular rigidity is very marked on the injured side, and is a valuable means of distinguishing real from asserted injury, especially in medico-legal cases, as it cannot be simulated.

The **diagnosis** of severe sprains followed by great helplessness and by some degree of paralysis will sometimes be difficult, as the condition may closely simulate that of fracture. In the latter, however, the paralysis is more absolute, the disability more complete, the tenderness over the spine less diffuse, and there is often an irregularity in the line of the spinous processes which will serve at once to indicate the more serious character of the injury.

Treatment.—This does not differ in its general principles from that of sprains elsewhere. Rest of the part, counter-irritation by dry cups or by some rubefacient, gentle frictions with a liniment containing belladonna, followed later by massage of the affected part, constitute the essentials of treatment. It should always be borne in mind that there may be retention of urine. The use of laxatives is frequently indicated.

The **later symptoms** of spinal sprains are, after all, the most serious and annoying. At the time of the accident there may be the form of general nervous depression which we know as shock, which may even deepen into its graver variety of collapse; or in neurotic patients there may occur the more localized disturbance of cerebral origin known as acute hysteria, but this, as a rule, will disappear within a short time. Later, however, two forms of sequelæ may occur which take a chronic character, and which are classified by Thorburn in his excellent book on this subject as neurasthenic and traumatic hysteria. In the former condition there is a general defect in the nutrition and nerve-power, which when it follows a traumatism is manifested by weakness, loss of memory, mental confusion and irritability, insomnia, headache, eye-strain, photophobia, irregular and frequent pulse, dyspepsia, etc. These symptoms occur in patients who have had mild shock at the time of the accident, and they will generally pass away after rest and tonic treatment. They are very common, and are often associated with those belonging to traumatic hysteria, which Thorburn describes as a functional affection of the nervous system resulting from an injury, due probably to a change localized in some portion of the cerebral cortex, and manifested by well-defined and localized symptoms. He adds that it has no known organic basis, is not reflex in origin, and is neither shock nor neurasthenia. It is an affection of middle life, three times as common in the female as in the male, occurring especially in persons of a neurotic temperament or in those addicted to the excessive use of alcohol. It is favored by great fright or by horrible surroundings at the time of the accident which produces it.

The symptoms may be either psychical, including epileptiform attacks and hysterical insanity; motor, including paralysis and contractures of the limbs and special effects upon such organs as the larynx and the bladder; sensory,

in which case there is anesthesia, hyperesthesia, or paresthesia of the general or special sensory nerves; or lastly, there may be vaso-motor, secretory, or trophic trouble.[1]

As to its essential cause, the theory of Charcot, that traumatic hysteria is frequently identical with the conditions produced by suggestion during hypnotic sleep, is the most plausible which has yet been advanced. In lightly hypnotized persons a slight blow on an extremity is often followed by motor and sensory paralyses if these are forcibly suggested by the operator; the same symptoms may follow even without suggestion. The trifling traumatism evokes from the cerebral cortex in its unaltered state the idea of severe injury, and this is promptly followed by the loss of power and sensation which might really follow a genuine injury. In traumatic hysteria the nervous shock replaces the hypnotism, and the abnormal sensation caused by the injury gives rise, as in the above instance, to the "auto-suggestion" which replaces suggestion by the operator.

The treatment should consist in isolation, and in endeavoring to obtain control over and influence upon the patient, and should conform to the principles which govern the treatment of neurasthenics by the rest cure.

Concussion as applied to injuries of the spinal cord is a term which may be retained for convenience, but which has no accurate pathological signification. When it is remembered that the cord does not entirely fill the spinal canal, that it is connected with it only at those places where the nerves pass through the intervertebral foramina and by the ligamentum denticulatum, that it is closely embraced by its pia mater, that it is surrounded by fluid, and that the canal and its contents are protected in the most thorough manner imaginable from the effects of violence transmitted through surrounding structures, it is evident that a traumatism which without causing some gross lesion would produce a condition of the cord justifying the use of the term "concussion" must be of rare occurrence. As a matter of fact, it is probable that some actual lesion in the substance of the cord occurs, possibly a rupture of delicate nerve-fibers, possibly a capillary hemorrhage, or, it may be, merely a vaso-motor disturbance with slight serous exudation. In any event, the symptoms are those which attend a moderate degree of shock; that is, a tendency to syncope, pallor of the face, nausea and vomiting, cold perspiration, etc., superadded to which are the special symptoms which arise from the cord, such as numbness or tingling or loss of power in the lower extremities; or hiccough, wry-neck, temporary paralysis of the arms, a sense of constriction of the thorax, or similar symptoms if the upper portion of the cord suffers. The treatment appropriate to sprains of the spine applies to injuries of this character.

Contusion of the spinal cord may result from severe sprain, but usually occurs as a consequence of forced flexion of the vertebral column. It is accompanied by hemorrhage into the substance of the cord—hematomyelia—which usually occupies the gray substance, and may extend to a considerable distance. It is accompanied by motor and sensory paralysis and a diminution of the reflexes. It may be followed by acute myelitis and all the phenomena attendant upon degeneration or destruction of the substance of the cord. It is obviously difficult to diagnosticate from a fracture in which no deformity exists. The prognosis is, however, more favorable, and in cases of contusion of the cord of moderate severity the improvement which occurs at the end of the first or second week will serve to show the character of the lesion.

[1] For a detailed description of this condition, with illustrative cases, the monograph of Thorburn on the Surgery of the Spinal Cord should be consulted.

Wounds of the spinal cord are comparatively rare. From in front the cord is obviously inaccessible, except to injuries otherwise fatal; from behind, the oblique downward direction of the spinous processes serves as a protection. The most exposed region is between the occiput and atlas and the atlas and axis. Of course if the vulnerating body takes an upward direction it may reach the cord in the dorsal region, and in cases of gunshot wound the cord may be wounded by the ball or by fragments of bone, just as in other fractures. As a rule, wounds of the cord are fatal, especially those which are inflicted in the upper segments, and if the wound be in the cervical region above the origin of the phrenics, death will follow almost immediately.

Compression of the Spinal Cord.—(*a*) From **blood.** Spinal hemorrhage may occur as a consequence of injury, and may proceed from the vessels contained in the substance of the medulla or from those between the latter and its membranes, or from the large plexus of veins found in the space between the dura mater and the walls of the spinal canal. The symptoms of *extra-medullary* hemorrhage as given by Gowers, Mills, and others are as follows: 1, sudden and violent pain in the back, more or less diffused; 2, pain along the course of the nerves passing through the membrane near the extravasation; 3, abnormal sensations, tingling, etc., and hyperesthesia, referred to the same parts; 4, spasm involving vertebral and other muscles supplied by affected nerves, and also sometimes the muscles supplied by the cord below the seat of the hemorrhage; 5, general convulsive movements; 6, spasmodic retention of urine; 7, consecutive paralytic symptoms, but not usually complete paralysis.

Some points of differential diagnosis between meningeal hemorrhage and extravasation into the substance of the cord should be borne in mind. Symptoms of irritation, such as pain, hyperesthesia, and spasm, in meningeal hemorrhage usually arise immediately or very early, and may precede paralysis, which is commonly not complete. In hemorrhage into the substance of the cord paralysis may be complete at first or may rapidly become so, and symptoms of irritation may be very largely wanting. Hemorrhage may, and not infrequently does, involve not only the membranes, but also the substance of the cord, giving rise to complex symptoms.

The symptoms of *intra-medullary* hemorrhage are as follows: The onset is sudden; there is a history of traumatism or of disease associated with profound blood-changes; the symptoms are bilateral; there is pain in the back, with disappearance of the reflexes connected with the affected segment; spasms, rigidity, and paralysis come on rapidly, as does also the girdle symptom. Bed-sores, incontinence of feces, and retention of urine develop very early in the case, which runs a rapid course and is often fatal.

The **treatment** of spinal hemorrhage will depend upon the severity and the persistence of the symptoms. The presence of rapidly-extending paralysis, thought to be due to extra-medullary hemorrhage and threatening life through involvement of important centers, might justify an immediate resort to operation. Persistent paraplegia with the development of bed-sores and the occurrence of cystitis, these symptoms extending over some weeks in a case in which the lesion is believed to have been one of hemorrhage, might also warrant a consideration of the propriety of operation. The prognosis will be the more favorable, either with or without operation, the lower the seat of the compression of the cord. The most favorable cases will be those in which a clot occupies the lowest portion of the canal, pressing upon the lumbar cord or the cauda equina.

(*b*) Compression from **lymph.**—Meningitis may result from any one of the forms of injury which have been considered, and may be accompanied by an exudation of inflammatory lymph, which in many cases is sufficient to cause

grave compression symptoms. The most common form of this is the external pachymeningitis of Pott's disease, already described. More rarely a meningitis becomes transformed into a myelitis which involves a certain portion of the cord transversely, and is accompanied by progressive paralysis, pain in the back, the girdle symptom, increased reflexes, ankle clonus, etc.

As to the **diagnosis** of these various forms of injury, the time which elapses between the accident and the development of the symptoms is one of the most important factors. (1) If the symptoms occur instantaneously after a grave injury, the cord has probably been compressed by a displaced vertebra, and the case has been one of fracture or luxation or of the common lesion which combines them both, the so-called fracture-dislocation. (2) If the symptoms have not made their appearance for some time, possibly hours, after the injury, the cause is probably hemorrhage, paralysis not having been produced until a sufficient amount of blood had accumulated to cause the necessary pressure. If the hemorrhage is intra-medullary, less time will elapse than if it occurs between the membranes and the walls of the canal. (3) If the symptoms of paralysis do not appear until a period varying from a week to one or two months, they are probably due to pressure by inflammatory lymph the result of an external pachymeningitis.

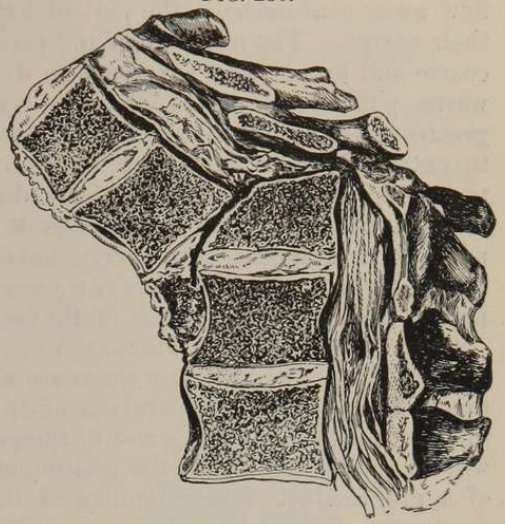
FRACTURES OF THE SPINE.

As compared with other fractures, those of the vertebræ are rare, constituting only 3.3 per cent. of nearly 52,000 fractures treated in the London Hospital during thirty-five years. Gurlt's table shows that fractures of the cervical and dorsal vertebræ are almost equally frequent, those of the lumbar vertebræ much less common; that the vertebræ most frequently broken are the fifth and sixth cervical, the last dorsal, and the first lumbar; that is, those which are situated at the junction of the more movable with the more fixed portions of the spinal column. More than one vertebra is usually broken when the injury involves the upper portion of the column. The cervical fractures are by far the most fatal. The great majority of spinal fractures occur during middle life. They are found more frequently in males than in females, probably owing to the greater exposure of the former to injury. The body of the vertebra is the portion fractured in the majority of cases, constituting, according to Gurlt, about two-thirds of all fractures in the cervical region and seven-eighths of all in the dorsal region. Fracture of the arches is found in about one-half of the cases of cervical fracture, one-seventh of those in the dorsal region, and one-eighth of those affecting the lumbar vertebræ. There is reason to believe that the frequency of fracture of the arches has been somewhat under-estimated. Stimson remarks that it does not seem improbable that some of the severe sprains of the lower portion of the back which leave a more or less permanent weakness or sensitiveness of the part may be fractures of the arch without displacement and possibly without union. Certainly when the fracture occurs from direct violence, which is comparatively rare, the arches are especially likely to be broken. In 81 cases of resection of the spine for fracture and luxation White found a record of fracture of the laminæ or arches in no less than 45 per cent. Of course, as he remarks, this does not represent the actual frequency of this form of fracture, as doubtless in many of these cases it was recognized previous to the operation and constituted one of the principal indications therefor. The most common cause of fracture of the spine is forced flexion, the head and neck being bent forward upon the chest, or the thorax upon the pelvis. This occurs commonly in accidents in which embank-

Fracture of the spine.

ments cave in or scaffoldings fall, and probably enters into those forms of fracture in which the patient falls upon the feet or the sacrum or the head from a considerable height. In all these cases we have associated with the fracture, as a rule, tearing of muscles, laceration of ligaments, crushing of the cancellated tissue of the body of the vertebra, hemorrhage into the spinal canal, and commonly some displacement. The portion of the spine above the fracture slips forward and pinches the spinal cord between the arch of the vertebra immediately above and the edge of the body of the broken vertebra (Pl. XVII and Fig. 230). Occasionally a piece of bone is driven into the spinal canal and compresses the cord.

FIG. 230.



Fracture of Spine, with laceration of the cord (Shaw).

The **symptoms** common to all fractures of the vertebræ are pain, increased on motion, tenderness on pressure, ecchymosis, and more or less extensive paralysis of motion or of sensation or of both. Subsidiary symptoms found in the majority of cases are deviation of the spinous processes and occasionally angular deformity of the spine, phosphatic urine, and disorders of the sexual organs, shown in the male by priapism.

The **prognosis** in all cases is unfavorable both as to recovery of function and as to great prolongation of life, becoming more serious in direct proportion to the higher situation of the fracture, the severity of the injury which causes it, and the amount of crushing or of dislocation.

FRACTURES OF THE LOWER THREE LUMBAR VERTEBRÆ.—These are not very common, and are frequently unattended by serious symptoms. Owing to the fact that the cord terminates at the level of the second lumbar vertebra and that the long roots of the cauda equina surrounded by a firm fibrous membrane slip smoothly one upon the other, and thus slide out of the way of fragments of broken bone, they often escape injury altogether. On account of the lessened rotation in the lumbar portion of the spine and of the large muscular masses that surround the vertebræ there is apt to be no crepitus, deformity, or preternatural mobility, and in the absence of paralysis the only symptoms are local pain and tenderness and a feeling of weakness and instability when the patient attempts to stand. As this, however, would obviously accompany a severe contusion of this region, it is evident that a positive diagnosis is scarcely possible. In exceptional cases paralysis and other symptoms of fracture are present. As a rule, the prognosis is favorable as to life, and, in fact, complete restoration to strength and to functional ability often follows.

FRACTURES BETWEEN THE SECOND LUMBAR AND TENTH DORSAL VERTEBRÆ.—These fractures are followed by paralysis of the portions of the body which receive their nervous supply from the lumbar and sacral plexus. Paralysis of the lower limbs and of the bladder and rectum is exceedingly common. Sensation is sometimes not so completely abolished as motion, but, as a rule, the paralysis of both motion and sensation is absolute. There is at first retention of urine, which as the bladder becomes distended is imperfectly relieved by a slight overflow or dribbling, the so-called "incontinence of reten-

tion." This, in cases which are neglected or in those in which septic instruments are used for catheterism, or, in many cases, in spite of the greatest care, is followed by a violent cystitis, with phosphatic and ammoniacal urine. The retention of feces which at first occurs is due to a paralysis of the muscular walls of the intestine; as these gradually recover their power to some slight extent, the contents of the bowels are passed on toward the lower intestine, and, owing to the paralysis of the sphincter, escape involuntarily. When the motions are solid, this takes place at long intervals; when they are liquid, they flow away continuously, the patient having neither control nor knowledge of their escape. The nutrition of the paralyzed parts is feeble; the skin becomes coarse and branny and covered with desiccated epidermic scales. The muscles waste, points exposed to pressure become red or purplish, and unless the greatest care is exercised gangrene follows, producing bed-sores which tend to extend, rapidly involving in such cases the entire thickness of the soft tissues down to the bone and spreading in every direction.

The **prognosis** in these cases is distinctly unfavorable, although some undoubted instances of recovery have been recorded. Life is usually prolonged for from six months to two years. The patients die finally from exhaustion or from the septic effects of the bed-sores or the cystitis.

Fractures of the Dorsal Vertebræ.—In fractures between the tenth and second dorsal vertebræ there are all the above-mentioned symptoms, with the addition of marked paralysis of the abdominal muscles, distention of the intestines with gas, giving rise to tympany, and difficulty in respiration, which will be greater the higher the position of the fracture, owing to the involvement of a progressively larger number of the intercostal muscles. In addition to the causes of death already mentioned, such patients may die from hypostatic congestion, or from pneumonia which gradually follows the plugging up of the air-vesicles and the bronchi with mucus, which the patient is unable to dislodge by coughing or expectoration. The expectation of life is distinctly less than in the dorso-lumbar fractures.

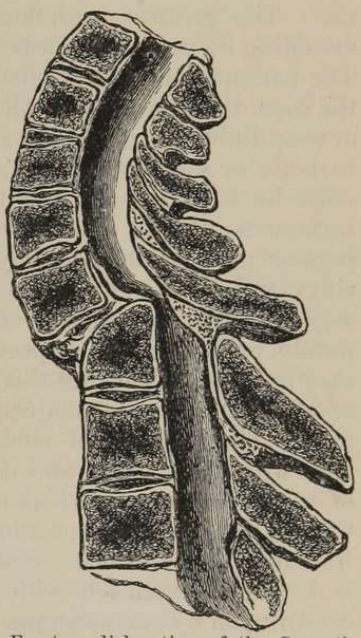
Fractures in the Cervico-dorsal and Cervical Regions.—There is in these fractures, of course, paralysis of sensation at a much higher level than in those already considered. A want of symmetry in the sensory paralysis is often observed at first, but disappears as degenerative changes occur in the cord. Occasionally there is a hyperesthetic area immediately above the upper limit of anesthesia, due probably to the congestion and irritation of the region just above the seat of injury. If the fracture involves only the first or the second dorsal, but one cord of the brachial plexus will be involved and the paralysis of the upper extremities will be incomplete. If, however, it runs through the lower cervical vertebra, there is likely to be absolute motor and sensory paralysis of both arms. It is important to remember that the seat of the compression of the cord will in the great majority of cases be higher than that of the anesthesia or paralysis by the length of the course of the nerves involved within the spinal canal, and that it will usually be caused by the forward luxation of the vertebra above the seat of fracture. For example, the nerve which supplies the interosseous muscles and the intrinsic muscles of the hand is the first dorsal. Its root in the spinal cord is, however, on a level with the seventh cervical vertebra. Therefore if, in a case of fracture, we had marked prominence of the spinous process of the first dorsal vertebra, we would understand that the cord was probably injured by the dislocation forward of the vertebra immediately above it, and that the highest level of the paralysis which would follow would be indicated by the distribution of the first dorsal nerve.

Thorburn's tables, which are probably approximately correct, but require confirmation, give the distribution of the most important nerves as follows:

Fourth	cervical	nerve		supplies	the supra- and infraspinatus.
Fifth	"	"	"	"	biceps, brachialis anticus, deltoid, and supinators.
Sixth	"	"	"	"	subscapularis (this appears to be the highest), pronators, teres major, latissimus dorsi, triceps, pectoralis major.
Seventh	"	"	"	"	extensors of the wrist.
Eighth	"	"	"	"	flexors of the wrist.
First dorsal		"	"	"	interossei and intrinsic muscles of the hand.

This is very well illustrated by one of Thorburn's cases, in which there was a fracture-dislocation of the seventh cervical and first dorsal vertebræ, the first dorsal having been fractured while the seventh cervical was displaced forward, carrying with it the fragment of the first dorsal. The cord was compressed at that level, and was softened for a short distance above and below the site of compression, its centre being occupied by an effusion of blood reaching as high as the fifth cervical nerve-roots in the form of a narrow cone (Fig. 231). In this case the injury was at the extreme lower part of the cervical region, and must at first have involved the region of the first dorsal nerve, and probably to some extent that of the eighth cervical. At first there was paralysis only of the intrinsic muscles of the hand and the interossei, but thereafter from day to day it was possible to watch the extension upward of the myelitis, the motor power failing in the following muscles in the order named: (1) flexors of the wrist; (2) extensors of the wrist; (3) triceps and pectoralis major; (4) latissimus dorsi; (5) teres major and subscapularis; (6) deltoids, flexors of the elbow, supra- and infraspinati.

Fig. 231.



Fracture-dislocation of the Seventh Cervical and First Dorsal Vertebræ (Thorburn).

In the majority of cases of fracture of the spine in which life is prolonged for any time a similar series of phenomena will be observed.

Fracture of the Atlas and Axis.—In fractures above the fourth cervical vertebra when the cord sustains damage the injury is either immediately fatal, or more often the patients survive for a period of time varying from a few hours to two weeks. In one case (Hilton) the patient lived fourteen years, and in another (Shaw) for fifteen months. Fractures of the upper two cervical vertebræ, however, are especially dangerous, on account of the close relations between these vertebræ and the medulla oblongata, and also from their position above the roots of the phrenic nerves and of the nerves supplying the external muscles of respiration.

The symptoms of fracture are complete paralysis of all the parts below the seat of the fracture, rigidity of the neck, pain in the neck or occiput, and sometimes distinct crepitus. These symptoms, however, result also from dislocation, and a differential diagnosis is frequently impossible. The axis is more frequently broken than the atlas, and the odontoid process is sometimes broken alone. The structure of the body of the axis is more spongy than that

of the atlas, and its weakest point is about one centimeter below the neck of the process, which explains the seat of one of the most common fractures. In cases of fracture of the odontoid process with accompanying dislocation, the head is rigidly maintained in a fixed position, and in cases of unilateral displacement is turned to the opposite side. There is often an unusual prominence of the larynx, and the posterior wall of the pharynx may be pushed forward by the body of the dislocated vertebra.

The **treatment** for such an accident should consist in gently straightening the spine and placing the patient in a supine position, with fixation of the head if the fracture involves a cervical vertebra, by applying sand-bags to each side. The character of the bed upon which the patient is placed is of great importance. The water-bed is preferable to any other, but in cases where this cannot be procured an ordinary mattress covered with mackintosh may be employed, and air-cushions and rubber rings may be used to protect the most salient points. The bladder should be emptied every six hours by means of a Nélaton or Mercier catheter, which should be kept scrupulously aseptic. If cystitis occurs in spite of this, it is sometimes useful to wash out the bladder with solutions of boric acid, peroxide of hydrogen, etc. If the constipation which immediately follows the accident is persistent, it is well to give a cathartic. The greatest care must be exercised in cleansing the parts after any dribbling of urine has occurred or after there has been an action of the bowels. The patient should be washed daily and turned gently from side to side, so that the hips, the sacrum, and all portions of the back may be rubbed with alcohol or soap liniment, and afterward anointed with zinc ointment containing enough carbolic or salicylic acid to prevent decomposition of the secretions. The bed must be kept smooth and the drawsheets and other bed-clothing absolutely without wrinkles. If bed-sores form in spite of these precautions, the affected regions must be immediately relieved from all pressure by the use of rubber rings, and the sores themselves cleansed and dressed antiseptically. In this way the greatest amount of comfort may be obtained while carrying out a purely palliative and expectant treatment. It is obvious, however, that the case is being left during this time to the unaided efforts of nature, the results of which in the great majority of cases are, as has been seen, most unsatisfactory. The tendency of modern surgery is toward rather more active interference with these cases, and it is probably safe to say now that in the majority of spinal fractures in which there is recognizable deformity immediate rectification of the abnormal position is thought to be indicated, just as in any other fracture. This in many cases can be done by the usual methods of extension and counter-extension with manipulation. The lower limbs may be gently drawn upon by one assistant, while the head is firmly held in position by another with his hands upon the chin and occiput. The surgeon can often under these circumstances press the displaced bones into position while the patient lies either upon his face or upon his back. If the fracture is high and the abdominal muscles and external respiratory muscles are paralyzed, great care must of course be observed in turning the patient on his face not to interfere with the action of the diaphragm by pressing upward the abdominal contents, as this has been known to cause fatal asphyxia.

If the deformity cannot be relieved in this way, extension on an inclined plane may effect the same purpose, and a fixed dressing can be applied at the same time by slipping beneath the upper portion of the trunk of the patient, as he lies supine upon a mattress, a many-tailed bandage made of stout flannel and then three to six layers of crinoline plaster bandages. The ordinary suspension collar used in Pott's disease should then be applied to the chin and occiput, and

the head of the mattress or of the bed gradually raised so as to use the weight of the patient's body as an extending force, the collar being fastened to the head-piece of the bed or being held very firmly by an assistant. The layers of bandage may then be moistened and brought into position, a strip of ordinary bandage being interposed between their anterior extremities, so that the jacket may be easily opened and removed if it seems desirable. Extension from the shoulders in cases of dorso-lumbar fracture, or from the chin and occiput in cases of fracture at a higher level, may then be cautiously applied daily, or in some cases may even be made permanent during the process of consolidation.

The results in a number of cases in which this method or some modification of it has been adopted are sufficiently encouraging to warrant its trial in a much larger proportion of fractures of the spine than heretofore, ten cases out of sixteen reported by Burrell having been greatly benefited. In many cases, however, no results follow, and of course the method is open to the objections that there are some risks of increasing pressure on the cord in rectifying the deformity, and, further, that it is difficult to avoid unpleasant pressure effects in spinal cases in which a fixed dressing of this sort is used. Remembering, however, the extremely unfavorable outlook in cases of fractures of the spine treated expectantly, it seems worth while to run these or even greater risks if in a fair proportion of cases the patients can be benefited. Of late years resection of portions of the spine has been employed with increasing frequency in those cases in which the expectant treatment or the treatment by extension had obviously failed, and in some cases has been resorted to immediately after the fracture. The observations are now sufficiently numerous to show that even extensive resections of the laminæ do not greatly or permanently weaken the spine, that under antiseptic methods the risk of consecutive inflammation of the cord or membranes is practically very slight, and that danger from hemorrhage or from loss of cerebro-spinal fluid is not to be feared. They also show that it happens not infrequently that the cord is directly compressed by fragments of the laminæ themselves. The operation is therefore one which should no longer be rejected on the sole remaining ground that we cannot be certain in any given case as to the exact amount of damage which has been done to the tissues of the cord. On the contrary, in the light of experience this would seem rather to favor operation than to contraindicate it. White's statistics show that thirty-seven operations for fracture performed during the antiseptic era have resulted in 6 complete recoveries from the operation and injury, 6 recoveries with benefit, 11 recoveries unimproved, and 14 deaths, a mortality of 38 per cent. Those cases in which the lesion occupied the lumbar region, and especially those in which only the cauda equina were involved, were, as might be expected, especially favorable. So, too, those cases in which fractures of the arches or laminæ existed gave on the whole good results, while the prognosis, just as in the expectant treatment, became unfavorable in direct proportion to the severity of the injury and the height of the fracture. It is safe to say, however, that the results of recent operative interference in properly selected cases of fractures of the spine are encouraging, and are likely to lead to the more frequent employment of resection of the posterior arches or laminæ (*a*) in all cases in which depression of those portions, either from fracture or from dislocation, is obvious; (*b*) in some cases in which after fracture rapidly progressive degenerative changes manifest themselves; (*c*) in all cases in which there is compression of the cauda equina from any cause, whether from anterior or posterior fracture or from cicatricial tissue; (*d*) in the presence of characteristic symptoms of spinal hemorrhage, intra- or extra-medullary.

Operation is contraindicated by a history of such severe crushing force as would be likely to cause disorganization of the cord. What will remain in doubt previous to operation will usually be the extent of damage done to the cord and the possibility of its reparative action. As to this, the safest rule is that which has been formulated by Lauenstein—namely, that if after the lapse of six or ten weeks there is incontinence of urine with cystitis or incontinence of feces, and especially if there are also the development and spreading of bed-sores, but little is to be hoped for from the unaided efforts of nature. If, however, these symptoms be absent, and if there be the least improvement in either sensation or motion, it will be proper for the surgeon to delay operative interference still longer.

The operation itself—**laminectomy**—may be done in the following manner: The patient is placed in a prone position, a gentle curve having been given the spine by means of a firm small pillow placed under the lower ribs. A long incision should be made directly down to the tips of the spinous processes, the middle of the incision being opposite the seat of the fracture. The muscles should be freely separated from the sides of the spinous processes and the posterior surfaces of the laminæ. The periosteum may be reflected by making an incision through it along the angle between the spinous processes and the laminæ, turning up its edge at this point with the help of dissecting forceps, and then scraping the surfaces of the vertebral arches with a curved periosteal elevator. This should be done neatly, so as to leave as little ragged muscular tissue as possible, since this may become necrotic and produce later trouble. Then the periosteum is similarly reflected on the opposite side. Retractors of moderate size, not large or clumsy enough to be in the way, are all that is needed to keep the muscular masses from interfering with the subsequent procedures. This being completed, the hemorrhage should be arrested by hemostatic forceps, by packing hot sponges between the spinous processes and the detached muscular mass, and by ligatures. The next step consists in the division of the spinous processes close to their bases by means of large, strong bone forceps set at an obtuse angle. This adds nothing to the severity of the operation, while it affords much freer exposure of the laminæ, which are the next parts to be attacked. They can be expeditiously and safely divided by the rongeur forceps or by a pair of strong bone forceps, either straight or having a large obtuse angle as may be preferred by the operator. The vertebra at the center of the incision or the displaced vertebra should be selected, and the vertebral spaces above and below its laminæ should be recognized with the tip of the finger. The laminæ should then be cut through by successive short nips of the bone forceps, the line of section being as close to the transverse processes as possible. This gives the greatest exposure of the cord and of the membranes.

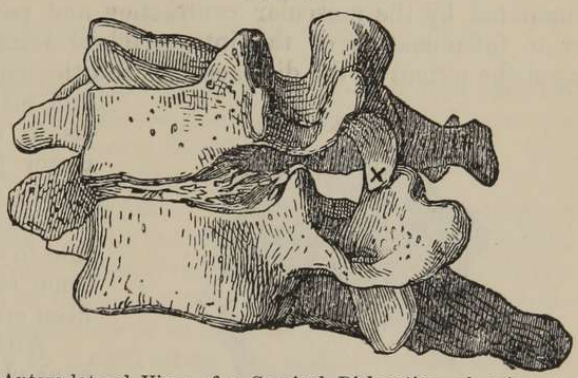
The color of the dura should be noted, particularly with the view of determining in cases of traumatism whether it is or is not necessary to open it. If it be dark or purplish from the presence of exuded blood beneath it, or yellowish from the presence of pus, it will, of course, be proper to incise it in order to empty and to explore the subdural space. If it is determined to open it, it may be picked up in the median line and at the middle of the incision with a pair of delicate toothed forceps, nicked with a knife or the scissors, and then divided either upon a director or with a pair of blunt-pointed scissors to any required extent upward and downward. It can be easily and gently retracted to either side, so as to expose the whole posterior surface of the cord to both inspection and palpation, permitting the gentle insertion of the tip of the finger between its inner surface and the lateral aspect of the cord, and permitting

also, if need be, the investigation of the anterior and antero-lateral subdural spaces by means of a blunt curved instrument, such as a pedicle needle or an aneurysm needle. The inspection having been completed, or it having been determined after removal of the cause of compression that no indication for further operation exists, the incision in the dura should be stitched up with fine interrupted catgut sutures. These may be introduced very readily and speedily by means of a pair of staphylorrhaphy or Hagedorn needles, the one not in use being threaded by an assistant while each stitch is being put in place; the stitches should be inserted at intervals of about one-eighth to one-sixth of an inch, and when all are in place can be easily tied, the ends being cut off short. A small rubber drainage-tube and a dozen strands of chromicized catgut should then be laid throughout the entire length of the wound, the muscles being united above them by means of buried chromicized catgut sutures, after which the skin and aponeurosis are brought together by silk or silver wire as may be preferred. It is hardly necessary to say that the most rigid antiseptic precautions should be observed from first to last.

DISLOCATIONS OF THE VERTEBRÆ.

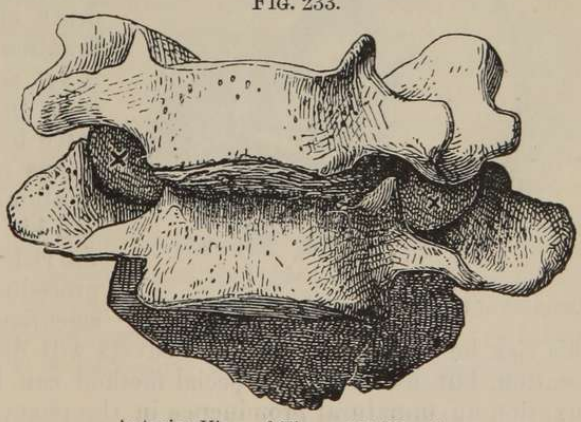
These, as has been said, are commonly associated with fracture, but a number of cases have been reported and verified by post-mortem examination in which uncomplicated dislocation has occurred. They were nearly all of the cervical region. A few dorsal dislocations have been noted, the majority of them affecting the twelfth dorsal vertebra. Only three or four cases of dislocation of the lumbar vertebræ without serious fracture have been recorded and confirmed by autopsy.

FIG. 232.



Antero-lateral View of a Cervical Dislocation, showing the prominence of the upper vertebra, and at x a displaced articulating process (Koenig).

FIG. 233.

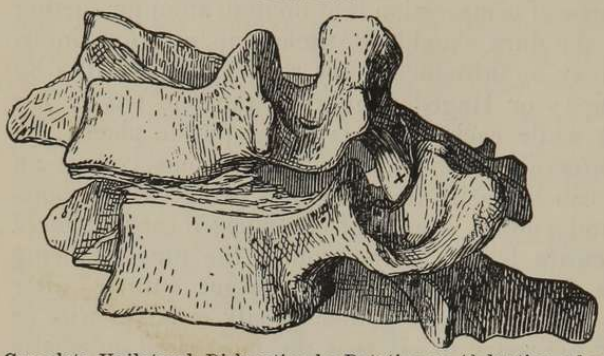


Anterior View of Figure 232 (Koenig).

Vertebral dislocation may be caused by forced flexion or extreme extension. When produced by such forces they will uniformly be *bilateral* and either forward or backward (Figs. 232 and 233). They may also be produced by extreme lateral motions of the spine or by excessive rotation. In either of these cases they may be *unilateral*, either forward or backward, and may be *incomplete*, that is, the articular surfaces may remain in contact at their edges; or *complete*, in which case the inferior process of the upper vertebra passes farther forward and sinks into the notch between the body and the superior articular process of the lower vertebra (Fig. 234).

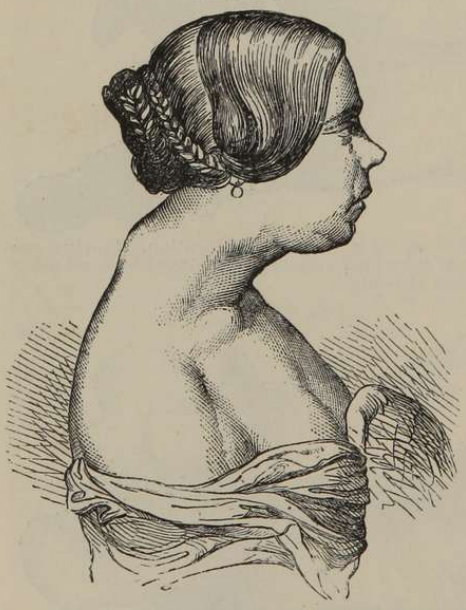
It is usual in treating of dislocations of the vertebræ to speak of the upper one as the vertebra that has been dislocated. Of course there are the usual associated lesions, including rupture of ligaments, muscles, and blood-vessels, injuries to nerves, and often laceration of the intervertebral disks. In the absence of deformity the symptoms will be the same as those of fracture of the vertebræ. Crepitus and preternatural mobility are not always obtainable in fracture, and indeed cannot with propriety be sought for in the majority of such cases. In the cervical region it may be possible to recognize the change in the relations of the transverse processes, the body of the dislocated vertebra may be felt through the pharynx, and the absence of the corresponding spinous process may be noted on the back of the neck. The rigidity and the attitude in which the neck is held will often be very suggestive (Fig. 235), but may be closely simulated by the muscular contraction and pain due to contusion of muscles or to inflammation of the intervertebral joints. The paralysis will depend upon the extent of the displacement and the corresponding damage to the cord, and may vary from a very slight paresis to extensive paraplegia. Usually motor paralysis is more marked and extensive than sensory paralysis, and both kinds are apt to be less absolute in dislocation than in fracture. In some cases of dislocation paralysis has been entirely absent.

FIG. 234.



Complete Unilateral Dislocation by Rotation or Abduction of a cervical vertebra (Koenig).

FIG. 235.



Luxation of the Fifth Cervical Vertebra (Blasius).

Although many surgical authorities have objected to any effort being made to reduce luxation, on the ground that the attempt may cause the immediate death of the patient, especially if the luxation is in the upper cervical region, it yet seems proper in the majority of cases in which dislocation is diagnosticated to attempt to replace the part by means of traction aided by flexion or rotation. It is right that the patient and his friends should be informed of the risk of immediate death during this procedure, but the surgeon may conscientiously and urgently advise that this risk be accepted. The manœuvers will depend upon the seat of the dislocation, but, as a rule, no special method can be indicated. If in a cervical luxation an unnatural prominence in the pharynx can be felt, reduction may be facilitated by making backward pressure with the finger through the mouth while at the same time traction is kept up from the chin and occiput. When

the displacement is unilateral, rotation should be used in addition to extension and counter-extension. The head, which is apt to be inclined to one side, should be carried still farther in that direction, so as to disengage the processes of the luxated vertebra, after which it should be gently rotated and bent toward the opposite side, extension and counter-extension being kept up during the whole of this procedure. In the lower segments of the spine the methods already described for rectifying the deformity in fractures apply equally to luxations. In the majority of cases the operator will be in doubt as to whether or not a fracture coexists.

The **prognosis** is, of course, more favorable in uncomplicated luxations which have been reduced than in fracture, but the injury in all cases must be regarded as a very serious one. Even after reduction paralysis often persists, and death ensues on account of the injury to the cord.

CHAPTER III.

SURGERY OF THE RESPIRATORY ORGANS.

SECTION I.—THE NOSE AND NASAL CAVITIES.

Congenital and other Deformities of the Nose.

The nose varies naturally within wide limits in shape and size, and has been studied alike by the artist and the surgeon, but outside of the natural limits of variation we occasionally see more or less conspicuous deformity. This may be either a failure to develop properly or an unusual width of space between the nasal processes of the upper jaws. A few instances are on record where the nose was totally lacking at birth. On the other hand, a supplementary nose of such size as to cause the individual to be regarded as having a double nose is not unknown. The fissure between the lower lateral cartilages has been known to remain so conspicuous as to cause the individual to display a bifid nose. Failure to develop in length along the dorsal aspect may give rise in a prominent degree to that condition commonly known as snub-nose. That peculiarities in conformation of the nose are particularly likely to be transmitted by heredity is illustrated peculiarly well in the Jewish race. The subjects of inherited syphilis frequently present noses which have little or no bridge or which are so flattened between the orbits as to be unpleasant to regard.

But the most common deformities of the nose or nasal cavities are not those which appear externally or which leave more than a slight external sign, but those which produce variations of contour within the nasal fossæ. Perhaps the most common of these is deviation of the nasal septum, which, though often acquired, is most often of congenital origin. This may be slight in extent or may be so marked as to lead to the virtual occlusion of the nasal passage on one side. Furthermore it frequently happens that the pressure of such a bulging septum against the turbinated bone produces various reflex irritations which are at times quite severe. When the degree of deviation is slight there is but little evidence of it, but when it is extensive there is usually irregularity of external configuration.

The **nostrils** are occasionally contracted from birth, and rarely are completely occluded by more or less tough membrane. When this membranous

occlusion is met with later in childhood, in the majority of instances it will be found to result from cicatricial tissue following ulceration about the anterior nares. Such nostrils may be enlarged by a slow process of dilatation; or a combination of incision and stretching, which latter must extend over a long period of time, may be practised. When the nostrils are completely occluded or obliterated a combination of incision and dilatation is absolutely necessary.

A form of elephantiasis occurs rarely in middle or later life. It has been known to attain enormous proportions. It can be treated only in one way, if at all; that is, by excision of the affected tissue and proper closure of the wound,—if necessary, by some plastic method.

A diseased condition much resembling the above, but due to a very different cause, is that known as **rhinoscleroma**. This is described by Hebra as an affection of the nose, the nostrils, and even the upper lips and the adjoining parts. It is characterized by the appearance of hard swellings or tumors,—in other words, of cutaneous nodosities,—sometimes almost polypoid in shape, isolated or confluent, sometimes of a darker color than the adjoining parts. These nodosities are more or less separated by fissures from which exudes a yellowish fluid. The growths themselves may present cartilaginous hardness. They distort the nostrils and make hideous the nose, and invade even the parts about the mouth. Bacteriological researches of the last few years have shown that they are due to tissue-irritation by a certain specific micro-organism, a bacillus. Stepanow has been able to reproduce the disease in animals by inoculation. It is amenable to but one form of treatment,—that is, free excision during its early stages.

Fissures of the Nose.—These are almost always connected with defects of development and failures to close at or near the middle line, and are nearly always confined to cases of cleft palate and hare-lip in which the fissure extends up into the nasal fossæ. Their proper consideration and treatment are connected with the surgery of the mouth and face. It has happened once to the writer to see a fissure of the septum, the effect of which was that there appeared to be three nostrils. Under chloroform the thickest portion of this divided septum was cut away and the third nostril abolished.

Asymmetry.—Asymmetry of the nasal portion of the face has been studied especially by Zuckerkandl and Allen. While it may be of congenital origin, in the majority of cases it is due to pre-existing stenosis of one nasal fossa, which is thereby deprived of its proper nutrition and does not develop symmetrically with its fellow. This view is corroborated by the result of excluding the entrance of air into one nostril of young animals. A variety of experiments and clinical experiences makes it certain that obstruction of the respiratory canals by enlargement of tonsils, hypertrophy of mucous membrane, and adenoid vegetations in the pharynx occurring early in life is the principal exciting cause of developmental defects in the nose.

Synechia, or adhesion or fusion of parts within the nasal fossæ, is not care, although those cases in which it is properly of congenital and developmental origin are rare, since it is usually the result of some previously existing ulceration.

Diseases and Displacements of the Septum.

Abscess.—Abscesses in the septum may be acute or chronic. Acute abscess comprises those forms which follow local traumatism, *i. e.* the purulent transformation of a clot beneath the mucous membrane, as well as those abscesses consecutive to furuncle, in the vicinity of a foreign body, or to adjoining ulcera-

tion. Commonly the swelling of the septum can be noticed by inspection through the nostrils. It feels warm and is extremely painful to the touch. Not unfrequently perforation of the septum or loosening of its bony or cartilaginous margins results. When due to spread of septic influences from the neighborhood this affection may be unilateral. The local treatment consists of early and sufficiently free incision.

Chronic abscess is a more progressive and slowly destructive condition, with minor or no inflammatory signs and few if any acute symptoms. It has been mistaken for polyp and for a malignant disease. It is usually either of syphilitic or of tubercular origin. When either of these forms of intranasal disease is primary, it may be followed by erysipelas of the face, by more or less local destruction of tissue, or even by deep phlebitis and meningitis. They are quite likely to be followed by loss of the septum and consequent deformity of the nose.

Acute Coryza.—This is an acute inflammation of the Schneiderian membrane, affecting, at least at first, that portion of it which covers the septum and the lower turbinated bone, and is that condition known to the laity as severe "cold in the head." A similar condition met with in the new-born or in very young infants is a not uncommon sign of inherited syphilis. Except for the distress which it sometimes causes or its reflex effects, it is scarcely of surgical interest, unless it occurs in those who have already some pathological changes in these parts. The influence of cold and wet is predominant in its causation, since a slight chilling of the body is often enough to produce it. It may also be caused by irritating vapors, *e. g.* of bromine, by certain animal or vegetable products, such as pollen, by the odors of certain flowers in susceptible individuals, by various foreign bodies, including polyps, by traumatism, or by eczema or other eruptions within the nose. It may also be attendant upon periostitis, upon furuncle or carbuncle, upon severe conjunctivitis, or it may appear in the course of certain general diseases, like measles, diphtheria, the grippe, etc. In certain individuals it appears so constantly with attacks of asthma as to indicate something more than mere coincidence. The young and those of a tubercular diathesis seem to be more frequently affected.

Its local signs are those of profuse discharge of nasal mucus, with extreme susceptibility and irritability of the Schneiderian membrane, and so much obstructive swelling as to impair or make impossible nasal respiration. A peculiarly uncomfortable and tickling sensation within the nose and a tendency to sneeze on little or no provocation are its most marked symptoms. So tumefied does the mucous membrane become as not merely to prevent that passage of air through the nose which distinct speech requires, but even the quality of the voice is changed. When the disease is severe the frontal and maxillary sinuses are affected by extension, and the pain and discomfort are thereby considerably increased. Often pharyngitis will further complicate the disease, in which case there will probably be more or less implication of the Eustachian tube, with its attendant complaints. In proportion to its severity the sense of smell is impaired or temporarily lost.

An uncomplicated case of this character will ordinarily last five or six days. If anterior and posterior rhinoscopy be practised an excellent demonstration of the cardinal signs of inflammation will be afforded.

Treatment.—Acute coryza is virtually a self-limited disease, but its course may be shortened by local and general treatment. The administration of a brisk cathartic, followed by foot-baths at night, a sedative and antipyretic mixture internally (phenacetin and quinine with small doses of morphia), the

inhalation of steam from boiling water into which a little powdered camphor has been thrown, and the use of antiseptic alkaline spray to which ½ to 1 per cent. of cocaïne and 3 to 5 per cent. of antipyrine are added, will be found to give very great relief. A solution of cocaïne is often of great value. When the watery discharge is profuse the addition of one-tenth of 1 per cent. of atropine to the spray will materially diminish its excess. If local distress be very great, a triturate may be ordered of 1 part of morphia with 25 parts of bismuth subcarbonate or subnitrate, and the insufflation of a few grains of this will have a happy effect. Avoidance of exposure to draught and cold is of course an important adjunct in the treatment.

Ozena.—This is a term applied to a condition of fetid ulceration commonly due to syphilis or other disease of the Schneiderian membrane, or else to an atrophic form of inflammation of the same commonly known as *atrophic rhinitis*. The ulcerative form gives rise to discharges of a mixed muco-sanguino-purulent character, with expulsion of crusts and scabs, and imparts a most unpleasant and fetid odor to the breath. In the atrophic form of the disease there is little or no ulceration, but so much lack of moisture as to lead to the partial evaporation, decomposition, and drying of what discharge there may be, with more or less disposition to the same characteristic odor of the breath. Some writers include under this term disease of the adjoining sinuses and cellular cavities, which undoubtedly frequently occurs, though not necessarily. Practically, the term is applied to those cases of intranasal disease which give rise to fetor of breath rather than any one distinctive pathological condition.

In every such case careful rhinoscopy should be practised, the **treatment** depending upon the condition found. In most cases before such examination can be satisfactory nasal douches must be repeatedly given, and crusts and hardened masses washed away by means of a spray with a compressed-air force of from ten to fifteen pounds. Not until the nasal cavity has thus been thoroughly cleansed and the immediate congestion caused by this interference subdued, either by waiting a little or by the application of a very weak solution of cocaïne, can an exact estimation of the condition be made. In ulcerative forms small, ragged, more or less unhealthy ulcers may be found in almost any part of the cavities, though these occur more commonly in parts most easy of examination. More than this, it often happens that small or relatively large areas of spongy bone will be found necrosed and loose or easy of detachment, or that a necrosed area of cartilaginous or bony septum will be discovered. Patients will sometimes present small portions of bone which have been expelled spontaneously, which will be very suggestive.

Ulcerations in the nose which produce this condition may be of the following varieties: 1, simple, which may have been originally of traumatic origin, due to the finger-nail of the individual, to the presence of some foreign body, or to the effect of some caustic previously applied; 2, tubercular, in which case the general condition of the patient will be extremely significant; 3, syphilitic, where there are almost sure to be other evidences of secondary or tertiary disease, the examiner having probably to look no farther than the mouth of the patient in order to corroborate his diagnosis.

In all these forms of ulceration diseased or dead bone may occur, but this is relatively infrequent in the first. The entire turbinated body, or one or more of the turbinated bones, along with the septum, may be thus destroyed, and even exfoliated externally, and many a sunken bridge of the nose is evidence of the destruction which has gone on beneath, due for the most part to the ravages of tertiary syphilis.

The **treatment** of this variety of ozena consists in the main of removal

of diseased bone, cauterization of the ulcer proper and its conversion into healthy granulating tissue, and such measures as may be appropriately directed toward cleanliness and antisepsis. If necessary, operation may be undertaken, with cocaïne or general anesthesia, for removal of sequestra. During the treatment the general condition of the patient should not be neglected, and in syphilitic cases a vigorous antispecific and tonic treatment will effect almost as much benefit as do the measures instituted locally.

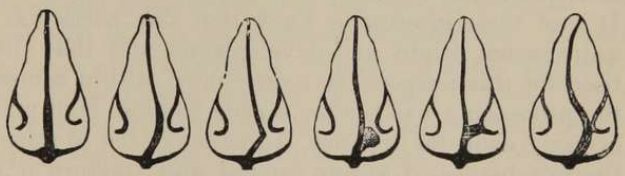
In that form of ozena due to atrophic rhinitis there is frequently necessity for general and constitutional treatment, while the local treatment is directed first toward cleanliness and freedom from the presence of decomposing crusts, and secondly toward gentle stimulation of the mucous membrane in order to favor healthy secretion. The powders or sprays that are used for this purpose contain substances which are mildly stimulating, such as preparations of benzoin.

Perforating Ulcer of the Septum.—Under this name there has recently been described an ulcerative process occurring usually along the border of the cartilaginous septum, which determines later its perforation, and presents characteristics which apparently entitle it to separate description, inasmuch as it is independent of syphilis, tuberculosis, or lupus. The ulcer is round or oval, and when oval has its long diameter placed antero-posteriorly. The mucous membrane appears to be first affected. Local destruction advances more and more deeply; finally the ulceration thus formed usually tends to general cicatrization about its borders. It appears to attack old men oftener than others. Histologically, the lesion seems to consist of an infiltration with epithelial cells, as well as their subsequent multiplication.

Concerning its intimate cause we are yet ignorant. In some respects it seems to correspond to perforating ulcer of the foot. It calls for little save antiseptic treatment.

Deviation of the Septum.—Deviations of the nasal septum are very common (Fig. 236), and constitute the most important abnormalities of the nose. Mackenzie, for instance, in examining 2152 individuals, found deviation in 77 per cent., and of a total of 3446 cases examined by several observers there was deviation in about 60 per cent.

Fig. 236.



Varieties of Deflection of the Nasal Septum (Roberts).

Deviation toward the left appears to be more common than toward the right. It varies in amount and character from a simple warping of the septal plate to complete displacement. The causes of the deviation are by no means clear. In the infant the nasal fossæ are small and simple in conformation. The sinuses are not yet formed, and the plates of the ethmoid are still cartilaginous. The cribriform plate is even membranous and continuous with the falx cerebri and the dura mater, and is thus flexible at a time when the vomer is already ossified. At the age of two the frontal and ethmoidal sinuses, as well as the antrum, have begun to form. The development of the turbinated bone is also tardy, and relative activity of growth of these parts is a somewhat late manifestation. The posterior or free boundary of the vomer is seldom misshapen, since it is thick and strong, but its anterior portion is very liable to displacement, of which traumatism is a frequent cause. Thus it appears that the vomer, occupying the middle of a cavity with walls more rigid than itself, frequently

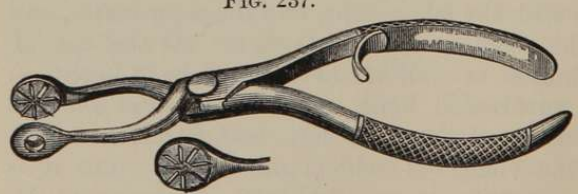
bends in the direction of least resistance, owing to injury or to unequal development of surrounding parts. Deflections of the cartilaginous sections are most common, next those of the bony parts, and finally those of the entire septum. The cartilage may be bent upon itself vertically or horizontally, presenting along the line of deflection a bulging sufficiently prominent to occlude the nares. Horizontal bending is much more common. The deep concavity of the opposite nostril often corresponds with the convexity of the bend. It may cause serious obstruction to the respiration. When the warping is but slight it ordinarily gives rise to no symptoms and calls for no interference. It not unfrequently happens that we have to deal with an enlargement of the middle turbinated bone corresponding with the deflection of the septum, and secondarily with a greater obstruction.

Another form of deformity of the septum is caused by development, near the sutural line of the vomer and the palatal process, of a bony or cartilaginous ridge which constitutes a spur, as it is usually called, and which is in fact an exostosis or ecchondrosis, and may extend horizontally for some distance. It may be met with on one or both sides; it helps to obstruct the inferior meatus, always leads to thickening of the overlying mucous membrane, and should always be removed when met with. When the septum exhibits a double curve, being warped first to one side and then to the other, it is described as representing a sigmoid flexion. This may meet and touch the inferior turbinated on one side and the middle turbinated on the other.

As might naturally be supposed, when the septum is markedly deflected we frequently find the hard palate to be very high-arched or Gothic in contour. Its transverse diameter is short, and the alveolar arch may be much more oval or relatively smaller, by which the front teeth are thrown forward and a characteristic expression given to the face. Delavan calls attention to the fact that this condition is frequently associated with the habit of mouth-breathing, and that it is often a family peculiarity.

Treatment of Deviated Septum.—For the rectification of this deformity a large variety of operative methods have been suggested, depending in their conception and for their successful performance upon the degree of deflection. It is of some interest to know that this particular branch of surgery is one of quite recent origin and development, and that almost all the operations practised for this purpose have originated within comparatively few years, although the proceeding itself, after a rude fashion, is of great antiquity. By a few surgeons, Adams for instance, it was suggested to seize the crooked septum between the two blades of strong forceps and fracture it sufficiently to allow of restoration to its normal outline. To keep it in the desired position head-bands with pads and screws, or masks with adjustable pads, or intranasal apparatus of more or less elaborate form, were called into requisition. Then it was suggested to cut out of the septum, with a punch (Fig. 237) fashioned after a conductor's punch, smaller or larger pieces of shape according to the fancy of the operator, by which the septum would be so weakened as to be easy of replacement. This method is open to the objection of leaving an opening where nature did not intend one to exist, and furthermore leaves the septum so weakened as sometimes to lead to subsequent falling in of the bridge of the nose. A much more successful

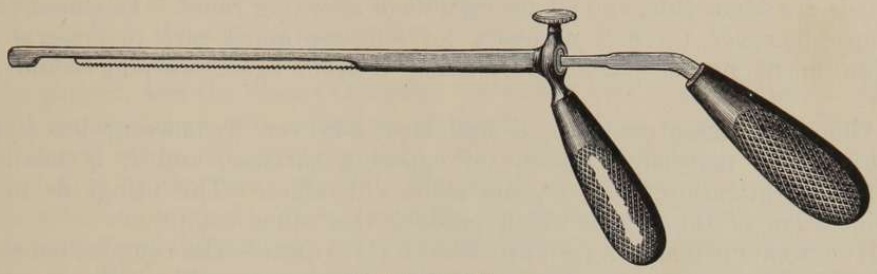
Fig. 237.



Jarvis's Punch.

application of this form of instrument is that by which a stellate incision is made in the septum, yet without removal of any of it. This so weakens it that it can be sprung back into position, and yet leaves no perforation; but this, like all other procedures where nothing is removed, requires the subsequent use for a considerable length of time of plugs by which the partition shall be held in place until its tendency to warp is overcome. The same objection of leaving a perforation often obtains against the use of the nasal saw (Fig. 238), which

FIG. 238.

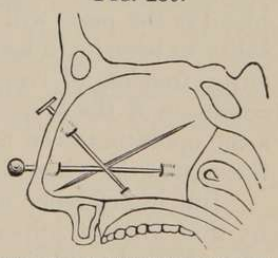


Park's Nasal Saw.

otherwise is a very useful instrument. Its especial range of usefulness is in the removal of outgrowths from the turbinated bones or of spurs or bridges from the septum. It will be spoken of again later. A very simple method for uncomplicated cases is that of incision through the protuberance along its long axis, after which the septum is forcibly replaced by means of the finger in the nostril. Its elasticity being thus temporarily overcome, it is held in place by packing the previously obstructed nostril with plugs of antiseptic gauze or of rubber or other suitable material. These are removed daily, and the parts carefully cleansed, after which the plugs are replaced. If necessary, any redundant portion can be pared with a knife or removed with a saw.

Ingals has modified this plan by incisions through the mucous membrane, its detachment from the underlying cartilage, and the removal of a triangular portion of the latter, the base of the triangle being at the floor of the nose. Of course the membrane on each side of this piece should be detached. Roberts has devised an ingenious and very effective way of overcoming septal deformity. If there is angular deflection, he makes an incision from front to back; if the deflection is a grooved one, he splits the cartilage along the most prominent portion, and cuts into the rest of the septum repeatedly until it has lost its resiliency. Any small portions that protrude at the lower margin are removed with knife or saw. If only small fragments of the entire thickness are cut away, the little perforations thus caused subsequently heal. The septum is now held in place by steel pins made for the purpose, which may be inserted through the nostril or from the outside (Fig. 239). The point is thrust through the inferior portion of the septum, which is then placed in the desired position, after which the pin is thrust still farther onward and its point buried deeply in the firm and untouched tissues at the back part of the nasal chamber. Two or more pins may be used for this purpose; they should be left a few days *in sitû*. By this method the use of plugs is avoided, and antiseptic douches, powders, or sprays can be used as frequently as desired. When ridges or projections of mucous

FIG. 239.



Pins inserted for Deviation of Septum in Roberts's method of operation.

membrane are the cause of the obstruction, or even when this is composed of soft cartilage, Jarvis recommends to transfix them with a needle and then remove them with his steel wire snare.

Besides the methods thus briefly described (for more information concerning which the reader is referred to special text-books), it has been proposed to remove the offending cartilage or bone by rapidly revolving burrs or trephines operated by the dental engine, by hand power, or by small electric motors, or to attack them with fine chisels and gouges, the force being applied either with the hand or with a small mallet. When properly performed, any or all of these methods are admissible, and all are capable of affording relief. In almost every instance, however, there is necessity for long-continued care to preserve the septum in its proper place and prevent it from again warping while still weak.

Almost all these cases are complicated, however, by more or less hypertrophy of the mucous membrane of opposing surfaces, and it is relatively seldom that attention to the septum alone will suffice. This brings us to the consideration of the causes which produce this other condition.

Hypertrophic and Atrophic Nasal Catarrh.—The complicated structure and character of the Schneiderian membrane, as well as the fact that, especially in its lower portions, it is studded with large numbers of minute glands whose function it is to secrete the nasal mucus, must not be overlooked in accounting for this condition. These, being true glands, partake of the usual adenoid-tissue arrangement. Evidently, then, irritations which affect the membrane will also involve the glands, and the hypertrophy of one without a corresponding affection of the other is out of the question. This membrane is more exposed to external influences than any other. Thus it happens that repeated attacks of acute inflammation or the continuous action of relatively trifling irritations lead to, first, a chronic congestion, and second, tissue new-formation. This process, once begun, rapidly increases in extent and severity. The new growth is very likely to occur along that inferior turbinated bone which comes most closely in contact with a deviated and protruding septum, and, as a rule, the structures over the lower turbinated bone are much more commonly and extensively involved than those over the other bones. This diseased tissue is usually more or less spongy or erectile in character, and is composed of such a mixture of glandular and parenchymatous elements as to be commonly termed *adenoid*, the one form or the other predominating according to the type of the structure first attacked. Hypertrophy of the mucous membrane over the posterior portions of these turbinated bones is more frequent than of that over the anterior portions. The stenosis caused by these conditions may be partial or complete and temporary or permanent. Many individuals have just so much thickening as to suffer from alternate stoppage and patency of the nostrils according to the condition of the weather and their freedom from congestions due to colds. Anything which favors flow of blood to the parts will occasion stoppage. Hence some persons complain of inability to breathe in bed through that side of the nose which is lowermost. Others enjoy freedom of respiration in dry weather, while because of the hygrometric condition of the atmosphere they suffer inconvenience during damp weather, and some operators even take advantage of this latter circumstance in order to seize these growths when their increased size makes them easier to attack.

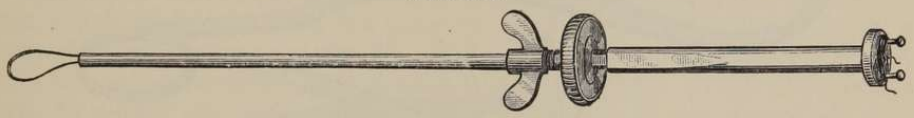
But interference with respiration is by no means the only trouble produced by this kind of hypertrophy. When the stenosis is posterior, and especially when the adenoid tissue of the naso-pharynx is involved, pressure is made upon the orifice of the Eustachian tube, with the result of more or less impairment

of hearing. It is very important to bear this in mind, since not a few cases of deafness in one ear, or in both ears, depend primarily not upon disturbance in the middle ear, but upon this condition of the naso-pharynx. Therefore in treating patients for deafness an examination of the throat and nose is as essential as an examination of the membrana tympani.

After having made a careful examination and having recognized, so far as possible, the condition above described, there is considerable range of choice as to methods for obviating the difficulty, the choice being mainly between the radical method of extirpation of the obstructing mass and that of its partial destruction by caustics or the actual cautery, trusting to the resulting cicatricial contraction to produce the desired diminution in size. The choice must be governed to a certain extent by the occupation and the personal and constitutional habits of the patient, and the means at hand. In either case local anesthesia can be usually accomplished with solutions of cocaïne varying in strength from 2 to 8 per cent., using the stronger only when the weaker fail. These may be applied first by the spray, then by contact of small plugs of cotton saturated in the solution, or rarely, when necessary, by its injection into the tissues with the fine needle of the ordinary hypodermatic syringe. The operator must always expect the deeply colored and turgid appearance of these growths to be modified by the constringing effect of the cocaïne. Small crushing forceps and scissors have been devised with which those parts of the nasal cavity most subject to this condition can be reached, and the hypertrophy when distinct or pedunculated can sometimes be most easily removed by their aid.

But some form of wire snare or écraseur is perhaps the favorite instrument for this purpose, and of the various forms of this instrument none, at least in this country, is more popular than that suggested by Jarvis (Fig. 240).

Fig. 240.



Jarvis's Snare.

Its wire loop is passed within the nose, and by the aid of artificial illumination is lodged around the base of the mass which it is proposed to remove, after which the loop is slowly tightened, and the fine wire cuts its way through the tissue so slowly that, vessels being crushed across, the operation is almost bloodless. In the attack upon posterior hypertrophies the manipulation is sometimes quite difficult and requires the skill of an expert. It is made more difficult by the sensibility of the part and by the reflex motions of the palate and pharynx, which are usually beyond the possibility of voluntary control. These are in some measure obviated by the use of palate retractors, or by the introduction of tapes through the nostrils into the pharynx and bringing them out through the mouth and tying them in front of the upper lip. By their aid not only is the palate retracted and its movements controlled, but illumination of the parts is also possible. These masses are sometimes removed with a peculiar burr attached to some revolving mechanism, by which removal is made as effective, though much more bloody.

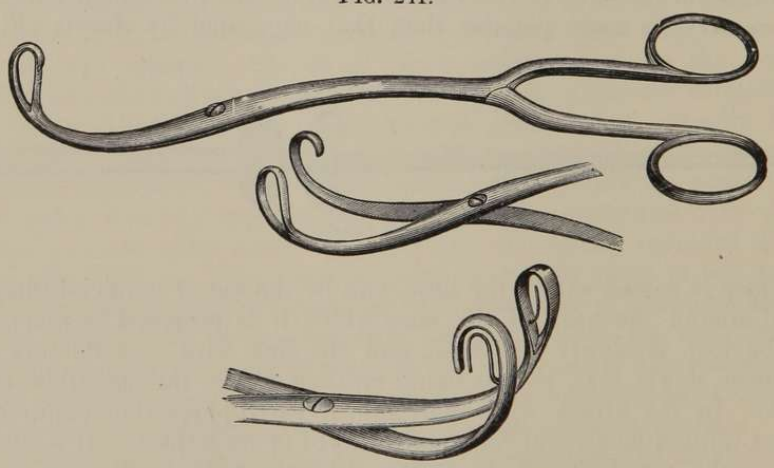
The other method of treatment, by the use of caustics, avoids some of the unpleasantness of an operation, but usually produces much more pain and discomfort, while snaring off a mass of adenoid tissue with the wire loop causes frequently very little pain.

An even more effective and commonly less painful method, certainly one which leaves fewer unpleasant immediate consequences, is the use of the galvano-cautery: the parts being prepared as above, the galvano-caustic knife or point is applied as was the caustic, and is made to burn more or less deeply and widely according to the effect desired. The resulting sloughs separate in about the same length of time, and the after-treatment in each instance consists mainly in local cleanliness and antisepsis. The final benefit may not be obtained until after the lapse of a number of weeks. This latter procedure of course implies the possession of a suitable cautery or storage battery and the necessary electrodes or cautery points, all of which are expensive. But when it is applied with skill the result is usually very satisfactory.

A collection of adenoid tissue seldom exceeding 7 or 8 mm. in diameter has been described by Luschka as the pharyngeal tonsil. This is found at the vault of the pharynx, and may become enlarged under the same conditions as those which give rise to hypertrophy or as those which produce adenoid tissue in the nose.

The *pharyngeal tonsil* is itself of interest, since along with another collection of similar tissue spread out at the base of the tongue it constitutes what has been called the ring of adenoid tissue around the pharynx, the principal portions of this ring being of course formed by the faucial tonsils. When this tissue in the pharynx is involved in hypertrophic changes, it must be removed, either with spoons fashioned for the purpose or with cutting forceps with somewhat dulled edges (Fig. 241). When diseased it may

FIG. 241.



Raynor's Naso-pharyngeal Scissors.

produce various reflex disturbances of about the same character as those mentioned under Neuroses of the Nose.

The Lingual Tonsil.—Completing the circle of glandular tissue around the oro-pharynx there is more or less of lymphoid and adenoid structure across the base of the tongue, which, described together, has been known as "the lingual tonsil." The principal difference between it and the faucial is that the adenoid tissue here is disseminated in small groups over a considerable surface. There are here no glands, properly speaking, nor excretory ducts nor outlets, but small enclosures, three or four lines in diameter, of adenoid material covered by mucous membrane. These follicles much resemble Peyer's patches in the intestines. They exist in the normal condition,

but they become much hypertrophied, and of about the size attained by lesions of adenoid tissue in the other parts of the pharynx. They are located between the circumvallate papillæ and the epiglottis, and are inconspicuous except when enlarged.

Normally, there is a free interval between the base of the tongue and the epiglottis, but this is more or less encroached upon when this tissue is hypertrophied, and sometimes the tip of the epiglottis may seem almost buried in a mass of tonsillar structure. This hypertrophy may even extend laterally to a considerable extent. When carefully viewed these masses will be seen to form an aggregation whose component parts may be distinctly distinguished. When these tissues are hypertrophied, there is sometimes complaint of pain shooting up toward the ears, or there may be reflex discomfort in the larynx or along the course of the pneumogastrics; and when inflammation complicates the hypertrophy there may be actual sharp pain. The voice is more or less altered, and fatigue in speaking and singing is a common symptom. In certain cases the voice is made uncertain and unreliable. Most patients suffer from more or less reflex cough, either violent, spasmodic, or incessant, or else of a hacking character. Part of this cough is due to friction between the tongue and the glottis. It is quite likely that the so-called "globus hystericus" is in many instances a sign of value, and due to the presence of enlargements of this lymphoid tissue. Dyspnea and even asthma may occur in patients with enlarged lingual tonsils. The only radical treatment consists in the removal of the hypertrophies by caustics or mechanical measures. The latter will consist either of the wire snare or of the sharp spoon in some of its modifications. The galvano-cautery is often resorted to, and is probably the most satisfactory method of treatment. These operations can usually be made by aid of cocaïne without pain.

Atrophic Catarrh.—This is to a large degree a result of the previous form, which when untreated has gone on to such complete formation of new connective-tissue elements that the glandular portion has disappeared. The result is now not so much the impediment to respiration as the dryness of the parts, by which the patient's comfort in breathing is very materially diminished, and he has probably by this time, if not before, become changed from a nose-breather into a mouth-breather. Still, with all this, there may be such relics of previous hypertrophic obstruction as to call for purely surgical relief by one or another of the methods above described. This form of disease is likely to be more offensive than the previous, since the dried and thickened mucous membrane is covered with crusts of desiccated secretion, which may be more or less advanced in decomposition or which may cover over actual ulceration in the tissues beneath. In this way we may have to deal with a combination of atrophic catarrh and ozena. On account of the length of time required to bring about this condition these cases pursue a very stubborn and chronic course. Their treatment is, first, local cleanliness; second, the removal of any actual obstruction; third, applications to whatever ulceration may exist; and finally, the endeavor to stimulate the long-disused remaining glands into greater activity; in other words, the restoration of the natural secretion. This is to be accomplished mainly by stimulating and antiseptic sprays or other applications, fluid or dry. It will require daily attention at least by the patient himself, and often by the surgeon, and is a process so slow as often to lead to discouragement and disappointment. Nevertheless, if carefully persisted in, it may be productive of great good, if not of complete restoration of the normal condition.

NASAL CATARRH.

Besides the acute and chronic forms of inflammation of the Schneiderian membrane already referred to under the headings of Coryza and Adenoid Thickening, there is another form of chronic inflammation which is as common perhaps as any, and which deserves consideration by itself under the term of chronic catarrhal inflammation. This may begin almost as a chronic condition, or may be secondary to acute inflammations. As a rule, the more chronic the condition the more it involves the posterior nasal surfaces along with those of the pharynx, and we have practically to deal with a retro-nasal or naso-pharyngeal catarrh. Narrowness of conformation may exert some predisposing influence. Nevertheless, the condition prevails in all countries and climates; but it appears to be most frequent where atmospheric changes are most sudden. For the treatment of this condition, which is in the main medical, the reader is referred to special text-books.

ULCERS.

Ulcers and ulcerations within the nasal cavities may be of the following types: 1. Catarrhal; 2. Tubercular (and Lupous); 3. Syphilitic; 4. Leprous; 5. Malignant. It seems hardly necessary here to go into a description of each of these forms. Their nasal characteristics in no wise differ from those which the same forms of lesion display elsewhere. Among the first must be reckoned the kind of ulceration which one may see where two surfaces which were not intended to touch each other have come into contact, or which the surface of a nasal polypus, for instance, may exhibit. Tubercular ulceration of anything like long duration will probably be accompanied by caries or necrosis of the underlying bone. The same is true of the syphilitic form. Leprous ulceration cannot be considered apart from general leprous disease, nor can it so occur. Malignant ulcers are simply expressions of degeneration of malignant neoplasms, and, while they may be regarded as among their disagreeable phases, the ulcer itself is of little consequence as compared with the primary disease, unless it produce frequent hemorrhages.

In the above statement no note is made of two or three other specific varieties of ulcerations which may occur in the nose, such as those accompanying glanders, actinomycosis, etc. These are so rare in this country as to deserve only mention.

The treatment of each of these forms must be obvious. The catarrhal ulcer needs only cleanliness, freedom from irritation, and proper restoration to a condition of healthy granulation, in order rapidly to heal. The tubercular form may require removal of diseased bone, and certainly should be thoroughly cauterized or scraped, after which it can be coaxed to heal by simple measures, unless the systemic infection be too pronounced. The treatment of the syphilitic form is inseparable from that of constitutional syphilis, and calls for anti-specific medication. When one has to deal with a malignant ulcer in these parts, the question is in the main whether the primary disease can be removed by operation, no matter how severe, or not. If it appear that it can be, no time should be lost in practising it. If, on the other hand, the case appear inoperable, much may be done by repeated curetting, or destruction of neoplastic tissue with the actual cautery, or its removal, or at least the removal of so much of it as is accessible, with the scissors, knife, or snare. In this way, without thought of radical cure, life may frequently be prolonged or made less offensive both to the patient and to those around him.

EPISTAXIS.

The term epistaxis originally denoted bleeding from any point about the nose, but is now generally limited so as to mean hemorrhages from the nasal and connecting cavities. It may occur either as the result of trifling or severe injury or spontaneously, and it may be active or passive. No mucous membrane in the body is so naturally disposed to bleed both by liability to insult and by character of construction as that which lines the nose. Hyperemia is very easily produced, and the blood-vessels of the part have little or no natural support outside of their own walls. The traumatic form follows various injuries, not necessarily applied directly to the nose. Falls of all kinds will frequently produce it, and especially falls or blows upon the head. It is known to occur frequently in connection with fractures of the skull, especially of the base. It may occur from picking the nose or from rude introduction of something into the nostrils, and occasionally follows explosions of some violence; thus men handling heavy pieces of artillery, especially within small compartments, are frequently annoyed with it. When slight causes give rise to it, there is nearly always some local or constitutional predisposition, usually in the so-called full habit of body, or, in the aged, extreme fragility of vessels, or a more or less varicose condition of the parts, in those who have this condition elsewhere. The so-called spontaneous form may arise from inhalation of irritating vapors; from over-filling of the capillaries, due to violent over-action of the heart or to too severe exercise; from some act like coughing or sneezing; from previous ulceration; from the presence of foreign bodies or parasites; or from the presence of tumors; in fact, from anything which tends to produce a filling of arteries and obstruction to venous return. It is common in plethoric children and adults. It is frequently the precursor of apoplectic lesions in the brain and eye. It occurs often in passage from dense to rarefied air or the reverse, as in balloonists or those working in caissons. In such cases, in fact, it is to be regarded as an apoplexy of the Schneiderian membrane. It is a symptom of several acute diseases, for instance of typhoid, and accompanies scurvy, purpura, chlorosis, etc.

It may be of a vicarious character, and may then occur from suppression of menses, urine, or perspiration, or even of hemorrhages from varicose veins or malignant tumors. Children approaching the age of puberty seem to be liable to it, and some pregnant women frequently suffer from it. Extremes of heat and cold upon the surface seem often to favor it, and psychical impressions are occasionally sufficient to excite it. In degree and extent it may vary from the escape of a few drops of blood to a hemorrhage so violent as to endanger life or even terminate it. It usually comes from one nostril, sometimes from both, and may escape through the naso-pharynx into the mouth, whence it may be expectorated or swallowed. The presence of blood which has thus entered the stomach may excite the act of vomiting, by which still further hemorrhage may be favored. As a rule, it escapes from some point in the anterior nares, perhaps more often upon the septum than elsewhere.

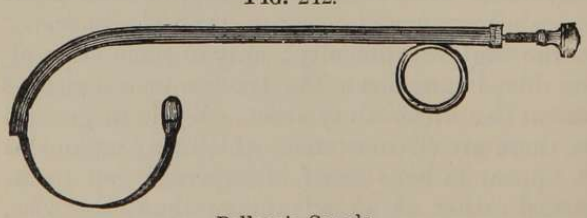
The **diagnosis** seldom offers the slightest difficulty; only in some cases of grave constitutional disease where blood runs down the trachea or œsophagus without the knowledge of the patient can uncertainty arise. While in general epistaxis is to be checked at once, there are circumstances which may make this inadvisable. If, for instance, it appear to be a relief of supercharged intracranial vessels, it should be regarded rather as an advantage than otherwise, and checked only in case it become excessive. Many congestions of the brain and important parts within the skull have been relieved by this spontaneous

venesection. But, as a rule, it is something which should be checked as soon as practicable, especially if collapse threaten.

Treatment.—To begin with, if possible, the cause should be ascertained and removed. Removal, however, is seldom practicable, and treatment must depend upon the exigencies of the case. First of all, position and rest should be attended to. Naturally the higher the head the better, and patients should not be allowed to lie down unless they be very weak. All pressure of clothing about the neck and thorax should be removed, and patients should be cautioned against coughing and sneezing, as also particularly against constant efforts to blow the nose and thus expel the blood, since by this act the formation of a clot is prevented. It has been found that extension and elevation of the arms above the head produce, by reflex vaso-motor mechanism, contraction of the nasal vessels, as does also sometimes pressure at the root of the nose or about the nasal region of the face, and these measures are to be recommended as worthy of trial. Pressure against the bone upon either side of the ala nasi will often check epistaxis occurring from the anterior portion of the nose, as the lateral nasal vessels supply the mucous membrane of this portion of the nasal cavities. Pressure upon the carotid would also be indicated were it not that the jugular vein is obstructed at the same time. The application of cold to the back of the neck, ice-water enemata, and similar measures may also produce reflex vascular spasm within the nose. If these measures be found inefficient, astringents may be employed by the nasal douche, such as ice-water or water as hot as can be borne, or solutions of alum, tannin, etc. The stronger the astringent, however, the more disagreeable the general effect, and if the bleeding point can be localized it will be much better to apply some dry astringent directly to the part. It has been a common practice to employ tents within the nostrils or to pack the anterior naris with some material like cobweb, which not only acts as a styptic, but also serves to entangle the blood and favor coagulation. For cases of moderate severity or for hemorrhage following ordinary intranasal operations the writer has found a solution of antipyrine, of 5 to 10 per cent. strength, the most serviceable and the least disagreeable. Its effect upon the blood-vessels is like that of cocaïne, only more lasting, and it makes a very serviceable styptic for general surgical purposes, since to its astringent properties is added that of being antiseptic.

When hemorrhage is alarming, however, it is better not to waste time with measures of the above character, but to proceed at once to plugging the nasal passages. If the hemorrhage be anterior, the introduction of tampons through the nostril may be quite sufficient. A series of these should be tied to a single piece of stout silk, by means of which all are under control. If, however, this be not enough, the posterior naris may be occluded by a very simple procedure which gives rise to no particular pain. The most serviceable instrument for this purpose is the little canula devised by Bellocq (Fig. 242); but in the absence of this an ordinary silk catheter may be armed with a piece of stout silk or twine by threading one end of a piece, 15 inches long, through its eye. This catheter is now passed in along the floor of the nose until it is deflected downward by the posterior wall of the pharynx. So soon as its point is seen behind the uvula the silk thread may be caught with

Fig. 242.



Bellocq's Canula.

a tenaculum or forceps and drawn out through the mouth, while the catheter is withdrawn from the nose. One end of the thread is now hanging from the nostril, the other from the mouth. The middle of the latter is firmly tied around a pledget of cotton or of sponge, which is then drawn backward and upward by pulling on that portion which hangs from the nose, guiding the tampon with the index finger of the other hand over the tongue into the pharynx and then up and behind the soft palate. It is an advantage if the portion which still hangs out from the mouth have been left so long that, a day or two later, when it is desired to remove the tampon, this may be done by pulling downward again by means of this portion rather than having to dislodge the plug with curved forceps in the pharynx or to push it backward by something introduced again within the nose. If this end be left long enough for this purpose, it may be brought out of the mouth and knotted to the other end, so that by means of this continuous loop perfect control of the tampon is afforded. After plugging the nostril posteriorly, anterior plugs may be inserted in case the other be found insufficient. This method is usually very effective, and if the plugs be not left so long in place that decomposition takes place, it is quite safe. Posterior plugging without means of control by attached threads is by no means free from danger, since death by suffocation during sleep has been known to occur from its spontaneous dislodgment. Such a plug should never be left in place for more than two days. If there be necessity for longer protection it should be renewed. Plugs inserted through the nostril should be tied successively to a single piece of stout silk, so that later they may be easily dislodged and withdrawn by pulling gently upon its anterior end.

FOREIGN BODIES.

The ears and nose alike are exposed to the introduction of foreign bodies either by accident or by design. This occurs naturally most frequently in children who have not yet reached the age of reason. A list of possible foreign substances would include almost everything of size not too large to enter the nostril, and no attempt need be made to catalogue them. Introduced nearly always from without, it may be possible for them to enter from the naso-pharynx, as when a substance is taken into the mouth and almost swallowed, being finally expelled, not into the mouth again, but upward into the posterior nares. These substances are by no means necessarily always inert, since insects not infrequently effect an entrance into the nostrils. A small particle is usually expelled by a reflex act as soon as introduced, but if it remain long it may gather about it sufficient tenacious mucus to retain it in place or even enable it to resist expulsion. On the other hand, a mass which is large enough to be introduced with some difficulty or one which by imbibition of moisture may expand may give rise to a great deal of trouble in its removal.

The signs and symptoms of foreign bodies in the nose are usually unmistakable. Little children will sometimes not give evidence of their presence until decomposition or bleeding or profuse discharge attracts attention.

Treatment.—When the foreign mass is visible with ordinary artificial illumination, it can usually be grasped with forceps and removed or be dragged out after the insertion of a small hook or tenaculum point, and ordinarily there is nothing difficult about this manœuver; but young children are frequently so uncontrollable that the assistance of an anesthetic is necessary, and the surgeon can accomplish in a few seconds by the aid of chloroform that which would require a long struggle without it. At times when the mass is

located too far back within the inferior meatus for easy withdrawal it will be found much easier to pass in some simple instrument and push it backward so that it shall drop into the naso-pharynx, whence it should be removed by the surgeon himself in order to avoid further complications. Sometimes sudden forcible blowing into the other nostril by means of a tube over the end of which the nostril is closed will expel the foreign body. Only when some simple procedure of this kind fails—and this will be very rarely—will anything in the nature of an operation be required. If it be a piece of metal or something rigid which has been already lodged in a position not permitting withdrawal, then it may be necessary to cut away some portion of the turbinated bone or make some atypical operation according to the exigencies of the case.

RHINOLITHS.

These are calculi or calculous concretions varying in size from 1 mm. to 2 or 3 cm., which are formed, much as are those in the bladder, by the deposition of alkaline salts, mainly phosphates, around a foreign particle within the nasal passages. This foreign particle may be a small mass of desiccated mucus. They are usually unilateral, and commonly lie against the septum or within the inferior or the middle meatus. The general congestion or inflammatory changes around them may give rise to symptoms already described.

When the rhinolith, as such, produces **symptoms,** they are much like those produced by any other foreign body. Nasal discharge and obstruction to respiration, with accompanying alteration in tone and voice, and perhaps anosmia (loss of smell), will be the most common results. If any portion of such a concretion presents to the view, it will probably be discolored and perhaps almost black, appearing much as necrosed bone in the same location often does, and may be mistaken for it. Furthermore, its gritty surface may increase the liability to error; but it is very seldom that diseased bone alone will give rise to so much fetor as accompanies an aggravated form of rhinolith. Careful examination of the nasal cavities after approved methods will enable a diagnosis to be made, after which it will probably be an easy task with suitable dressing forceps or a small spoon to dislodge and remove the concretion. If necessary, and if no tissue around it calls for removal, the rhinolith may be broken into pieces, being usually very friable, and removed piecemeal.

PARASITES.

The parasites which infect the nasal passages are mainly insects and worms. In this country they are very rare. In the tropics such cases are frequent, and sometimes of serious character. Danger comes not so much from the adult insect as from the larvæ which it may deposit, and which may be aspirated into the deeper cavities with inspiratory movements. Almost the only parasite found in this country in the nose is the maggot. In certain catarrhal and ozenous affections there is sometimes such fetor of discharge as to attract flies, which penetrate the nasal cavity during sleep, deposit eggs there, and leave them to be hatched as maggots, their incubation being favored by surrounding warmth and moisture. By any of these larvæ the mucous membrane may be destroyed, and the cartilage and the bones become necrosed.

The principal symptom is an itching in the nose which sometimes becomes intense, with various ill-defined but well-located disagreeable sensations, which in nervous and susceptible children may precipitate convulsive attacks. Almost always there will be reflex headache, especially in the frontal region. Hemor-

rhages may occur there purely as the result of ulceration or of violent expulsive efforts. Sometimes a cellulitis of the nasal region of the face may be set up, and swelling may be so severe as nearly to close the eyelids. In the tropics the condition may be fatal within a few hours, from local and general disturbance. Antiseptic douches and inhalations of chloroform vapor or of a solution of iodine in chloroform will be effective in destroying the parasites.

POLYPI AND TUMORS.

The principal neoplasms of the nasal cavities are myxomata and myxo-fibromata, which usually occur in polypoid form, vascular tumors, adenomata, exostoses and osteomata, enchondromata, and the malignant tumors, including various forms of sarcomata and carcinomata. Of these the **polypi,** which are usually nearly pure forms of myxomata, are the most frequent. They are composed of very soft tissue of gelatinoid consistence, varying a little in firmness according to the amount of fibrous tissue which they contain. They are usually pyriform in shape and pedunculated, of a pale flesh tint, almost translucent, varying in size from that of a pea to that of an almond, and annoy mainly from the discomfort which they cause and their obstruction to respiration. The causes of nasal polypi are very obscure. Certainly it cannot be chronic inflammation alone, otherwise they would be met with in a large majority of individuals. Men are more liable to them than women, and children usually escape. They are met with sometimes singly; at other times they occur by dozens and form a cluster, several of which may perhaps be removed at one time. Some of these are throughout of the same consistence, others have a cystic interior; they are covered with epithelium, and have very few vessels, if any, and no nerves at all. The ordinary mucous polypi do not adhere to the bone. Those which spring from parts beneath the mucosa must be largely fibrous in their structure. If they grow rapidly they cause more disturbance than when of slow growth.

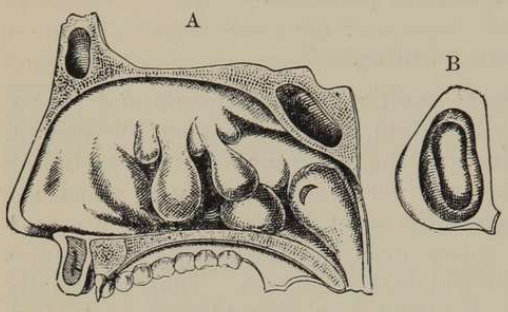
So far as their location is concerned, they grow most frequently from the middle turbinated body, next from the superior turbinated bone and meatus. They rarely spring from the lower turbinated bone and meatus; in other words, they will usually be found in the upper and more anterior portions of the nose. They almost never spring from the septum. While they may extend backward into the naso-pharynx or occasionally into the sphenoidal sinus, they never fully escape spontaneously from the nostrils. When of considerable size they may adhere at different points, so that the determination of their pedicle is difficult. It is stated that the pear-shape forms arise from sharp prominences, while those with broad bases arise from flat surfaces.

Symptoms.—These are at first insignificant and vague. The patient usually complains of copious secretion from the nostrils and of difficulty in breathing through one or both of the nares. Later comes complaint of some discomfort, and the patient will frequently snuff in the endeavor to free the nostrils from some obstruction. After a while the secretion becomes muco-purulent, with perhaps unpleasant odor, and the voice acquires a peculiar twang which is always indicative of nasal obstruction. Perhaps the occurrence of epistaxis may be the means of directing especial attention toward the nose. The symptoms are augmented by humidity of atmosphere, since mucous polypi are very hygrometric. Respiration may become audible, accompanied by a whistling sound. These signs and symptoms will vary, of course, with the extent of the disease. Aside from these purely local features, there occur more or less frequent reflex disturbances, among which should be mentioned asthma, cough—often distressing—hemicrania, facial and cranial neuralgia,

vertigo, and even epilepsy. When the nasal cavity is filled with polypi, the nose often becomes more prominent and distended (Fig. 243).

It is of course taken for granted that any complaint of nasal obstruction will lead to a careful examination of the nose. Nasal polypi can scarcely be taken for anything else save possibly adenoid and catarrhal hypertrophy of the mucous membrane. When cocaïne solutions are applied to the former, they are not at all affected, while the latter at once shrink and retract under their influence. It will be found also that a probe carefully manipulated may be passed under or around the ordinary polypus, so that it can perhaps be moved, or as it were swung, from its stem, while it may often be seen to sway or move in a current of expired air. Aside from the local reflex annoyance which it causes, the condition can scarcely be considered dangerous. There is a great liability to recurrence after removal, which is due undoubtedly to failure to make extirpation complete and to cauterize and destroy the surface or base from which each polyp has sprung. Moreover, when the condition is multiple, minute or incipient polypi may elude observation, develop later, and take the place of those which were removed. Furthermore, the very causes which operate in the first place to produce them may continue so to act.

Fig. 243.



A, Mucous Polypi in the Nose; B, anterior view of same, normal size (Sajous).

While polypi may be spontaneously expelled, their proper **treatment** is always surgical. Formerly the endeavor was made to inject into them some escharotic, such as acetic, chromic, or carbolic acid, or some powerful astringent; but safer and more dexterous manipulations have taken the place of these rude attempts, and measures for their removal now include avulsion, excision, and the galvano-cautery. By avulsion is meant the use of forceps of suitable device by which the polypus is seized as firmly as may be, and with as little force as is necessary twisted off from its base. If the operator know thoroughly his anatomy and can make out the exact location of the growth, he will work much less in the dark than according to the old-fashioned way of practically tearing away with the forceps whatever they may seize. This latter method is painful and bungling, and likely to produce copious bleeding, whereas the former is satisfactory so far as it goes. The naris should be illuminated, and when the polyp can be neatly grasped it is better to twist it off by revolving the instrument until it is dislodged than rudely to tear it away. In this as in the other operations cocaïne solutions give the greatest aid, not only by obtunding sensibility, but also by causing retraction of surrounding tissue and better exposure of the growths.

For excision or abscission a most serviceable instrument is that form of écraseur devised by Jarvis, by which pedunculated growths can be bloodlessly and almost painlessly removed (Fig. 240). Some dexterity and practice are necessary for its skilful manipulation, yet these may be easily acquired. The base of the growth is caught by the wire loop, and its size rapidly or slowly diminished according to the amount of discomfort caused. After removal of the polyp its base should be cauterized with some chemical caustic or the galvano-cautery. Of course both indications are carried out when the galvano-caustic loop is employed. The principal objection to this

method is the number of repetitions usually necessary to secure entire removal of myxomatous tissue. Almost always after thus operating some local treatment will be found necessary in order to overcome the condition of chronic hyperemia or inflammation consequent upon it.

Naso-pharyngeal Polyp.—A denser and more fibrous form of polypoid growth, composed of mixed mucous and fibroid tissue, occurs farther back in the nose, and occasionally polypoid tumors of nearly pure fibromatous character springing from the periosteum or the bone at the base of the skull or the adjoining facial bones will be found projecting into the pharynx. These become of more serious nature in proportion to the amount of fibrous tissue they contain, since the latter will prove a pretty accurate index of their vascularity.

When these spring from the septum or turbinated bones, they can usually be **removed** by the expert with the snare or the galvano-caustic loop, but a genuine fibroid growing from the base of the skull and projecting downward into the naso-pharyngeal cavity is an affair of a most serious nature. For the removal of such growths operations of the greatest magnitude have been undertaken, with varying success. The upper jaw of one side has been resected, or the roof of the mouth cut away, or both upper jaws so far loosened from their connections as to be temporarily depressed, an incision being made clear across the face, by means of which extensive operative procedure access has been gained to the naso-pharynx. Even after this has been done the removal of the growth is by no means an easy matter, and the writer has seen in one case a patient perish on the table from hemorrhage from one of these growths during such an operation, which even the skill of a celebrated surgeon could not check. Langenbeck's osteo-plastic resection of the upper jaw consists in an incision from the inner angle of the orbit to the malar bone, and a second from the nostril to the malar bone, joining the first. The soft parts are left adherent to the bone. The bone is then sawn through both incisions to the retro-maxillary fossa, which is exposed, when the bony flap thus made hinging on the central line of the nose is thrown over on the opposite cheek. This lays open the whole naso-pharyngeal cavity and retro-maxillary space. The parts are then returned to their normal position after removal of the tumor.

VASCULAR AND OTHER TUMORS.

Angeiomata in the nose are rare. They are to be sharply distinguished from a simple varicose condition of a limited area of mucous membrane, which is quite common. They occur mostly in males during adolescence. Of the symptoms, epistaxis is the most frequent and most prominent, the bleeding being most profuse and persistent.

Adenomata.—Enough has already been said to show that a multiple adenomatous affection of the mucous glands is very common, and such enlargements constitute the principal type of adenomata occurring in the nose. As a rule, they are inseparable from hyperplasia of the surrounding tissue. Transformation from adenoma into carcinoma, though infrequent, is well known to occur. When met with, the tumor must be removed after the approved fashion with the cold or hot wire loop.

Exostoses and Osteomata.—Outgrowths of bone which after a fashion simulate physiological or normal protrusions are to be considered as exostoses, while those which bear no such resemblance are termed osteomata. These are sometimes of cancellous bone, but more often of compact bony tissue. They are not common, are most often met with in the young, and at times may attain large size. The symptoms which usually attract attention are increased dis-

charge of mucus, hemorrhage, a feeling of obstruction and of discomfort or itching, sometimes severe neuralgic pain, and perhaps loss of smell. Proper examination will reveal the obstruction, and the probe or other instrument must be used in order to determine by its hardness and rigidity whether it be composed of soft tissue, cartilage, or bone. If of long duration there may be ulceration and even necrosis. If the latter have taken place there will be a fetid discharge which will certainly attract attention. In size and shape they vary very much. Fortunately, it is usually easy to separate them from the bone from which they spring. This removal may be effected with the wire loop, with stout scissors adapted to the purpose, or with one of the forms of intranasal saw. In a few instances when the growth was large and firm it has been found necessary to lay open the nose so as to expose well the nasal cavity of one side; but such operations are done much more often in Europe, since American ingenuity has devised the dental engine or its substitutes, by means of which a rapidly-revolving trephine or burr may be made to cut away even firm osseous tissue with little shock and with no necessity for external incisions.

Enchondromata.—These are much more rare than bony tumors, although an ecchondrosis corresponding exactly to the idea conveyed by the term exostosis is a very frequent occurrence in the nose, forming a cartilaginous spur or projection often seen on the septum. Their detection and removal in no wise differ from those of bony growths, and need no further description here.

Malignant Tumors.—Although the nose is frequently involved in cancerous growths, they are rarely of primary origin in this locality. Even with all the irritations to which the Schneiderian membrane is exposed, primary epithelioma is very uncommon. Sarcomata arise more frequently from the septum, while epitheliomata are perhaps equally common upon the septum and upon the turbinated bones. While thorough extirpation here as elsewhere is the only serviceable method of treatment, this may be done perhaps better by the actual cautery operated through the natural passages than with more formidable cutting operations. If complete destruction can be accomplished safely by some chemical means, such as lactic acid, there is no reason why it should not be as effective as removal by operation. In proportion as these growths affect the parts nearer the pharynx they become less accessible, more likely to infiltrate and affect the surrounding lymphatics, and both more difficult and more dangerous to attack by operation. Still, whatever good is to be accomplished in such cases must be achieved either by use of instruments or by the galvano-cautery.

AFFECTIONS OF THE SINUSES.

FRONTAL SINUSES.—**Injuries.**—These occur, as a rule, from direct violence upon the forehead, which may cause either simple, compound, or comminuted fracture of its walls. Simple fracture, with absence of cerebral symptoms, is common. It may be complicated by emphysema of the surrounding soft parts, which may occur through the escape of air from the nose. If there be depression of the outer table, it should be elevated to prevent deformity. Compound and comminuted fractures may be complicated by the lodgment of a foreign body. They are made more serious when the posterior wall is also broken and the dura exposed. Operative interference is always indicated in such a case. They are known to have been followed sometimes by fistulous openings through which air may pass, and plastic operations have been made for their closure.

Foreign Bodies are either introduced from above or make their way upward from the nose. The latter are usually insects which creep up and may either die there or deposit larvæ which hatch and live. It is said that centipedes have been found within the frontal sinus. These parasites, if they cause any trouble at all, will usually set up an acute inflammation which will terminate by abscess.

Inflammation.—This may be acute or chronic. When the latter, it is usually due to tuberculosis or syphilis. Inflammation may be the result of extension from the mucosa of the nose or from the surrounding bone. According to its intensity will be the severity of its symptoms, which consist in the main of pain and headache and a sense of weight and fulness in the forehead, with usually the symptoms of acute coryza. The local signs are swelling and tenderness, more or less fever, rigors, and even delirium in the most acute cases. When pus has formed and has escaped from the sinus proper into the cranial cavity, it may produce various pressure-signs. An erysipelatous blush of the overlying skin sometimes occurs. When the disease is of syphilitic origin there will be other signs of the constitutional condition. When of tubercular origin it will probably be accompanied by caries or necrosis of the enclosing bone, with other local manifestations.

A collection of pus in the frontal sinus is often spoken of as **empyema** of the same, which, if old, will have produced marked change in the external contour of this part of the face. The roof of the orbit is sometimes depressed, and even the globe of the eye altered in position. When long existent the bony wall may have so far disappeared by absorption as to yield a kind of parchment crepitation upon pressure, with fluctuation underneath. This purulent collection tends to evacuate itself spontaneously in the direction of least resistance, which may be either externally into the nose or orbit or internally into the ethmoid cells or the cranial cavity.

When signs of inflammation first present themselves here, leeching will often afford relief. This may be combined with whatever other treatment is suggested by the condition within the nose; but just so soon as signs of pus are present or of cerebral disturbance or any other serious condition, no time should be lost in perforating the external surface with a small trephine or other instrument and cleansing and draining the cavity. In spite of the resulting scar, it is wiser to do this by external incision rather than by operating through the nose, as many have done in time past.

Cystic Dilatation or **Dropsy of the Frontal Sinus** has been described by various writers, as well as hematomata and hydatid cysts. It is enough here to mention the possibility of their occurrence, referring the student to the larger treatises for their further description.

Tumors also occur within this sinus, both benign, like myxoma and fibroma, and malignant, such as sarcoma and scirrhus. If considered suitable to attack, they must be removed by external incision. The entire thickness of the frontal bone has been more than once removed in order to extirpate growths of this kind, and, providing the condition of the patient be at all favorable, no operation can expose to so much damage and danger as does such a tumor.

ETHMOIDAL CELLS.—The ethmoidal cells are liable to affection by direct extension from the Schneiderian membrane, by which they are occasionally involved in catarrhal thickening, polypoid growths, and even caries with perforation of the bones of the skull, according to Virchow. Diphtheritic disease has also extended as far as these cells, and it is stated that a frequent cause of ozena is to be found here.

SPHENOIDAL SINUS.—What has just been stated with reference to the

ethmoidal cells holds good also with reference to this sinus, but with this difference, that disease here is more favorably located for surgical relief. Escape of cerebro-spinal fluid has been observed after injuries of this sinus. Furthermore, by virtue of its intimate relation with the internal carotid and the cavernous sinus, injuries to these vessels have followed wounds to this bony cavity, and pulsating exophthalmos has been known thus to result. Caries and necrosis of the body of the sphenoid may produce lesions of the nerves above mentioned, separation of fragments of bone, hemorrhage which may be fatal, retro-pharyngeal abscess, thrombosis of the cavernous sinus, and perforation of the base of the skull. We may also have an empyema of this cavity from causes similar to those mentioned before, the signs and symptoms of which would include headache and spasmodic and sympathetic affections of the nerves in intimate relation with it; for example, photophobia and blepharospasm. The sinus has been operated upon in recent years by three different paths: through the naso-pharynx; through the orbit after enucleation of the eye; and by the nose, which seems to be the preferable route.

Tumors of the same character as those which involve the frontal sinus may also be met with here, although much less amenable to operative relief.

The Antrum of Highmore, or the Maxillary Sinus.—The outer wall of this cavity is quite exposed, and is liable to simple fracture by a blow, or to compound injury with perforation by a weapon or other foreign substance. The entire cavity is sometimes perforated by a foreign body, such as a bullet. When the outer wall is depressed by injury or comminuted, it may perhaps be elevated by instruments introduced directly or from within the mouth or nose. Swelling of the overlying soft parts, which may occur very frequently and very quickly, will sometimes mask a depression of the bone. Mistake can be best avoided by exploration with the finger in the mouth.

The antrum is sometimes filled with blood, either as the result of injury from without or as the result of epistaxis. Almost always after plugging the nose blood will force its way into the cavity. Ordinarily it will be easily and quickly resorbed, but decomposition may result and abscess ensue. Insects and foreign bodies may also exceptionally be found in it.

The most common affection of the antrum is **inflammation** with subsequent **abscess.** This may be the result of a propagation of the inflammatory lesion from the nose, or not infrequently of disease following up the roots of the teeth, which sometimes project a little distance into this cavity. As to the former, it may be said that the average size of the opening of the antrum into the middle meatus of the nose is 4 by 8 mm. A second opening rarely exists, and has been ascribed by Giraldès to a rarefying atrophy. When we remember the ease of communication from one cavity to the other, the wonder is that abscess does not occur much more frequently than is the case. Not a few cases have followed attacks of the grippe in which the nasal symptoms were especially severe. The presence of polypi appears to be sometimes the exciting cause. The second form appears to be an extension by an alveolar periostitis which is the result of dental caries; and a third form may arise from purely traumatic causes.

Whatever the cause, the symptoms are about the same, consisting of local pain radiating in various directions, especially toward the nose, swelling of the overlying soft parts, and thinning of the bone so that sometimes it gives rise to a parchment-like crepitation. If the nasal outlet be still patulous and pus be present in the antrum, it will be found that in certain positions of the head it will flow into the nose, passing either anteriorly or posteriorly. When this pathognomonic symptom is present the pus is very frequently offensive.

With the nasal speculum it may perhaps be seen trickling into the nose. When the symptoms are very severe there may occur an expansion of the whole jaw with elevation of the malar bone, displacement of the eyeball, extreme alveolar tenderness, and extension of trouble along various nerve-sheaths, with spontaneous perforation in some direction if timely relief be not afforded. Percussion over the two antra will reveal a dull sound on the side of the abscess. Attention has been called to the possibility of deriving information from the use of an electric light in the mouth, but Zeim does not think the diagnosis of suppuration in the antrum can be made with any certainty by this means. Between long-existing abscess, cystic degeneration, and tumor within the antrum there may be some difficulty of diagnosis, but the presence or absence of early signs of inflammation will aid as between the first two, while as between cystic degeneration and tumor the existence of cachexia or of local signs of inflammation will be most significant.

The **treatment** of inflammation previous to the formation of an abscess may consist in leeching and hot applications, with appropriate general measures. When pus has already accumulated, a free opening for its evacuation is essential. If the disease has extended upward from a tooth, the old method of removal of the tooth and the perforation of the antrum at its base will be proper. But when the teeth are sound, it is a pity to sacrifice one of them for this purpose, and it is preferable to perforate the antrum at the point of election, which is above the point of the root of the second bicuspid, about an inch above the border of the gum. The mucous membrane of the buccal fold may be incised at this point and the thin wall of bone perforated with a trocar or a delicate gouge with the exertion of very little force. By this means a free opening can be made with drainage into the mouth. More perfect drainage, however, may be obtained by making a counter-opening into the inferior meatus of the nose, *i. e.* on a level with the floor of the antrum; and if this be done a drainage-tube may be drawn through from the mouth into the nose and left protruding at the nostril for a few days. This permits such thorough irrigation as to ensure reasonably rapid recovery from the empyemic condition without making the operation in any sense more severe or more serious. Daily irrigation should be practised, and one or both openings should be kept patulous with a proper packing or suitable device so long as any pus is discharged.

Tumors.—Morbid growths within the antrum are by no means uncommon, originating less frequently from the alveolar border than from the muco-periosteum. Of 307 cases tabulated by Weber, 133 were carcinomata, 84 sarcomata, 32 osteomata, 20 cysts, 17 fibromata, and the remainder miscellaneous; in other words, on the average two-thirds of the tumors of the antrum are malignant. Their general character as to benignity or malignity must be judged by their rapidity of growth and by the general condition of the patient. Their earlier stages are marked by few if any symptoms, while their later symptoms are almost identical. If affection of the neighboring lymphatic glands can be detected, the probability is that they are malignant, although it must be said of cancer of the antrum that, as a rule, the external lymphatics are slow to become involved. If a tumor be recognized in this location, a decision as to whether to operate must be formed partly upon the age and general state of the patient, and partly upon the absence or presence of signs of involvement of the adjoining and especially the surgically inaccessible parts. To this end careful examination of the nose and naso-pharynx should be made, vision should be tested, and all the nerves of special sense, as well as the motor and sensory nerves of this region, should be studied in order to recognize signs of involvement of any of them. It having been decided to operate, the operation is

practically that of removal of the upper jaw, which is described in another place. If the trouble be malignant, the surgeon cannot be too thorough in removing tissues which are even suspicious. If the neoplasm be benign, it may be enough to lay open the cheek by the usual incision for the more formidable procedure, and then to expose the interior of the antrum by cutting away its anterior wall. This will permit the easy extirpation of polypi, fibromata, cysts, etc.

INJURIES OF THE NOSE.

Fractures and Dislocations of the nasal bones are considered elsewhere.

Wounds of the nose may be contused, incised, or lacerated. They demand care in treatment mainly for the prevention of deformity. Accurate coaptation of edges, readjustment of parts in proper position, and reduction by suitable means call for a high degree of surgical skill. Some internal support, as from a rubber or glass tube or an antiseptic plug, may be advisable, and externally the collodion dressing reinforced by a few cotton fibers will be found admirable. When a portion of the nose has been actually carried away, some plastic operation for its repair becomes necessary. Experience has also shown that when the nose has been partially or even completely detached it is possible for complete union to occur if it be immediately restored to its proper position and suitably held in place. Foreign bodies, of course, should be immediately removed. Burns and scalds of the nose are of particular importance, because of possible cicatricial contraction and consequent deformity. This is bad enough at any part of its surface, but is worst of all when occurring around the nostrils. It is to be guarded against by the utmost care during the healing process, and perhaps by some artificial intranasal support, which must be worn steadily for some time and after a while may be worn only during the night.

Surgical Emphysema of the Nose.—This occurs quite commonly after any injury by which a lesion of the mucous membrane is produced, especially after fracture and dislocation. The term implies a distention or blowing up of the cellular tissue by air, especially during the expiratory act, and is particularly likely to take place when clots of blood fill up the nasal cavity and by their presence excite the patient to frequent involuntary efforts to expel them. The condition varies from the slightest recognizable puffiness of the skin about the bridge of the nose to a most marked swelling of the soft parts about the face, eyes, and forehead, by which the patient's features may be made almost unrecognizable. When the palpating fingers are placed upon the distended tissues a very fine bubbling crepitation is at once detected. This condition, though terrifying to the laity, is one by itself of no serious importance. Only in case germs of decomposition enter and set up a septic cellulitis will any trouble follow. Should this result, the phlegmonous cellulitis might be serious or even fatal. It would call for constitutional treatment and free incisions.

RHINOPLASTY.

The term rhinoplasty includes all operations having for their object the restoration or repair of the nose. They are called for: 1st, for correction of congenital deformity; 2d, to repair effects of injury; and 3d, for restoration from the ravages of disease, the latter being malignant or ulcerative, with or without caries or necrosis of the bone. No operation of the kind should be performed until the destructive process has been positively checked or all actually diseased tissue removed by excision or ablation. These ope-

rations date back to the earliest days of surgery, and seem to have been successfully practised at a time when operative surgery in general was very crude. Rhinoplasty is divided into total and partial. For the relief of partial deficiencies, such as defect of one of the alæ, a flap may be taken from the upper side of the nose or from the tissues of the cheek; usually only when it requires to be very large will it be necessary to take it from the forehead. These flaps are almost invariably made by the process of transplantation, leaving a pedicle for vascular supply, which should not be twisted too tightly, lest this supply be cut off. After the flap is firmly implanted in its new position, say in from ten to fourteen days, the pedicle may be divided, or, if necessary, a redundant portion exsected. An extreme condition of pug-nose has been remedied by cutting transversely across the nose, drawing the tip down to the desired position, and then transplanting flaps from the cheeks to fill the wedge-shaped defect. A new columna nasi is sometimes formed from the upper lip by exsecting a small part at the middle line and then turning the strip upward, the inside of the tip of the nose being freshened for its reception. The wound in the lip is then closed, as in the case of hare-lip, with pins or sutures. For the relief of fistulous openings on one or both sides it is necessary cleanly to excise the ulcerated or cicatrized margin, and then to slide or transplant a flap from the adjoining cheek.

For restoration of the entire nose two quite different methods have been suggested, both of which are old. The procedure is as follows: First of all, it is necessary to have an idea of the amount of skin to be transplanted. In order to do this, a pattern is made with a piece of oiled silk by fashioning it over the normal nose of some other individual, or by building up on the face of the patient with wax, clay, or dough a model of a nose which shall suit the other features. The pattern thus made will be rudely pyriform, and it will be seen that a peculiar projection is to be arranged for at the distal border, from which the columna or septum is to be formed. This pattern is to be used on either the forehead or the arm of the patient, according to the selection of the operator.

The Tagliacotian method (Fig. 244), named from Tagliacozzi, a famous Italian surgeon of the sixteenth century, comprehends the use of a flap of skin raised usually from the left arm of the patient. This flap is marked out upon the arm by means of the pattern already referred to, allowing one-third on every side for shrinkage, since the human skin may be always expected to shrink to about this extent after the division or raising of a flap. The original procedure includes the detaching of this flap except its pedicle, and leaving it for about two weeks in order that it may become more vascular and thickened and its lower surface covered with granulation. After two weeks the stump or remains of the original nose are pared, and all surfaces to which it is intended that the new flap shall unite are freshened with scissors or knife, and then the arm is brought up to the head, the flap trimmed to the exact necessary shape, and fastened in its new position by numerous sutures, after which the hand is placed upon the top of the head, and hand and forearm suitably bandaged thereto by a somewhat complicated combination of slings and bandages: a substitute for the original apparatus may be made of plaster of Paris. As soon as the flap is supposed to be firmly ad-

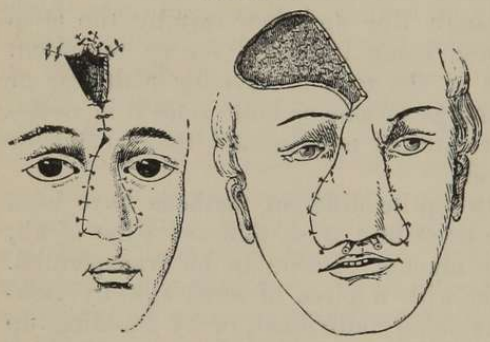
FIG. 244.

Warren's Apparatus for resorting to Tagliacozzi's Method.

herent, say in ten or twelve days, its pedicle is divided and trimmed as may be necessary. The columna is subsequently made from the upper lip. The original operation contemplated that the flap should be made from the arm. Modern operators have modified it by taking it from the forearm, but the necessary confinement of head and arm is so irksome that the operation is at present scarcely ever done, although in certain cases it offers good prospect of success, provided the subject be patient and acquiescent.

The other operation, now generally practised, is that commonly known as the Indian method, and was brought to Europe from Hindoostan. The model and the pattern are made as before, but the flap is now taken from the forehead, still allowing one-third for shrinkage, the pattern being applied either perpendicularly or obliquely, depending much upon its contour (Fig. 245) and the distance between the eyebrows and the hair. The incision is carried down to the periosteum, beginning at the right margin of the defect and terminating at the upper end of the left superciliary ridge, the pedicle of the flap being about two centimeters wide. It is necessary not to interfere with the angular artery, since upon it depends the nourishment of the flap, but the flap thus outlined is dissected off and is made to include the frontal aponeurosis. Sometimes the periosteum is raised, at least over the lower part of the flap. Koenig has suggested to raise along with the periosteum the outer table of the skull or at least its superficial portion, especially along the central and lower portion, in order that a firm bony bridge of the nose may be produced. If this be done—and the writer has practised this with success and urges its performance—the integument should in no wise be raised from that portion of the periosteum and bone which it is intended to utilize. Except in the very young it will be impossible to detach this bone with the chisel or any other instrument in anything like a continuous layer: the bone-flap will, in fact, be more like a series of thin flat chips which cling to the periosteum. By virtue of the osteoblasts which abound on the outer surface of the bone and in the deeper layer of the periosteum, perfect osteogenetic power is preserved, and the result will be the same. As soon as hemorrhage has subsided the flap is rotated into its proper position, and the process of attachment with fine and rather numerous sutures begun. The alæ and nostrils are formed by an inward duplication of the lateral parts, and the septum is formed from the appropriate portion and stitched down to the outer portion of the upper lip, in which a groove should be made for it. The more perfect the apportionment of amount the more ornamental the result. The defect in the forehead will at first be larger than the size of the flap, since the edges will retract. It will be worth while to dissect the tissues loose from the frontal bone for an inch or two all round this defect, in order that by sliding and by the tension of silk sutures the size of the defect may be reduced at least by one-half. Sometimes it will be worth while to extend the incisions upon the scalp, so that by rearrangement of the flaps the defect may be still further covered. The portions which cannot thus be protected must be allowed to heal by granulation, or it may be possible to accomplish a good deal by skin-grafting after

FIG. 245.



Indian Method of Rhinoplasty (Prince).

Thiersch's method. The wound upon the forehead is best dressed with iodoform and green silk protective underneath the ordinary aseptic dressing. The new nose may need some artificial support, which can be furnished externally with a dressing of cotton or collodion, while internally the nostrils are kept patulous and the flap supported by the introduction of rubber tubes. It is best to make the flap apparently too large, since the new organ, which seems disproportionately large at first, will in the course of months shrink and perhaps cause disappointment because not large enough. Noses thus built up are often very satisfactory, and leave but little evidence of the somewhat extensive disturbance by which they were first produced.

For more exact descriptions and variations in methods the reader is referred to the special works on plastic surgery. When from one cause or another it may appear impracticable to reproduce this organ by plastic surgery, much may be done by plastic art in another direction, and artificial noses are now prepared from celluloid or similar materials, which are kept firmly in place by spectacle-rims, as if the patient were wearing glasses. These can be made with such accuracy and worn with such exactness and comfort as almost to defy detection except on close inspection.

SECTION II.—DISEASES AND INJURIES OF THE LARYNX AND TRACHEA.

Congenital Deformities and Defects.

Congenital absence of one or more of the laryngeal cartilages has been noted, as well as a relative diminution in size of the entire larynx. In a few cases also membranous partitions or connections between the various parts, by which their action is interfered with or made impossible, have been observed. The most common congenital anomalies about the parts, however, are fissures and fistulæ. These are to be attributed to defect in normal closure of the third or fourth branchial cleft or to defect in union of the third or fourth branchial arch during fœtal existence. In the former case the opening would be unilateral and in the neighborhood of the sterno-mastoid muscle; in the latter case in the middle line. Fissure of the epiglottis has also been observed. Tracheal fistulæ are the least uncommon of all these anomalies, and may be so minute as to elude ordinary examination. The symptoms are the daily discharge of two or three drops of muco-purulent fluid from a minute orifice in one of the localities mentioned, with perhaps the expulsion of air-bubbles on forced expiration. The treatment of these congenital openings must consist in stimulation of the margin by caustics or in the performance of a plastic operation.

LARYNGITIS.

Laryngitis may be either acute or chronic, and may be catarrhal, croupous, diphtheritic, ulcerative, tubercular, or syphilitic. If it be of a suppurative character, it is anatomically submucous, and clinically is spoken of as phlegmonous, save when circumscribed, when we have an abscess of the larynx.

Acute Catarrhal Laryngitis may be primary or the result of extension from the pharynx above or from the trachea below. When idiopathic it is usually the result of exposure. It may also be mechanically induced by over-use of the parts in speaking or singing, and it may be produced by irritation of noxious vapors or by foreign bodies, as dust and smoke. Erysipelas of the larynx also is described, as well as rheumatic or gouty laryngitis. The acute forms are usually diffuse, giving rise to constant embarrassment of respiration and to

frequent violent and even suffocating attacks of coughing, with partial or complete loss of voice. Upon laryngoscopic inspection the mucous membrane will be found congested and swollen, the swelling being usually symmetrical. Accumulations of mucus at various points may simulate ulceration, and will be found especially on the vocal cords. Should the symptoms be very severe, œdema of the larynx may ensue.

The **treatment** consists in the removal of the cause when recognized; furthermore, in inhalations of steam impregnated with sedative and astringent substances, as well as in the administration of aperients and sedatives and the continuous application of cold wet compresses or else the employment of leeches over the larynx. Weak solutions of cocaïne will give the same relief here that they do in similar affections in the nose, but are usually to be avoided for the reasons already given. There is danger in the application of strong astringents, such as nitrate of silver, etc., that they may produce sudden and serious œdema. The medicinal treatment of croup and of diphtheria is not considered here.

Chronic Laryngitis.—This, too, may be idiopathic or secondary. The former may be the result of repeated attacks of acute inflammation or of extension of similar trouble from above. The latter is almost always an extension of similar trouble elsewhere, and may occur in arthritis (gout), tuberculosis, syphilis, lupus, and cancer. The chronic variety is attended with thickening of mucous membrane, more or less constant irritation, and usually with hypersecretion. Erosions are unusual. A peculiar variety of chronic laryngitis called *laryngitis sicca* occurs principally in females; it involves especially the mucous glands, the viscid products of which adhere to the mucous membrane, where they dry into crusts which are sometimes fetid. These are detached by violent coughing-spells, and leave behind them excoriations which may bleed. The result of this is an atrophic and dry condition of the mucous membrane. These affections are to be treated after about the same manner as the similar condition in the naso-pharynx, namely, careful dislodgment by the alkaline antiseptic spray of mucus and crusts, and then the application of stimulating and antiseptic solutions.

ŒDEMA OF THE LARYNX.

The most violent and serious sequel of inflammation of the larynx is the condition known as œdema, which is sometimes incorrectly spoken of as œdema of the glottis. This is an infiltration of fluid into the submucous connective tissue of the larynx or that of the epiglottis or the mucous membrane immediately adjacent. This is less often a mere passive accumulation of serum than an active inflammatory fluid exudate, the fluid being sometimes sero-sanguinolent or sero-purulent. In certain cases this occurs with great rapidity, especially when serous, and may destroy life by suffocation within a very short time, an amount of infiltration which elsewhere would be trifling serving at this point to obstruct the passage of air through the narrowest portion of the air-channel. So serious is it as to call usually for the promptest surgical interference. In time past this condition was confused with that of croup. The deaths of General Washington and the empress Josephine were due to œdema, and not, as has been ordinarily stated, to croup. Of course the œdema is owing to impediment to free circulation, whether from purely inflammatory process, mechanical obstruction by tumor, or perhaps vaso-motor paralysis. It has often followed wounds, sometimes even of the neck when the larynx has not been implicated. It has been noted also in aneurysm, erysipelas, typhoid, glanders, whooping

cough, pneumonia, septicemia, etc. A death from this cause occurred on the baseball field a few years ago, due to fracture of the larynx.

The **symptoms** are sometimes so sudden that even with aid close at hand the patient dies before it can reach him. The principal symptoms are local discomfort, increasing perhaps to agony, stridor in breathing, especially in inspiration, cough, impulsive and violent, loss of voice, dysphagia and dyspnea in fatal cases, rapidly increasing to apnea and death by suffocation. Along with these of course go intense agitation, flushing of the face, then lividity, and then cyanosis, protrusion of the eyeballs, gasping respiration, and flickering pulse. The picture above presented is that of a fatal case. In a mild degree it may be imitated during the recurring attacks of œdema which accompany acute or chronic laryngitis.

The **prognosis** must depend on the predisposition and exciting cause. The principal danger is that of suffocation; if this is avoided, much, if not everything, may be accomplished by treatment.

Treatment.—When the case is not too acute, the best treatment consists in multiple punctures into the tumid mass of swollen mucous membrane, which may be made with a sharp curved bistoury, the blade of which is protected nearly to the point with adhesive plaster. If possible, this should be done with the aid of the laryngoscopic mirror. These punctures should not be made in the interior of the larynx, but upon the swelling exposed to view by means of the mirror, since, although we desire free hemorrhage, we wish to avoid entrance of blood into the air-passages. When hemorrhage is insufficient it may be encouraged by gargling with warm water or by inhalations of steam. The punctures may have to be repeated at intervals of a few hours or days. Should the case be too violent to permit the time necessary for this kind of relief, intubation or tracheotomy will be indicated. The very condition which makes suffocation threaten will make intubation at least difficult, while appropriate tubes are not usually at hand. Tracheotomy can always be done with the simplest instruments, and a patient should not be allowed to die of suffocation from this cause if a reasonably sharp penknife be at hand. Indeed, as a precautionary measure, if the patient threaten to require tracheotomy at any moment, it will be far better and safer to perform it deliberately than wait to be called to do it hastily with the chance of arriving too late. The serous infiltration usually rapidly subsides after the performance of this operation.

ABSCESS OF THE LARYNX.

This may be intra-, peri-, or retro-laryngeal. It is almost invariably a secondary affection, most frequently resulting from disease of the cartilages. Still, phlegmonous and traumatic laryngitis, tuberculosis, syphilis, glanders, smallpox, pyemia, and the exanthemata have been mentioned as determining causes. The inferior surface of the epiglottis, the internal aspect of the arytenoid cartilage, and the false vocal cord are the most frequent seats of circumscribed abscess not resulting from injury. The local symptoms are pain, dysphonia, dyspnea, dysphagia, and cough. The patient may even be threatened with suffocation.

The **diagnosis** must be made by means of the laryngoscope, though it may be impossible on account of swelling above; but ordinarily the lesion can be recognized as a swelling the base of which is red and the apex yellowish. The principal danger is from suffocation either by the condition spoken of or by œdema. Spontaneous evacuation usually occurs if surgical relief be not previously afforded. The treatment, of course, is incision with a properly curved

and guarded knife-point, guided by the laryngoscope. Should this not be feasible or should suffocation threaten, a preliminary tracheotomy should always be made. Extra-laryngeal abscess is recognizable by the common signs of this complaint, and should be treated in accordance with the ordinary rules.

PERICHONDRITIS AND CHONDRITIS.

The latter is always preceded by the former, which itself may be traumatic or secondary to previous disease. Idiopathic perichondritis is nearly if not quite unknown. The most common causes of disease of the cartilages are syphilis, tuberculosis, cancer, typhoid fever, and the exanthemata; more rarely chronic laryngitis. Pathologically distinct, clinically the two conditions are indistinguishable. The cricoid and arytenoid cartilages are those commonly involved. When there is suppuration beneath the perichondrium, necrosis of the cartilage proper occurs, and then an abscess forms which often discharges spontaneously, following which there is usually cicatricial contraction, while stenosis is the final result. Sometimes the arytenoid cartilages are thus discharged entire. The route of pus from such a source to the surface is sometimes very indirect, while fistula often results and extensive emphysema may take place.

The **symptoms** are those of more or less severe laryngitis, with pain on motion or pressure and sometimes during deglutition or phonation. Later appear hoarseness, cough, and dyspnea with paroxysms of stridor: with an attack of unusual severity there may be spontaneous evacuation followed by marked relief. By suitable external and internal examination a pretty accurate diagnosis of the location of the disease may be made, especially if an abscess has already formed and broken.

Treatment.—In the earlier stages antiphlogistic measures are indicated, with the ordinary local treatment and such constitutional medication as the condition of the patient may call for. Should swallowing become impossible, nourishment by stomach-tube or the rectum will be necessary, while when local symptoms are severe, tracheotomy or laryngotomy, with cleaning out of the abscess-cavities, is the only rational course.

ULCERS OF THE LARYNX.

These may be catarrhal, tubercular, syphilitic, or malignant. Only the catarrhal will be referred to here, the other forms being described under their respective headings. Of this we may have all degrees, from the most simple erosion to an ulcer of large extent. They are, as a rule, the result of chronic processes, but possibly of injury, especially by lodgment of foreign bodies. The mucous membrane around the periphery is usually slightly altered and sometimes infiltrated. They may be found at almost any point, but most commonly are in the neighborhood of the vocal cords or upon them; at times they are even excavated. They may vary in size from that of a pin-point up. Sometimes in laryngoscopic examination we find cicatrices showing where old ulcers have been healed.

The **symptoms** of ulceration are scarcely distinctive, and are included under those of inflammation. When the vocal cords are involved their function is correspondingly impaired, and there is partial or complete loss of voice, usually with irritating cough and severe laryngeal irritation. When the larynx is in this condition there is always danger of œdema.

Treatment.—This consists in the ordinary methods of combating inflammation and in the local application of some stimulating substance, which is

usually practised by means of a laryngeal probe upon whose tip a little nitrate of silver is fused. Perfect rest should be insisted upon, and constitutional treatment, such as the exhibition of tonics, etc., is commonly required.

STRICTURE OF THE LARYNX AND TRACHEA.

This is usually spoken of as stenosis, and may arise from causes within or without these parts. One or both may be implicated, and sometimes there is more than one stricture. When produced from without it is called *compression stenosis*, and may be the result of abscesses, of tumors of the thyroid or thymus or lymph-glands or elsewhere about the neck, of cicatrices, or of aneurysm. Sometimes the stricture is produced simply by the deflection of the respiratory tube, sometimes by pressure and occlusion. Stricture from within, or *occlusion stenosis*, may be due to congenital causes, to foreign bodies, to tumors, to cicatricial contraction following ulceration, and to paralytic or spasmodic affection of the intrinsic muscles; also to œdema, to submucous hemorrhage, to the presence of false membrane, to inflammatory adhesions, and to the result of suicidal attempts. The constriction may occur at any point, the amount varying within the extremest possible limits. Even complete obliteration is known. Its most common situation is naturally at a point where the channel is narrowest, namely, at the glottis; and here, of course, it assumes an importance begotten of anatomical location.

It will be seen, then, that constriction may be temporary or permanent, slight or most serious, and implies various degrees of organic and tissue changes. In proportion to the amount of stenosis there will be dyspnea, especially on inspiration and exertion, by which the voluntary muscles of inspiration are called upon to an unwonted degree. Loud breathing merges into stridor, and this later into an agonizing suffocative and stridulous choking respiration. In extreme cases the face is anxious and cyanotic, the pulse becomes small and frequent, and the muscular effort to breathe is most painful to witness. The symptoms are about the same no matter what may be the cause. There is always danger that in a severe case of cicatricial stenosis there may be added, at the last, an œdema of the parts which will hasten the termination.

When time and opportunity afford, a careful study of the case should be made in order to locate the stricture and determine its character, suitable measures then being decided upon. On the other hand, when the case is extreme the trachea should be opened as low as convenient, profiting by the fact that most of these lesions are located above the lowest accessible portion of the windpipe. It may be that a large tumor or abscess so occupies the inferior and middle portions of the neck that even tracheotomy will be impossible. When there is time for careful study and deliberation, the relief must depend upon the cause. At one time it may be dilatation of a cicatricial contraction, at another the removal of a polyp or other tumor either by intra- or extra-laryngeal methods, at another the performance of a tracheotomy, or possibly a still more radical operation, such as removal of the larynx. At all events, tracheotomy is often the temporary and almost always the final expedient.

SYPHILIS OF THE LARYNX.

Syphilis of the larynx may be acute or chronic. There is an acute form which corresponds to the congestion and inflammation of the pharynx met with in the early portion of the secondary stage, which may give rise to temporary hoarseness and even to other signs of laryngeal irritation. When seen with a

laryngoscope the interior of the larynx will present the same livid and tumefied appearance that we recognize in the pharynx. The treatment for this form should be vigorous and constitutional, with such local measures as may be necessary to subdue irritation.

A chronic form of syphilitic laryngitis is common, and is marked by infiltration and inflexibility of mucous membrane, which, with time, go on to the formation of mucous patches or extensive granulomatous tissue-formation, or to extensive ulceration with destruction even of underlying cartilage, and in any event to more or less reduction of caliber, or sometimes to the formation of serious stenosis or even to complete occlusion.

Aside from mucous patches, extensive ulceration and even gummatous infiltration, or possibly formation of distinct gummata, may take place. About these ulcerations there is usually a symmetry of location which is one of the points of differential diagnosis between them and tubercular ulcerations. Ulceration of the epiglottis especially is a common manifestation of the tertiary stage. Such ravages as these seldom go on within the larynx without such external or other manifestations of syphilis as to leave scarcely a doubt concerning the nature of the lesion.

While local treatment is not to be excluded, the constitutional is the more important of the two, save when immediate consequences threaten.

TUBERCULOSIS OF THE LARYNX.

Primary tuberculosis of the larynx is rare. Although these cases are seen mostly by specialists, there is no reason why the general practitioner should not be able to recognize their characteristics. In the first place, there are the ordinary evidences of chronic laryngitis with thickening of the mucous membrane, which goes on to the formation of multiple ulcerations, ordinarily at first minute, coalescing later, accompanied by more or less hacking cough or alteration of the voice. There is no part of the larynx which is exempt from attack, but the most marked manifestations occur about the arytenoid cartilages, the vocal cords, and the epiglottis. The natural outlines of the larynx as seen in the mirror become blurred, and there is commonly an intumescence of the glotto-epiglottic folds and bands; later there occurs not only ulceration as such, but also the development of granulations, which, as a rule, are elevated above the surface, and which, when on the posterior wall and in the middle line, are by many authorities regarded as pathognomonic of the condition. This condition is usually secondary to pulmonary tuberculosis, but may be, as above mentioned, purely primary.

When the disease is of the primary type it requires usually to be differentiated from syphilis on the one hand and malignant disease on the other. Asymmetry of ulceration, with the peculiarity of granulation spoken of above, is always at least suggestive, while the absence on the one hand of evidences of syphilis elsewhere, and the existence on the other of a family history of consumption, or of a history of progressive emaciation, or of elevation of temperature, especially in the evening, will greatly aid in diagnosis. The crucial test, when it can be established, is the presence of tubercle bacilli, either in the infected tissue or in the sputum.

Between tubercular and malignant disease of the larynx it is at times in the early stages excessively difficult to determine, and it is necessary to watch for a time before making an absolute diagnosis. A study of family history, of temperature range, of constitutional conditions, will be of great aid. Malignant disease is more likely to have a more definite origin and limit, around

which healthy or nearly healthy tissue will be met with. Tubercular disease, on the other hand, is likely to leave its marks in almost every portion of the larynx, as well as to cause more local irritation, while there will be little if any such infiltration as to cause fixation of the larynx upon the outside or involvement of the lymphatic glands in the vicinity. More will be said on this topic when speaking of Cancer of the Larynx.

In time past primary laryngeal tuberculosis was supposed to be irretrievably fatal, but, while it is still to be regarded as of extreme gravity, much can be effected by **treatment.** This consists in both constitutional and local measures, the latter being those indicated in tubercular disease, and consisting of frequent applications of lactic acid to the ulcerated passage, and insufflation of iodoform or aristol or of some other dry antiseptic material by which tissue-changes are influenced, as well as of some anodyne powder, such as one containing very small portions of cocaïne and morphia, combined perhaps with bismuth subnitrate and sugar of milk. In aggravated cases absolute rest of the larynx as enforced by a tracheotomy is sometimes of great benefit. If we could be assured that the disease was purely local, it might be justifiable to extirpate the organ, but patients thus far have proved unwilling to submit to this extreme measure at a time when it promised them any abiding benefit.

TUMORS OF THE LARYNX.

Most laryngeal tumors involve the interior surface, although they may rarely develop on the exterior, whence they may perforate.

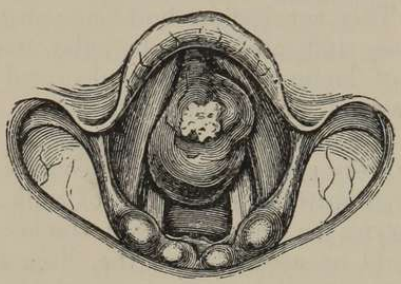
Benign Tumors.—The majority of laryngeal tumors are non-malignant, and of these two-thirds are probably papillomata. Their origin is always obscure, though they are usually referred to local irritation. They are rarely multiple, and the anterior portions of the larynx are most often involved. Males are much more liable, and children frequently present this condition, even young infants. Nearly all, if not all, of the so-called benign tumors have been met with within the larynx. They vary in size from that of a small seed to masses sufficient to protrude beyond normal laryngeal limits. They occur probably with greatest frequency in the vocal cords. It must never be forgotten that the transformation of benign into malignant tumors occurs more typically here than perhaps anywhere else in the body. This would include the change of papilloma into epithelioma, of fibroma into fibro-sarcoma, and of adenoma into carcinoma, this transformation taking place usually in elderly adults at that period when age predisposes to such changes in various parts of the body.

Symptoms.—The symptoms of laryngeal tumor are uniform, no matter what its histology. They vary only according to its size and location. Hoarseness or dyspnea occurs when the action of the vocal cords is interfered with, but seldom at other times. Preceding this condition, however, is one of uncertainty of voice, with alteration of timbre and of tone limits. What is known as double voice, or diphthonia, has followed symmetrical growths dividing the glottis into two portions. Finally, complete aphonia may result. Dyspnea occurs in proportion to the amount of obstruction of the respiratory channel. When the growth is slow there appears to be a compensatory arrangement of the parts by which even a large growth will cause but little obstruction. Dysphagia is rare unless the growth occupy some portions of the pharyngeal aspect of the larynx. Cough and pain are late symptoms.

The final **diagnosis** is made with the laryngoscope: when this is impracticable, as in children, the finger-tip inserted as far as may be carefully done

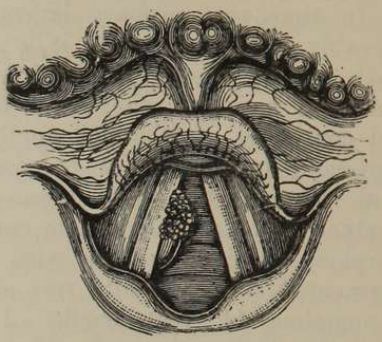
will sometimes aid. After making out the presence of the tumor in the larynx, a fine curved laryngeal probe should be introduced in order to determine its exact location and fixation. Papilloma and fibroma are usually pedunculated (Figs. 246, 247), the latter more often so than the former, and are commonly

Fig. 246.



Polyp of Larynx (Stoerck).

Fig. 247.



Papilloma of Larynx (Stoerck).

easily seen. Angeiomata are usually dark in color and seated upon the vocal cords. Cysts occupy, as a rule, the ventricles or the epiglottis. Enchondromata occupy merely the posterior portion of the larynx, especially the arytenoid cartilages. With the presence of these tumors there may or may not be signs of irritation or inflammation of the surrounding parts. The principal dangers which they cause are those of suffocation, and not a few deaths have been thus induced.

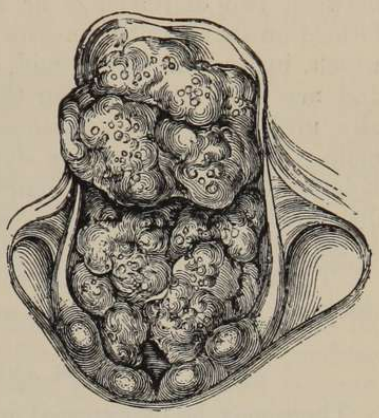
Treatment.—When removal is possible it should be accomplished with the smallest necessary disturbance. They may be removed by the natural channel or after external incision. The intra-laryngeal method includes cauterization, incision, excision, crushing, snaring, and avulsion. Very small and accessible papillomata may be attacked with chromic or nitric acid or with the galvano-cautery. These are all to be used with extreme caution, for fear of resulting œdema. The instrument-makers supply cautery points by means of which, guided by the laryngoscopic mirror and a steady hand, the action of the cautery may be limited to the desired point. Incision is resorted to only in cases of cysts. Excision is performed with curved scissors or guillotine knives. When crushing is resorted to, it is with a hope of destroying vitality and causing a slough. The écraseur has also been employed for intra-laryngeal snaring of tumors, but is difficult to operate. Avulsion, or rudely tearing away the growth by forceps, is perhaps the most common procedure. Pedunculated masses are thus readily removed, and sessile growths can be torn away *en masse*. All these instruments can be guided by the mirror. They require special dexterity and considerable practice, and such operations are mainly relegated to specialists. Great facility has been acquired in this direction by a few, and the intra-laryngeal method in the hands of an expert offers better possibility of success than does a clumsy incision at the hands of a general practitioner.

When, however, it appears necessary to open the larynx, the operation is known as **thyrotomy** or **thyroid laryngotomy**, and consists in incision in the middle line, with splitting of the thyroid cartilage beneath the line where the two alæ join, and the exposure of the interior of the larynx to sight and to more radical operative attack. The thyroid being so intimately connected with the cricoid below and the hyoid above, it will be usually necessary to divide the former as well as the membrane both above and below. After whatever

growth is present has thus been removed, the cartilaginous rings may be united by suture of the perichondrium, or even through the cartilage itself. It will be wise to extend the incision downward through the first and second tracheal rings and to insert a tracheal tube, since the laryngeal wound will heal much more kindly if thus placed absolutely at rest.

MALIGNANT TUMORS.—These are composed of various forms of sarcoma and carcinoma (Fig. 248). The epiglottis is perhaps the most common seat of sarcoma, which may be met with in relatively young patients. The large proportion of true carcinomata will be found to have resulted from generations of previously benign tumors.

FIG. 248.



Carcinoma of the Larynx (Stoerck).

Symptoms.—So far as symptoms are concerned, they are those of benign tumors already considered, plus sensations as of foreign bodies, greater dysphagia, pain, often shooting upward toward the ears, and emaciation and lymphatic involvement. Sarcoma is much less likely to be ulcerated. That it is not always possible even for experts to settle these questions of difference of diagnosis is evidenced by the case of the late Emperor Frederick of Germany. The prognosis is always bad unless the disease can be arrested by radical operation. An encouraging percentage of cure has resulted from operations involving complete or partial removal of the larynx. One case lived nearly six years after the extirpation, and then died of an acute disease.

Treatment.—The treatment of cancer of the larynx is addressed, according to circumstances, either to alleviation or to radical cure. The former consists in local astringent and anodyne applications, with perhaps the occasional removal of projecting masses or the application of the actual cautery, by which the growth may certainly be temporarily checked in many instances. When in time the laryngeal symptoms become so severe as to harass the patient, tracheotomy will give a respite of several weeks or months. On the other hand, when the disease is apparently local and no trace of it can be found outside of proper laryngeal confines, and when the general condition and fortitude of the patient warrant so severe an operation, partial or complete extirpation of the organ may be proposed, and, with the consent of the patient, carried out. The operation of laryngotomy will be described with other operations on the parts.

TUMORS OF THE TRACHEA.

Every variety of tumor has been found within the windpipe, although tumors arise more frequently from the membranous than from the cartilaginous portion, and are more common nearer its upper portion. These tumors are often, but by no means necessarily, associated with others elsewhere. Male adults are the most often affected. The causes are absolutely obscure. A considerable number of these cases are now on record, and the condition is one which can ordinarily be recognized with the laryngoscope. The benign tumors are usually pedunculated, the malignant seldom so. The symptoms are somewhat indistinct, and do not vary much from those of laryngeal tumor, save that respiration is more permanently affected and phonation much less so, if at all. The main sign is

dyspnea, which should always lead to laryngoscopic inspection. In almost every instance a tracheotomy will be called for, and according to circumstances it may or may not be possible to remove the tumor through the same incision, which may be prolonged to the necessary extent. The operation of resection of the windpipe has been suggested, but not yet made feasible.

TRACHELOCELE.

This term is applied to a hernia of the mucous membrane of the trachea between two of its rings or through a congenital defect. The tumor thus formed on its exterior consists of a cyst of mucous membrane, the contents of which, instead of being fluid, consist of air. It may be anterior or lateral, and may vary in size from that of a pea up to that of a hen's egg. Usually unilateral, it is sometimes bilateral. It is most common in the adult male. The symptoms are dyspnea, altered voice, sometimes even aphonia. Externally there will be found a compressible gaseous tumor, which may be distended when the patient makes forced expiration with closed mouth and nose. It may come on slowly or suddenly.

The **treatment** should consist at first in pressure, although radical operation may be necessary for its cure.

WOUNDS AND INJURIES OF THE LARYNX.

These may be of external or internal origin. Those from within are caused usually by foreign bodies, those from without in various ways. The most common of the latter are **contusions**, and incised **wounds** made in suicidal or homicidal attempts. The average would-be suicide is too ignorant to make his incised wound on the side of the neck, where the great vessels would be more easily divided, but makes usually an extensive gash in front, at a point where he most commonly divides the thyro-hyoid or sometimes the crico-thyroid membrane, and the violence exerted is expended before the region of the great vessels is reached. This constitutes the ordinary form of **cut-throat**, many instances of which occur every year. Sometimes the epiglottis is partially, perhaps completely, separated, and the incision may even involve the posterior wall of the pharynx. While the wound thus inflicted opens widely by a retraction of tissue, and presents sometimes a horrible aspect, it is not nearly so dangerous as it would appear to be, the majority of these cases recovering if early and properly treated.

Treatment.—If seen early, the treatment should consist in approximation of all the divided tissues, the deeper parts being united with catgut, while for the integument catgut or silk may be used according to fancy. In certain cases local rest should be ensured by performance of a low tracheotomy, and where feeding is difficult or impossible the stomach or rectal tube may be employed so long as necessary. Aside from such injuries, punctured wounds and gunshot wounds of the larynx or trachea may occur, and call for much or little treatment according to circumstances.

Wounds of internal origin are produced mainly by foreign bodies, such as fish-hooks, needles, fish-bones, pieces of glass, etc. These may tear or puncture according to their size and location, and may excite mild or intense symptoms of laryngeal irritation with inflammation and œdema or abscess. Similar substances frequently excite spasm of the glottis, which may necessitate tracheotomy or may even kill before such aid can be rendered. In all such cases the condition should be investigated with the laryngoscope if possible. If urgent symptoms arise, tracheotomy must be performed; if seen at once, the foreign

body can often be located and removed with suitable forceps. If not seen for some hours or days, it may be so hidden by tumefaction or by exudate and membrane as to be invisible. In such a case considerable local treatment which shall be astringent, antiseptic, and anodyne may be necessary before it can be discovered. Sometimes after such injuries hemorrhage occurs by which alarming or fatal results may be brought about. In such cases, when the patient survives, there is always a possibility of secondary hemorrhage. Should bleeding be alarming, it can be best checked by a tracheotomy, with plugging of the windpipe by a tampon above the tracheal tube. To wait for its arrest by syncope is to take very much more risk than is involved in making an early incision.

FRACTURES of the larynx are known, although quite infrequent. The fracture is usually limited to the thyroid and cricoid cartilages. Such injuries are produced usually by blows from without. In elderly individuals in whom senile calcification has occurred such lesions may be produced with much less violence than in the young. The most common cases are blows with the fist or some blunt weapon, or received from balls in athletic games, attempts at choking—accidental or premeditated—and falls upon hard objects with crushing violence.

The **symptoms** must vary somewhat with the cause of the injury and its extent. A blow on the larynx which does not fracture it will often produce unconsciousness, as has been seen upon the cricket field. In 1889 a death occurred upon the baseball field, where the player was struck in the throat by a swiftly-thrown ball which fractured the larynx. He fell unconscious, and died in a few moments of œdema, timely tracheotomy not having been performed. Pain, dyspnea, cough, ejection of frothy blood and mucus, dysphonia or aphonia, and dysphagia, are the common symptoms in cases not quickly fatal. They may be followed in a short time by emphysema spreading more or less widely, and by œdema of the larynx, always serious, sometimes fatal, as above. The prognosis is most serious when the cricoid has been broken, only two cases of recovery from this injury being on record.

Treatment.—The most timely and life-saving measure that can be practised is a tracheotomy, by which at least security from suffocation will be afforded. This still leaves an injury unattended to. It has been found inadvisable to try to suture broken cartilages in these cases, even though the fracture be compound. Perfect rest, such coaptation as external support may afford, and intralaryngeal medication to some extent, will bring about the best results.

DISLOCATION of the laryngeal cartilages is known, but is very rare. The most common form is luxation of an arytenoid cartilage from the cricoid upon which it rests. This may be associated with fracture. A pathological form of dislocation is known resulting from cicatricial contraction from within or without.

The **treatment** must depend on the urgency and permanency of the symptoms. Intubation or tracheotomy will probably be called for if anything be required, while in the pathological form measures for dilatation of the stricture will be indicated.

FOREIGN BODIES IN THE AIR-PASSAGES.

The entrance of a foreign body into the air-passages is one of the commonest of accidents. Ordinarily the substance is at once expelled in a violent and reflex fit of coughing. Natural expulsion may be aided by inverting the

patient, often a child, and slapping somewhat freely upon the back. These foreign bodies are most commonly introduced in a sudden inspiration, voluntary or involuntary, while the substance is in or close to the mouth. The greatest variety of substances are thus introduced, among the more common being artificial teeth, material rejected from the stomach during the act of vomiting, including curdled milk and particles from the alimentary canal or the respiratory passages above, fragments of teeth dislodged during attempts at extraction, particles of cork or sponge, broken instruments, necrosed bone, toys, etc. On the other hand, foreign bodies enter from the outside by direct puncture, as gunshot missiles, or through previous wounds, like that described when speaking of cut-throat. Fluids of all kinds, blood, pus, etc., also have easy access to the larynx and trachea in many instances. When inorganic these materials are not likely to undergo change, but when animal or vegetable they may absorb moisture and increase in size or macerate. When retained for long periods they may become covered with mucus or even calcareous matter. They are most likely either to be entangled at a point between the epiglottis and the level of the glottis, or to pass down and become impacted in a bronchus. It frequently happens that a very small particle will cause a prodigious amount of irritation.

The usual **symptoms** are spasmodic cough, spasm of the larynx, and a feeling of suffocation. At times the symptoms are violent, and the patient may become unconscious from deficient oxidation of the blood. Foreign bodies are also the cause of some cases of prolonged and chronic laryngeal symptoms, ulceration, or abscess, in which the actual cause is either unsuspected or cannot be detected. Inspection is always necessary, and the laryngeal probe will be of great assistance. Endeavors to locate and appreciate accurately the body are always necessary, save where urgency does not warrant any delay. In not a few instances, however, suffocation occurs within the moment during which there is no one at hand with sufficient knowledge to render any assistance. Thus the writer has known of two young men who were quickly suffocated by pieces of meat within the entrance to the larynx, and more than one death which has been ascribed to anesthetics has been caused by plugging of the parts with masses of undigested food rejected from the stomach during the reflex act of vomiting. This affords a most cogent reason for insisting upon an empty stomach before beginning anesthesia, as well as turning the patient upon one side or upon the face whenever vomiting occurs during this condition of loss of voluntary control.

The **prognosis** should be always guarded, as a foreign body, which to-day causes no distress and scarcely any symptoms, months or years later may kill by a slow process of ulceration, necrosis, or something equally disastrous.

Treatment.—Except in the severest emergencies the first endeavor should be to dislodge the substance by the simplest possible manœuvers, which consist, perhaps, in inverting the body and slapping the patient on the back or chest. Many substances, like those of a mineral nature, may be thus easily dislodged and expelled. If it be a body of some size, the presumption is that it has lodged within reach of the finger, in which case the mouth should be widely opened, if necessary held so, and the index finger pushed deeply into the pharynx and swept beneath the epiglottis and down toward the glottis. If there be any substance there which the finger alone cannot dislodge, it may be aided with anything at hand which will serve the purpose. It is often well in these cases to seize the larynx from the outside with the other hand, and raise it well up toward the lower jaw, by which it is brought within better reach of the inside finger. Effort of this kind failing, artificial light and the laryn-

goscopic mirror must be brought into play, and, according to the substance at fault and the ingenuity and dexterity of the surgeon, the foreign body when seen may be grasped and removed with more or less readiness. Various kinds of forceps and other means for removing foreign bodies have been devised, and may be used as required. Finally, in cases where there is every reason to think that some foreign body is present, although it cannot be seen, the better way will be to wait, making repeated examinations, accustoming the patient to laryngoscopic methods, and cultivating the throat to tolerate the mirror. It may be possible, after a process of schooling of this kind, to see and withdraw the intruding substance. While the medical attendant should be ever ready to operate by intubation or by tracheotomy, these procedures should be held in reserve so long as there is no urgent necessity for them.

One point which the student should always bear in mind is that symptoms of laryngeal irritation sometimes exist long after the expulsion of the substance which caused them, and that patients will sometimes insist that they have not yet been relieved when it is certain that the foreign body has been expelled. Moreover, the irritation of foreign bodies is often successfully imitated in hysterical individuals.

BURNS AND SCALDS OF THE LARYNX AND TRACHEA.

These are practically never dissociated from similar injuries to the parts above, and perhaps to the œsophagus. Burns are produced by the inhalation of hot steam and superheated air. Scalds are commonly produced by hot and caustic fluids. Caustic fluids taken internally are not always swallowed, but often "go the wrong way." The consequence of these injuries is a very acute laryngitis, which supervenes at once, with excessive intumescence and œdema. In proportion to the extent and severity of the lesion will be the amount and depth of the tissue-destruction. Following the first violence of the lesion a membranous exudate is formed which separates by sloughing, and, if the patient survive, may undergo extensive cicatricial contraction. These cases are often complicated with bronchitis of a most serious and even a fatal character.

The **symptoms** produced by burns are immediate and violent; those produced by caustics may come on much more slowly.

So far as **treatment** is concerned, immediate death by suffocation can easily be averted by tracheotomy, though it may not avail to save the patient from secondary lesions. Scalds produced by caustic acids or alkalies are usually seen too late to admit of any antidote or to avert their destructive effects. The symptoms must be treated as they arise, and while the introduction of a trachea-tube will make respiration easier, the probability is that the attendant will have to treat a complicated case of lesion of the mouth and larynx, if not of the œsophagus, which will finally baffle his most persistent and well-directed efforts. Iced and mucilaginous drinks, antiseptic mouth-washes and gargles, and anodynes under the skin or by the rectum, with rectal nourishment, sum up the principal indications in the way of treatment.

TRACHEOTOMY.

Under the general term tracheotomy are included all those operations by which the respiratory channel is opened from without at any point between the thyroid cartilage and the sternum. To be more exact, we speak of *laryngotomy* when the incision is through the crico-thyroid membrane or thyroid cartilage;

of *laryngo-tracheotomy* when the cricoid and upper rings of the trachea are divided; and of *tracheotomy* proper, or, as it is sometimes improperly called, bronchotomy, when the trachea itself is opened. One or another of these operations is done, partly according to the choice of the operator and partly according to the necessities of the case. They are undertaken for, first, croup and diphtheria; second, for œdema or acute inflammatory affections; third, in syphilis and tuberculosis of the larynx in order to give it rest; fourth, for malignant disease in order to relieve obstructions to respiration; fifth, in certain rare spasmodic affections or strictures; and sixth, for the removal of foreign bodies. Many of the indications for tracheotomy have already been discussed. We do not deem it wise here to go into the question of indications in cases of croup and diphtheria, beyond this remark, that a large proportion of fatal cases are the apparent result of operations postponed too long, and that it is very unfair to the operative procedure to speak of it as having terminated fatally. It should rather be said of it that it failed to save life because too long delayed. The interests of surgery and of humanity alike dictate that operation should be done at the earliest moment after the indication has arisen. Euthanasia may be a desirable achievement after a late operation, but the rescue of a human life usually depends upon early operative interference.

Operation being decided upon, the operator is next to elect at what point he will open the windpipe. This will depend in some measure upon the time which he feels can be devoted to it, or, in other words, upon the urgency of the case. When patients are in the last gasp of dyspnea, everything else must give way to the necessity for opening the trachea at once, and even if the isthmus of the thyroid be divided or some large vein be cut, one may be sure that hemorrhage can be checked within a few seconds, and that even if blood goes into the trachea, air will go in with it.

In these circumstances the trachea will be opened wherever it can be first reached. On the other hand, when the operator is afforded plenty of time he may select his point of attack, according to the age of the patient, the relative thickness and length of the neck, and the purpose for which he is operating. The two points most commonly chosen are the cricoid cartilage and the first ring of the trachea, by which we gain access above the thyroidal isthmus, or the tracheal rings immediately below it. This isthmus of the thyroid is rather a bugbear to young operators than an actual detriment, since when met with it is but the work of a moment to slip a double ligature underneath it, tie in two places, and divide it between them, or even to catch and divide it between two pressure forceps. In young children with very short, plump necks one works with greater ease if he keeps near the larynx. On the other hand, when the trachea lies near the surface and the neck is long, and when also the light is good, the opening can be made lower down.

Tracheotomy is simple upon the cadaver, and perhaps the easiest important operation which can be there made. In a living patient, under certain circumstances, it may be equally easy, but when in the presence of a desperate emergency, with poor light and untrained assistants and a windpipe moving up and down because of the violent efforts at respiration, it may be one of the most trying ordeals which even a skilled operator has to face. Two anatomical conditions especially serve to embarrass the operator or even endanger the patient's life. The first is the plexus of veins which sometimes, but not always, is spread over the anterior surface of the trachea. In the ideal normal condition these are arranged in such a way as not to involve the middle line, but, as is often the case, they may cross it irregularly and often, and sometimes a vein of good size will present at just that portion of the tube which we have exposed

for incision. When this condition is met with, these veins may be pushed aside or may be deliberately ligated or caught with forceps, or, if exigency require, they must be divided without these precautions. They are, under these circumstances, usually engorged in connection with the very congested condition of all parts of the head and neck. As soon as a few inspirations have been taken and oxygen has had access to the blood, a restoration of equilibrium takes place and this congestion quickly subsides. Consequently, the vein which bleeds viciously for the instant may almost entirely collapse a few moments or seconds later. It will comfort young operators if they remember this fact.

The other principal anatomical danger is an adventitious or abnormal artery which arises occasionally from the arch of the aorta, or sometimes from one of the large arteries at the base of the neck, and takes its course upward along the trachea, in rare instances to its full length. It is known as the *thyroidea ima*, and may lie directly in the track of the incision. When met with it is to be dealt with as any other artery would be. It must also be borne in mind that the innominate artery sometimes courses as high as the seventh tracheal ring. Lower in the neck the trachea is deeper and smaller, and is consequently less accessible. In young children the thymus gland may also be an obstacle; consequently with them it is always desirable to work on the upper portion of the respiratory tube.

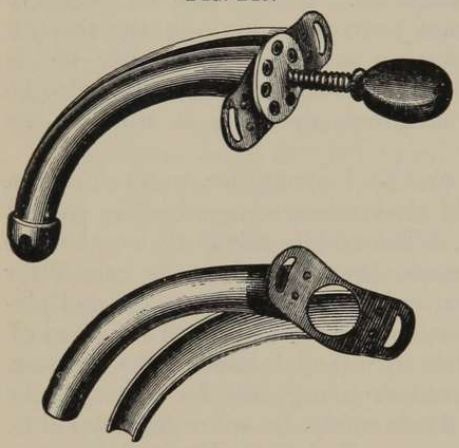
Whether in child or in adult, the head and neck should be stretched over a pillow or sand-bag, and an anesthetic should always be given, unless the patient be already unconscious or cocaïne be used. The middle line is always the line of safety, and in this line the incision is made, ordinarily from the cricoid for five to seven centimeters downward. After cutting through the skin and platysma the endeavor should be made to separate or cut between the pairs of pre-tracheal muscles. The trachea is steadied with the left hand of the operator, and the incision and dissection are continued, stopping only for arrest of the hemorrhage, until the cartilages are felt. Fortunately, these are unmistakable, and so long as the operator can feel them or can find them he need have no fear of going wrong. After they have been exposed and the bleeding has been checked, a tenaculum is used to hook up the trachea, in order to bring it well to the front before incision, and to steady it. When this is once secured it should not be let go until opened. The opening is made with a pointed knife and two or three rings are divided, or the cricoid cartilage and one ring, according to circumstances. At once there is a rush of air accompanied with violent and irregular respiratory motions. During inspiration blood, if present, will be sucked into the trachea, and during expiration blood and mucus, and perhaps false membrane, will be expelled, probably into the face of the operator, a danger to be carefully guarded against, especially in diphtheria. If there be only a hissing of air, without free play, it may be known either that the opening is not large enough or that it is plugged with some shred of tissue or with false membrane or some foreign body. In the former case it must be carefully enlarged; in the latter case it should be dilated, while with forceps or probes the membrane or foreign body is removed.

It will sometimes happen that just at the most critical moment the patient, usually a child, will entirely cease to breathe. This may occur just before or just after making the opening. In this emergency the tracheal wound, if made, must be quickly searched, to learn if it be plugged; if, on the other hand, it appear to be open, the most promising procedure will be to suspend the patient by the heels and to slap vigorously on the back, or while in this position to make artificial respiration by compressing the thorax by the arms and then raising them in order to expand it.

It is advisable to insert into the trachea, on each side of the incision, a silk suture, which is ordinarily passed through the skin as well. This should be tied and the ends left hanging long. In this way a permanent and most serviceable retractor is provided, by means of which the surgeon and the nurse have absolute control of the trachea. Indeed, so simple and so effective is this manœuver that one need never hesitate to practise tracheotomy even though he have no trachea-tube at hand, since by means of an elastic tied around the neck or extemporized hooks fastened into the suture and then connected with an elastic tape back of the neck, every purpose of the operator can be complied with. This is the so-called operation without tubes, which every practitioner should understand and be able to make in an emergency.

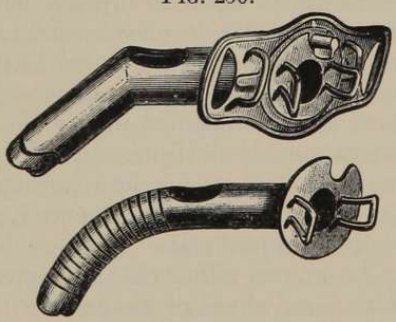
Trachea-tubes (Figs. 249–251) are made of hard rubber, as well as of silver and aluminum. The rubber tubes are heavy and thick, and those of aluminum are always preferable. They are made double, in order that the inner tube may be taken out and cleansed or freed from dry mucus as often as necessary. When cleansing them it is better to use an alkaline solution, by which the mucus is more readily removed.

FIG. 249.



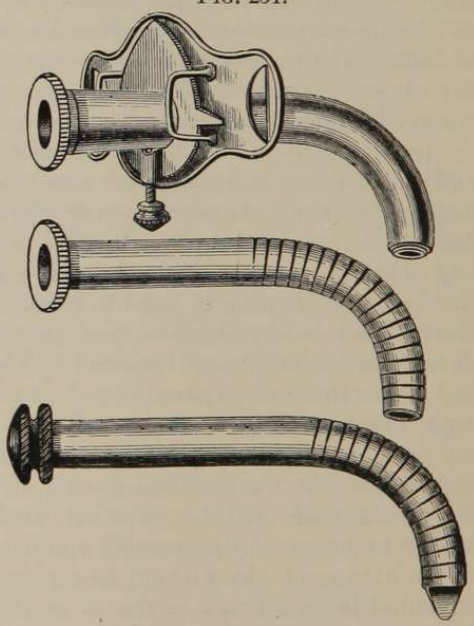
Park's Divided Trachea-Tube.

FIG. 250.



Keen's Trachea-Tube.

FIG. 251.



Johnson's Modified Durham's Trachea-Tube.

The outer tube has a little shield which is held in place by a tape passed around the neck. The largest tube which will comfortably enter the trachea should be used. In cases of obstruction from false membrane it is advisable sometimes to remove both tubes, and with a small probang firmly fastened to a handle or with a little cotton tightly wrapped around a wire quickly and dexterously to pass this down through the opening, and as quickly withdraw it, by which means membrane is dislodged and expelled by coughing. Even this procedure, however, is itself dangerous, and should not be practised oftener than may seem required by the trachea filling up with that which cannot be expelled.

After-Treatment.—The after-treatment of cases where tracheotomy has been performed requires to be almost as judiciously carried out as the operation itself. Inasmuch as air enters directly into the lungs, it should be properly warmed and moistened: the room should be kept at a temperature of 80° F. if possible, and the air kept moist with steam. Most of the conditions which necessitate tracheotomy are those which produce profound depression, and tonics and stimulants are essential. Of these strychnia and alcohol are the most desirable. The nutrition and the excretions should be carefully looked after, along with such internal medication as the surgeon may select. No rule can be given as to how long the tube should remain; this must depend upon the subsidence of the indication for which it was performed. If for a foreign body, usually one or two days; if for croup or diphtheria, five to ten days or longer; if for relief of ulceration or stenosis, perhaps for a month or months and even years; and if for temporary relief in case of cancer, until death terminates the case. Sometimes a mass of granulations develops around the tracheal wound after a few days, and causes considerable trouble either in reintroduction of the tube or in producing obstruction to respiration after its removal. Rarely they lead to cicatricial contraction later, and to what is known as **granulation stenosis** of the trachea. When present, if possible, these should be removed with caustics, with scissors, or with galvano-cautery. Other dangers connected with the operation are secondary hemorrhage, sloughing around the wound, emphysema, and ulceration and abscess. When the latter results, pus may burrow downward into the mediastinum and cause death. Cellulitis is probably the least common untoward sequel of the operation. It must be treated upon general principles.

INTUBATION OF THE LARYNX.

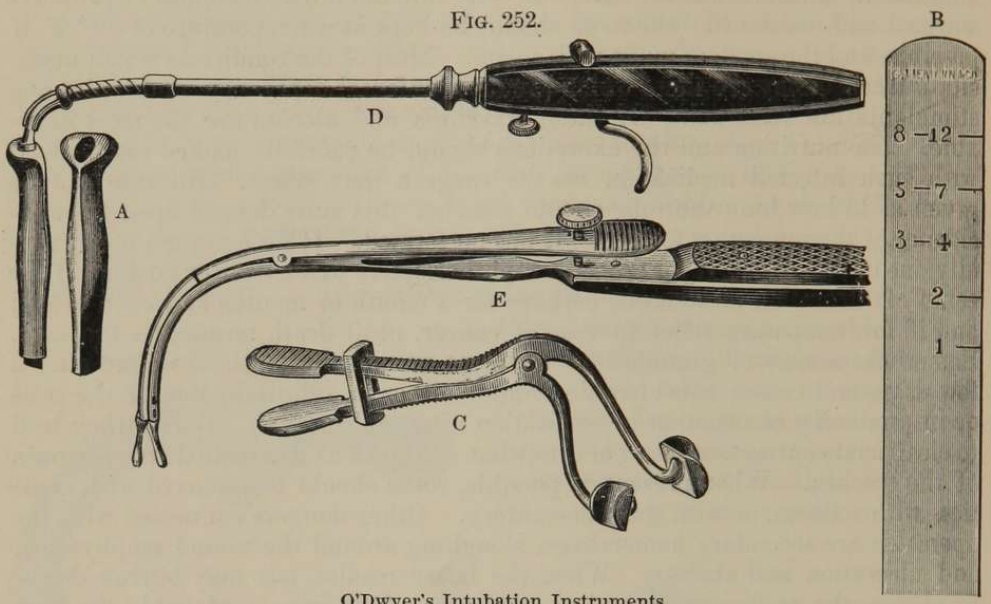
This is a distinctively American improvement upon the old operation of tracheotomy which we owe to the ingenuity and patience of O'Dwyer: not that previous efforts in this direction had not been made, but that he first made it practicable. Enough time has elapsed since its introduction to make it very plain that it constitutes a large addition to our means of affording instrumental relief, and to give it a dignity and importance which perhaps no other operation of equal simplicity possesses. The indications for the operation are, in the main, the same as those for tracheotomy. It is performed mainly in cases of diphtheria and croup, and occasionally for relief from symptoms produced by burns and scalds, by foreign bodies, and by pressure of tumors, especially those located outside the larynx; also for certain cases of ulceration and stenosis, the tube in this instance acting as a permanent dilator.

In the ordinary cases of obstruction it is obvious that the sooner it is performed the better, since by delay the patient is more exhausted and his blood more loaded with deleterious products. The originator of the operation considers that the most pressing indication for intubation is recession at those parts of the chest which yield to external air-pressure, with continued restlessness due to insufficient oxygenation, as well as feebleness of respiration. The two great advantages which intubation possesses over tracheotomy are the speed with which it can be performed and the bloodlessness and lack of shock following it. The principal disadvantage is that the necessary instruments must be at hand, while tracheotomy can be performed with almost any instruments.

As ordinarily sold, the set of intubation instruments comprises five tubes (Fig. 252, A), of sizes suitable for children from the earliest weeks of infancy up to the age of twelve. A metal gauge or scale (B) has marked upon it the lengths of the tubes and the ages for which each is suitable. Selecting the proper tube, a fine

silk thread is passed through a small hole near the anterior angle of its upper opening. This is for the purpose of retracting it if it should be lodged in a wrong

Fig. 252.



O'Dwyer's Intubation Instruments.

position. Each tube is supplied with a separate obturator, which is screwed into the handle by which it is introduced. The patient is held upright upon the lap of an assistant, the head upon the assistant's left shoulder. The arms should be secured, either by wrapping a towel or sheet around the patient's body or by being grasped below the elbows and held firmly against the body until the tube is inserted and the thread removed. Unless the hands are thus secured the patient may seize it and jerk the tube out of place. The mouth-gag (C) which accompanies the set is then inserted at the left angle of the mouth well back between the teeth, opened and clamped in such position that the mouth is open to its natural limit. Another assistant stands behind the patient with his hands firmly grasping the head, steadies it, and at the same time with his left hand keeps the gag in place. The patient should be so held that body, neck, and head are kept naturally in a straight line. The operator then, keeping the thread looped around his right little finger, holds the introducer (D) in the right hand while, inserting the index finger of the left, he seeks with the tip of it for the epiglottis, which he raises with it, thereby uncovering the glottis. By the time this is done the lower extremity of the tube has been passed down by a manœuver much resembling that by which the laryngoscopic mirror is put in place; the index finger is now the guide by which it is passed downward into the larynx. This manœuver is the most difficult of those by which intubation is performed. The tip of the tube must be kept in the middle line and close under and in contact with the epiglottis, which has been raised into a vertical position. At the same time the index finger must be shifted to the patient's right, in order not to take up that space in the pharynx in the middle line which the tube must now occupy as it is passed downward. As the tube is lowered by raising the other end of the handle, the introduced finger must also ascertain that it is not being passed into the œsophagus; on the contrary, that the posterior wall of the larynx can be felt behind the tube. When it is ascertained in this way positively that the tube is in the larynx, no time should be lost

in sending it home to its proper position, and at the same instant dislodging it from the obturator by pushing the slide upon the handle with the thumb of the right hand. If the upper end of the tube is not by this means sent low enough down, it can be pressed home by the finger which is still in the pharynx. It is recommended also, while the finger is still in the throat, to make sure by palpation that the tube is in place, which can be done by inserting its tip into the œsophagus and from that point feeling it in the larynx. With practice such dexterity is obtained that the entire little operation requires but a very few seconds from the time the finger is first introduced. The writer advises that, the arms of the child being still firmly held, the gag be for a few moments removed in order to make sure that there is no necessity for removing the tube at once, as well as that it is in place and affording the desired relief; then that the gag should be introduced for an instant while the finger is once more well introduced, and pressed down upon the upper end of the tube to hold it in place during the fraction of the second required to catch hold of one end of the thread and pull it out from the hole in the tube. Then the gag and the restraint are removed and the patient allowed perfect freedom. The instantaneous relief afforded by this operation is among the most cheering spectacles which the surgeon ever meets. There is usually some coughing, often with expulsion of membrane, and rarely expulsion of the tube as the result of violent cough. It is ordinarily best to reinsert the tube should it be thus expelled, using perhaps the next larger size.

The dangers of intubation are few. One danger is suffocation from too large a finger or one held too long in the larynx; consequently several rapid attempts are better than one prolonged effort. Another danger is that of pushing down membrane ahead of the tube in quantity sufficient to produce obstruction; but this happens very rarely. Should it occur, the tube must be quickly removed by the string, and then reintroduced as soon as the membrane has been expelled. Small pieces of membrane are usually coughed up and driven through the tube. Tubes when expelled from the larynx are rarely swallowed, but are ejected through the mouth. The only danger of losing the tube into the stomach is from not placing it properly in the larynx, or else from leaving the thread to be subsequently swallowed and draw the tube after it. Even if swallowed the tube will usually pass without trouble. These tubes are to be retained on an average for six days. Sometimes they may be removed sooner, or if coughed up may not need to be reintroduced. It must be remembered that they rest upon the false vocal cords, and not upon the true, and consequently the loss of voice which is apparent after their removal is not likely to be more than very temporary. Of course while the tube is in place the child can only whisper.

One positive disadvantage which these tubes entail is difficulty of deglutition, especially during the time they are worn. This is to be overcome in two or three different ways: First, by feeding the child only so small an amount of fluid that even if a part of it enter the trachea through the tube it can cause no serious irritation. Secondly, by putting the child in such position that the force of gravity will prevent this accident. This is done either by turning the child well over on its side, or, better still, by putting it in a position where the head is lower than the body while drinking or feeding. This can be easily done in spite of theoretical objections. Thirdly, by giving it food which is of semifluid consistency, and for this purpose ice-cream is often found to be soothing, palatable, and nutritious. During the time that the tube is worn the air in the room should be kept warm and moist, while such medical and local applications are continued as to the surgeon may seem fit.

Finally, after a few days comes the question of removal of the tube. This is sometimes solved by its expulsion by the patient; at other times it has to be removed by a manœuver quite similar to that by which it was introduced, the patient being held in the same way, and the left index finger being again the guide by which the point of the extractor (E) is carefully guided into the opening in the metal. The point being engaged in the caliber of the tube, the blades are sprung apart by the thumb of the right hand acting on the shank of the instrument, and the tube is, as it were, hooked out and withdrawn. This procedure is usually more difficult than the introduction of the tube, but practice, especially upon the cadaver, will quickly make perfect. These tubes are of metal plated with gold, with an expansion at their middle, and are purposely made heavy in order to prevent their spontaneous expulsion. After use in one case they must be carefully cleaned, sterilized over the flame or by boiling, and thus may be used over and over again. They may also be replated from time to time.

Intubation is also a measure which may be resorted to for the treatment of syphilitic or cicatricial stenoses of the larynx, and this simple method can be made to take the place of the more painful and less serviceable dilatations of the larynx recommended by various, especially foreign, surgeons. In a case of this kind it answers every purpose to let the patient wear an intubation-tube for a few hours, or a day or two, at a time, quieting reflex excitability, if necessary, by local applications of cocaïne or by morphine or other opiates internally. The advantage of the continuous dilatation lasting for several hours over a momentary dilatation by an instrument like Schroetter's will be apparent at once.

The systematic practice of intubation has been a distinct advance in the surgery of the windpipe and larynx, and a larger proportion of lives can be saved by this measure than by anything else that we know of. When the question of operative relief is raised, it should therefore be decided, if practicable, in favor of intubation early performed.

One practical hint in the after-treatment of cases either of tracheotomy or intubation seems of great importance, and that is not to lose sight of the fact that many of these little patients, especially those suffering from diphtheria, are in a state of profound systemic poisoning, with the heart muscle very much weakened, and that part of the secret of after-success lies in recumbency, in proper nourishment, and in appropriate tonic and stimulant treatment addressed to the heart, for which purpose alcohol and strychnia seem especially indicated.

LARYNGECTOMY.

Resection or extirpation of the larynx is one of the modern operations conceived of on theoretical grounds and proved feasible by experiment upon animals. It is performed especially in cases of malignant tumor located within the larynx, with little or preferably no involvement of adjoining tissue. The operation has also been performed for stenosis, for lupus, for necrosis, and once or twice for tuberculosis. A few operators have not hesitated to extend the field of operation beyond the larynx proper, and in one case Langenbeck extirpated the larynx along with the hyoid bone, the base of the tongue, the submaxillary glands, and a part of the pharynx and œsophagus; during the operation he was compelled to tie both the external carotids. The operation is always one of great gravity, the amount of which neverthless depends in an appreciable degree upon the condition of the patient. Nevertheless, its results have been so conspicuously successful in cases otherwise absolutely hopeless

that one need never hesitate to advise it when the general condition outside of the larynx is favorable.

When time is not too pressing, it is a great advantage to make a preliminary tracheotomy one or two weeks before the major operation. If the operator have his choice, the trachea should be opened high up, in order that a part or the whole of the same opening may be utilized later. This, however, is not absolutely essential, although it simplifies matters and accustoms the patient to breathing through the neck. The incision for laryngectomy should be a long one, in the middle line, from the neighborhood of the chin down well toward the sternum. This is to be deepened until the larynx proper is exposed, as well as the membranes above and below it. By careful dissection or separation, the soft parts, muscles, etc. which arise from the larynx or are adherent to it are separated from it, unless involved in the disease, in which case they are to be removed with it. Bleeding vessels are caught with forceps, and subsequently ligated if required. The isthmus of the thyroid, if not divided in the preliminary operation, must now be severed between two ligatures. The larynx and the upper ring or two of the trachea are thus freed anteriorly and laterally. The upper ring of the trachea is now carefully separated from the œsophagus without tearing it, and the latter is then carefully parted from the posterior surface of the cricoid cartilage, at the upper limit of which it terminates. Here it will be divided when the larynx is finally removed. The complete exsection of the larynx may now be begun from above through the thyro-hyoid membrane or from below by separation from the trachea,—it makes very little difference which; but, inasmuch as the patient is now breathing through the trachea-tube, it is necessary that blood should be prevented from trickling down the trachea along the side of the tube. This is done by tamponing with sponge or by using some form of tampon canula. The superior and lateral continuations of the larynx are now rapidly divided and the larynx quickly lifted out of its position. This being done and all hemorrhage checked, careful search is made to see that no remnants of the disease are left. The epiglottis is usually removed with the rest of the larynx, although when completely free from disease it has sometimes been left. Still, little is gained by leaving it, and it is probably better always to remove it. The wound of the previous tracheotomy having probably been reached in the more complete operation, the trachea-tube, which should be now large enough completely to fill the trachea, may be inserted through the previous opening or may be shifted so as to enter the upper divided end of the trachea.

The resulting wound is large and will gape widely, but experience shows that it is best to make little if any effort toward reuniting it, as it will heal quickly by granulation, with rapidity commensurate with the rearrangement of the parts under the new conditions established. The posterior wall of the œsophagus being continuous with that of the pharynx, the anterior portion will be divided at a point at the level of the cricoid. While the rest of the wound is tamponed with antiseptic gauze, and while the trachea-tube must be firmly packed with the same, it will be well so to arrange the packing that easy access may be had to the œsophageal opening, in order that should the patient vomit the whole dressing need not be disturbed, and in order also that after a day or two it may be utilized for stomach-feeding by the introduction of a stomach-tube. The air of the room should be kept moist and warm. The patient should be fed by the rectum for a little while, and nothing which may irritate the stomach or provoke vomiting should be permitted to enter it. After the first day or two the patient is fed with milk, raw egg, and peptonized meat preparations by the stomach-tube, which may be inserted three or

four times in the twenty-four hours, unless it has been left permanently in place, as is often done. After two or three weeks the wound will probably have so far filled up with granulations that the feeding-tube will have to be passed by the mouth.

As cicatrization follows the granulating processes, preparation should be made for the introduction of some artificial substitute for the larynx. This is known as the artificial larynx, and is commonly made of light metal, usually of silver. It consists of a trachea-tube of large size, through an opening in the upper surface of which passes a second or pharyngeal tube, the upper extremity of which occupies nearly the level of the glottis. If an opening in each has been made to correspond, air may enter through the mouth and pass down the windpipe, provided the external opening be closed with a cork or plug. Until the patient has acquired the ability to swallow under the new conditions it will be necessary for him to pass upward from without through the upper tube an obturator which shall so close it that food may not pass down into it; but after a while patients learn to swallow without this, and to breathe and whisper with ease. A further refinement has been made by the introduction, into the interior of the tube, of a vibrating metal reed which shall take the place of the vocal cords, and by which tone may be produced. This is so modified by the parts above, as in normal voice-production, that a number of patients supplied with this attachment have been able not merely to speak, but also to articulate so plainly as to be easily heard and understood at reasonable distance.

Unilateral laryngectomy is a modification of the foregoing which includes the removal of a lateral half of the larynx, naturally for disease limited to one side. It is performed upon the same general principles as the complete extirpation, but while less formidable in theory and in description, it is perhaps a more difficult operation, inasmuch as the mechanical details have to be carried out in a restricted space. The partial operation has been successful in about one-half of the total number of instances, and the complete operation in something like 25 or 30 per cent.

SECTION III.—INJURIES AND DISEASES OF THE CHEST, PLEURA, AND LUNGS.

Pleuritic Effusions.—Serous effusions into one or both pleural cavities may be the result of acute or chronic inflammation of the pleura or lungs, or both, also of the presence of tumors or foreign bodies. The tumors need not involve the pleura, but may cause passive effusions by obstructing the return circulation. The large majority, however, of cases of hydrothorax with which we have to deal are the result of so-called pleurisy with effusion. These cases become of special surgical interest, naturally, when the collection of the fluid assumes such magnitude or such permanency as to call for mechanical measures for its removal.

The **signs** of the presence of fluid in a pleural cavity are virtually the same whether this fluid be serum, blood, or pus. In brief, they are these: The patient is apt to lie on the affected side, by which the sound lung is afforded better play. On inspection there will be found limitation of motion of this side, and the intercostal spaces may bulge or at least be level with the surfaces of the ribs. The apex of the heart, too, will be dislocated to one side or to the other in proportion to the quantity of fluid present. Its displacement to the left is never so great as that to the right. The liver may be displaced downward. On palpation there is no friction; fremitus and vocal fremitus are diminished or lost over the fluid. When the chest wall is œdematous the con-

tained fluid is purulent. By measurement the affected side will be found larger than the well side. Upon percussion there will be dulness over the lower and posterior surface of the chest, giving place to flatness, and, as fluid is increased in amount, accompanied by a sensation of increased resistance under the percussing finger. This dulness will have a certain level, which in all probability will alter with the position of the patient, while there will be pulmonary resonance just above this line. When the amount of fluid is very great, flatness may extend upward to the clavicle. Over the sound lung there is exaggerated vesicular resonance upon auscultation; the respiratory murmur is weak or absent over those portions occupied by fluid, while, as the lung is compressed, the breathing takes on a bronchial character. In mild cases friction sounds are sometimes heard.

When these signs are found, one may be quite sure of the presence of fluid. In order positively to prove the diagnosis, if such conviction be required, the needle of a hypodermatic syringe or of an aspirator may be introduced; through this thin serum will always flow. It may be possible, however, for a small needle to become clogged by a fragment of blood-clot or of fibrin or of caseous pus, so that while the discovery of fluid with a fine needle is always positive evidence, failure with the same needle to get fluid is not necessarily the reverse, and only with the large-sized needle can this question be settled.

EMPYEMA.

This term is applied to a collection of pus in any cavity, but by common consent, unless some other cavity is specified, it is understood to refer to that of the pleura. Pus may be found here as the result of the same causes that bring about serous effusion, plus the contamination by organisms from the lungs or more remotely through the systemic circulation. In cases of penetrating injury of the pleura, when air has entered this cavity it is not unlikely that collections of blood or serum will become thus directly contaminated, and empyema be the result almost from the outset. As a rule, however, it is the result, perhaps the termination, of a chronic process. In recent cases the pleura does not have time to become very much thickened; but in long-standing cases, especially those in which spontaneous perforation has occurred, the pleura becomes infiltrated and altered, so as to lose all resemblance to its original structure, and to be found sometimes a centimeter thick. Under these conditions it is more like leather than like a living tissue. A collection of pus having occurred within the pleural cavity from any cause, several possibilities exist for it: its fluid portion may be gradually absorbed and its solid material remain to cement the pleural surfaces together and to caseate, and finally to disappear; or it may excite further production of fluid of the same character, which will produce such urgent symptoms as to necessitate relief; or it may evacuate itself either by rupture into a bronchus or bronchiole and escape by the mouth or by perforation elsewhere in any one of various directions. Thus it has been known to burrow down around the external intercostal muscles which terminate under the intercostal cartilages and to appear at various points about the thorax, or to perforate or burrow around the fibers of the diaphragm and cause perhaps a subdiaphragmatic abscess, or to take some other unusual course. It has, for instance, been known to perforate behind the mammary gland, and, pushing itself forward, to assume enormous size as a retro-mammary abscess; or to separate the diaphragm, and then the peritoneum, and to make such a dissection of it from the abdominal wall as to appear in the pelvis and in the abdominal wall as an enormous extra-peritoneal abscess.

But these are unusual cases, and it ordinarily gives rise to the same character of disturbance as a collection of serous fluid, with the addition of the constitutional signs of the presence of pus, such as chills, irregular high temperature, emaciation, hectic, etc.

I. The *idiopathic* forms of empyema may be thus classified:

a. Staphylococcus and streptococcus form of infection of pleuritic exudate.

b. Diplococcus form, from Fränkel's diplococcus pneumoniæ, probably originally the result of a pleuro-pneumonia, the pneumonic lesion having cleared up.

c. Tubercular form, the result of tubercular pleurisy, which may be contaminated with pyogenic cocci.

d. Secondary and embolic form, due to a suppurative focus elsewhere (*e. g.* retro-pharyngeal abscess, perforating peritonitis, pyemia, etc.).

e. Putrid form, from contamination by saprophytic bacteria.

II. The *traumatic* form must be regarded as comprising cases of—

Simple and mixed infection from burns, wounds, foreign bodies, etc.

The surgical **treatment** of empyema—and it scarcely permits any other—is by paracentesis, *i. e.* aspiration, or free incision and drainage. In simple cases the former may be first tried, as described above. Serious or long-standing cases should not have time thus wasted upon them, but should be subjected at once to some form of thoracotomy (p. 626).

HEMOTHORAX.

By this term is meant a collection of blood in the pleural cavity. It is almost always of traumatic origin, although the possibility of spontaneous hemorrhage cannot be excluded. We meet with it most often in cases of fractured ribs, where a sharp fragment of bone has scraped the surface of the lung during respiration until the lung is removed from harm's way by the presence of serum or blood pressing it away. Furthermore, it is seen in cases of gunshot or stab wound where an intercostal artery or some vessel in the lung has been divided, and where blood, even to fatal amount, has collected. The general physical signs already given in some detail will point to the presence of fluid, and the history of the case or of the injury, with aspiration, if necessary, will enable the surgeon to decide which condition he has to deal with.

OPERATIVE TREATMENT OF FLUID COLLECTIONS IN THE PLEURAL CAVITIES.

PARACENTESIS.—The indications for removal of fluid from the pleural cavities, without reference to the stage of the disease, in moderate effusions are dyspnea and distress, and the recognition of the presence of large amounts of fluid, whether other symptoms and signs are violent or not; furthermore, the failure of nature or art to cause resorption within reasonable time, on the average three weeks; spontaneous perforation into the lung; the presence of fever, perhaps with chills, and bulging of intercostal spaces, with œdema of the overlying skin, which are supposed to indicate the presence of pus; or the certainty from the history and physical signs that blood has been poured out and has not been resorbed. There are other reasons than the mere necessity to obtain immediate relief why evacuation should be secured. By the presence of fluid the lung is naturally compressed and its integrity impaired, with a prospect of permanent injury to its function if it be not permitted to resume its former shape and size within a reasonable time. We may also be sure that

the longer it has been compressed the less elastic it is and the more difficult will be its expansion.

PARACENTESIS THORACIS.—The term paracentesis is applied to evacuation of fluid from any cavity, the particular cavity being specified in the name of the operation. To Bowditch of Boston is due the credit of having first applied suction for the evacuation of fluid effusions, a method which has now become so general as scarcely to call for comment. For this purpose there are needed a hollow needle or fine trocar, some flexible tubing, and some mechanical device for suction. In the absence of all other means, siphonage may be practised through a yard or more of rubber tubing first filled with aseptic solution and its lower end kept constantly under water; or a Davidson syringe may be used, or one of the more elegant forms of aspirator, or the Allen surgical pump, although if the emergency be very dire an ordinary trocar, or even the puncture of a tenotome blade, may be resorted to. The two main indications are to withdraw the fluid and to prevent the admission of air. If air can be kept out, the lung must necessarily tend to expand in order to take the place of the fluid which is removed. Inasmuch as this should be anything but a rapid process, the needle should be only large enough to permit fluid to run easily through it and carry perhaps with it fine flocculi of fibrin, otherwise pulmonary hemorrhage, or at least violent intrathoracic distress, might ensue. Before using it the needle should be cleaned and polished and then sterilized by passing it through the alcohol flame. Unless patients are too weak to sit up, they are placed in a sitting posture. It is well to give a little stimulant before and perhaps during the operation. The needle is inserted in an intercostal space either just below the lower angle of the scapula at the back, or at the side just in front of the latissimus dorsi muscle. Before introducing the needle the skin should be scoured and made aseptic; and it should be inserted quickly. It is perhaps well to guard the needle with the finger, lest by too forcible a plunge it be inserted too far. There is always a possibility with a too fine needle that some particle of fibrin or clot or caseated pus may obstruct it so that nothing will flow out. Most of the aspirator needles are provided with wires which may be inserted into them after being cleansed, and with which they may be cleared out. Should fluid still refuse to come, especially if the anterior end of the needle appear to work freely as if in a cavity, it is better to withdraw it to see that it is clear, and then to introduce a larger one. The withdrawal of a needle should be done as quickly as its introduction; after which the puncture is sealed with plaster or collodion.

Sometimes patients become so weak or faint that it is necessary to put them in the recumbent position or even to stop the aspiration for the time. The sudden expansion of the previously compressed lung certainly does often cause a most disagreeable sensation, while the withdrawal of the fluid perhaps allows the heart quickly to return to its normal position, by which its action may be temporarily disturbed. Perfect rest should be enforced for a number of hours after the operation.

Should the lung persistently refuse to re-expand after repeated tappings, it is scarcely worth while to make many efforts. Constitutional treatment with tonics will probably do more for these cases than surgery. However, should it be necessary after prolonged effort to do something, it would have to be in the line, probably, of excision of ribs as described below. It has been recently found that empyema, following pneumonia, is occasionally cured by tapping. When, therefore, the pneumococcus is found tapping should first be done.

When the effused fluid is purulent the **prognosis** after simple aspiration

is not nearly so good. In rare instances, especially in children, and in pneumonic empyemas, one or two tappings may suffice, but a condition of empyema or pyothorax differs but little from any other large abscess, save that it has a bony and unyielding wall, and it calls for incision and drainage after the same fashion.

THORACOTOMY.

Thoracotomy, or opening the wall of the thorax for evacuation of collections of fluid, consists simply in an incision, perhaps two inches long, through the skin over an intercostal space, the opening through the pleura being an inch or half an inch in length. When performing this operation the skin should be cleansed, as well as the operator's hands; the skin may then be slid upward for an inch or more above the point at which the opening is to be made, in order that when it returns to its place it shall exercise somewhat of a valve-like action. This will be of little use so long as the drainage-tube is in use, but may be of service later. To avoid a mistake it is well before finally dividing the pleura to insert a needle or fine trocar to see if pus be underneath. If found, no hesitation need be felt in perforating the pleura, being careful only not to push the knife too far in; or in allowing the pus to escape, which it will probably do by jets because of the patient's breathing or coughing. The best point at which to puncture is at the side just in front of the latissimus dorsi muscle, certainly not lower than the eighth interspace, and perhaps even as high as the sixth. Here the pleura is near the surface, and we gain the advantage of gravity in draining the chest, while drainage-tubes at this point cause little discomfort. Of course air enters the chest through the external opening, the air-pressure on each side of the lung is equalized, and there is no fear of distress from too rapid expansion of the lung. The pus from these cases is frequently fetid, but the fetor will usually disappear in a short time. Some surgeons advise washing out the pleural cavity, by which means pus-clots are removed and fetor of discharge is subdued, but when there is neither fetor nor débris discharged it is perhaps as well to omit irrigation. When this latter is practised we may use strong or saturated boric solutions or solutions of mercuric chloride, 1 : 5000, followed by boiled water or dilute Labarraque's solution. Through the incision one or, preferably, two good-sized stout drainage-tubes are inserted and fastened by silk sutures to the skin. They should be just long enough to reach from without fairly into the pleural cavity, and are introduced partly for purposes of washing and drainage, and partly to keep the opening from healing too quickly.

In some instances the ribs are so close together that any tube will be collapsed by their pressure upon it. When this is the case a section of rib, probably of the seventh, about an inch in length, should be removed. After the complete evacuation of an empyemic cavity a large quantity of antiseptic and absorbent dressing should be placed outside the wound, and over all this some impervious covering such as rubber dam. Outside this an elastic bandage around the chest will be of advantage, provided it be not too uncomfortable. This dressing should be renewed the following day, and after that every second day. As soon as the discharge becomes serous, and has diminished to a very small amount, one drainage-tube may be removed, and the second when the amount is no greater than would be caused by the presence of the tube. When the chest has thus been opened, expansion of the collapsed lung is finally attained in many cases.

Excision of Rib.—In certain cases it is evident at the outset, and in other cases it becomes patent later, that mere incision with insertion of drain-

age-tubes will not afford large enough and permanent enough vent. In such cases it is a common practice to remove a section of one or two ribs through a single external incision, the bony pieces being from one to two inches long. This makes a somewhat more formidable operation than the foregoing, and is advisable mostly in cases of longer standing. Whenever it is necessary to incise the chest for this purpose, we must expect to find the pleura altered from a thin parchment-like membrane into one which seems more like leather, and which may be correspondingly tough.

THORACOPLASTY (ESTLANDER'S OPERATION).

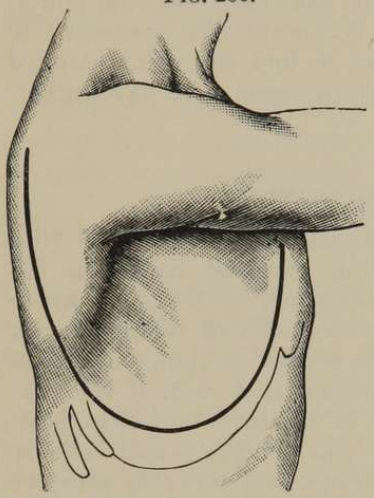
Finally, the surgeon is called at times to cases where the empyemic condition has existed for a long time, or where an encysted collection has formed, or where spontaneous perforation has occurred, so that he has to deal with a thoracic fistula, discharging at times a small, at times a large, amount of pus. In these instances the pleura has become so rigid and inflexible, and the lung so fixed in its abnormal position, that even if the cavity be widely opened by the ordinary method it is impossible for it to heal, since the lung cannot expand from within nor can the chest-wall collapse from without. The ribs now act like parallel hoops, and serve to preserve a cavity which we urgently desire to obliterate. This may be somewhat diminutive in size, or may be almost commensurate with the entire space normally occupied by one lung. It is in these cases that the thoracoplastic method devised by Estlander has rendered the most signal service. It is based simply on the theory that inasmuch as the inner wall of the cavity cannot expand to meet the ribs, the ribs must be so divided as to permit them to fall toward and meet the lung tissue. It offers a prospect of final cure for cases which are otherwise beyond such possibility. The smaller the cavity the simpler the operation, though one may not be deterred from resorting to it in extreme cases. Before deciding to operate, however, it would be well carefully to examine the patient and the urine, in order to recognize such signs of amyloid changes as would make it unwise to give anesthetics or perform any severe operation.

Inasmuch as it is usually necessary to attack several ribs, we must plan our incisions in such cases according to the size of the cavity and the amount of collapse desired. In the more simple cases it is enough to make a long incision from the axilla downward, and simply to divide or perhaps remove pieces from the third to the eighth or ninth rib. At other times an incision is made both in front and behind, and posteriorly at the inner border of the scapula, by which three or four ribs may be divided in front and from three to seven behind. Such an operation as this is very severe, and leaves the patient with a large passage clear through the chest.

When performing this operation, if the patient's strength hold out, it is well to do more than simply divide the ribs and the enormously thickened pleura. This pleura is practically the wall of an immense abscess, and from it shreds of membrane and disorganized tissue may hang like stalactites from the roof of a cavern. These cases are also usually tubercular, and such membrane is fraught with danger. It is advisable, therefore, to scrape and cut away from both pleural surfaces as much of it as can be safely removed without exciting too serious hemorrhage. No fear need be felt from the intercostal arteries, since it is a simple matter to check the hemorrhage with catch forceps and to pinch the bones sufficiently to compress the arteries. The altered pleura, as a rule, is not vascular, and it is surprising how so formidable an operation can be made with so little loss of blood. No attempts should be made to suture or

close the wound, but it is left as widely open as possible, and perhaps packed in order to keep it so. As granulations spring up on the freshened pleural surfaces we have a gradual process of healing by second intention or adhesion of granulating surfaces, by which the lung will be gradually drawn outward and the chest drawn inward. Considerable restoration of function also occurs.

Fig. 253.



Incision for Schede's Operation of Thoracoplasty (Esmarch and Kowalzig).

Schede's Operation.—In old cases, in which the pleura may be an inch thick, Schede has devised a still more radical operation. An incision (Fig. 253) is made from the level of the axilla in front to the second rib behind, the convexity of the incision reaching to the lowest limit of the pleura. The large flap is dissected loose down to the ribs, the scapula being lifted from the trunk. The ribs, from the second downward, from the costal cartilages to the tubercles, and the entire muscular chest-wall and the pleura, are then removed by large scissors or bone-forceps and the flap is replaced on the lung after thorough curetting. Any bleeding arteries are tied. Healing generally takes place by first intention.

GANGRENE OF THE LUNGS.

This may be either idiopathic or traumatic. It is more common in the lower than in the upper lobes. There are a diffuse and a circumscribed form. The former is usually of the embolic variety. Gangrene here, as elsewhere, is the result of bacterial invasion and putrefaction. The lungs may be invaded from within by foreign bodies taken in by inhalation or by "swallowing the wrong way." It occurs in marasmic patients, in the insane, in those that cannot swallow well nor cough, and in those with bulbar paralysis. It may also result from necrotic processes in the pharynx or larynx; also from perforation of septic foci from other tissue, as through the pleura or diaphragm, or from carious vertebræ or infected bronchial glands. It develops secondarily also from such conditions as fetid bronchitis or croupous pneumonia or bronchial dilatation; also by embolic processes from gangrenous bed-sores, puerperal septicemia, etc. It furthermore occurs as the result of injuries, such as lacerations, compound fractures, gunshot and stab wounds, etc.; or as the result of severe contusions with cerebral concussion by which respiration is interfered with and venous stasis encouraged; or by such injuries as cause endocarditis.

The **clinical signs** of gangrene of the lungs much resemble those of fetid bronchitis. The sputum as well as the breath has a most repulsive odor, and if the former be collected in a glass it forms usually three layers, the lower one consisting almost wholly of pus and débris. When of traumatic origin we have intense local and prolonged pain, severe initial chills, pyrexia, and, later, fetid expectoration. If the gangrene is localized in the lungs, ulceration may take place; when the pleura is involved it is fatal. By physical examination we can sometimes easily map out the extent of the gangrenous condition. Sometimes we get even the signs of a cavity. If such be near the surface, we may

be sure of adhesion between lung and chest-wall, and may see here a plain indication for surgical interference.

This may be rapidly and successfully performed by free incision down to the pleura, with resection of one or more ribs if necessary, and then the opening of the gangrenous pulmonary cavity, which is usually performed with the cautery knife. The danger of the operation can be scarcely as great as that of the condition if left unrelieved.

SURGERY OF THE LUNG.

Modern experimental methods have shown that in certain cases and in certain ways it is not only possible, but judicious, to attack the human lung. Centuries of clinical observation have made it clear that the entrance of air into the pleural cavity either from within or from without is by no means fatal, but may be an incident quickly recovered from. So long, then, as air has access, it matters little whether it be through a small opening or through a large one; that is to say, if necessary, we can expose the lung by a large incision. Thus far, the lungs have been attacked in cases of wounds, especially for the relief of hemorrhage, of gangrene, of abscess whether due to gangrene, dilated bronchi, or tubercular disease, for the drainage of cysts, for the removal of solid tumors, for the excision of foci of tubercular disease; and they may properly be attacked in certain cases for the removal of foreign bodies. We may distinguish between simple incision, or *pneumotomy*, and exsection of a portion of lung tissue, or *pneumectomy*.

Experiments on animals have shown that two-thirds or more of one lung can be removed through an incision in the thoracic wall with almost perfect impunity. So much as this of a human lung has as yet never been safely removed, but small portions have. Vivisection teaches us that although one pleural cavity be opened and its lung collapsed and made temporarily useless, the animal can get sufficient oxygen by respiring with the other lung, and that in case oxygenation be deficient or respiration suddenly stopped, it may be continued by artificial means almost indefinitely. Consequently, if the human patient must be subjected to some such ordeal as this, the surgeon should have at hand a trachea-tube and bellows or means for inducing artificial respiration. In the operations recorded, however, it has seldom been necessary to resort to them.

Pneumotomy in the presence of disease consists practically in the measures described above for opening gangrenous cavities. This is where we expect to find the lung adherent to the chest-wall. Should we fail to find it thus fixed, the lung should be drawn up toward the surface and snugly fastened there by a row of sutures. Within a few hours adhesion will have taken place, and the cautery may be used for penetrating deeper, as above mentioned. This would presumably be the better method for dealing with a foreign body in the lungs, provided we can locate it, and if it cannot be located it will be inadvisable to operate unless the chest has been already widely opened and the lung collapsed. In one instance after a stab wound of the chest a man was allowed to die because it was held that a large vessel in his lung had been wounded and that his condition was consequently helpless. It was found later, however, that the bleeding all came from an intercostal artery, through which the man had bled to death into his own chest. In this case the result might have been very different had free incision been made and the source of the hemorrhage sought for.

Pneumectomy may be done in a similar way, as when a hernia of the

lung, recent or old, is excised; or it may be forced upon a surgeon when in operating upon a malignant tumor of the chest he finds the lung adherent behind it and involved in the disease. Success has been obtained in such cases, the wound in the lung tissue being closed according to usual methods. Or it may be done with deliberation, as in the case where an Italian surgeon resected a tubercular lobe from one lung of his *fiancée*, and later committed suicide because of the fatal effect of his operation.

INTRATHORACIC TUMORS.

Intrathoracic tumors may spring either from the thoracic wall or from the thoracic viscera. Of the former, the most common are exostoses and enchondromata, which may develop in pedunculated form or as extensive sessile masses involving several bones or cartilages. Malignant tumors, the most common of which are sarcomata or mixed tumors, also develop in the same way. Tumors springing from the thoracic wall, whether developed internally or externally, constitute legitimate subjects for consideration with reference to operative relief, the decision being grounded upon their character, extent, and probable adhesion to the viscera of the thorax. Operations by which portions of several ribs involved in such tumors are excised have been performed with success, as well as operations for the removal of the sternum when that is the primary seat of the disease. They are extensive and most severe, and should never be made without a statement of their dangers to the patient and his assumption of risks. In most if not all of them the costal pleura at least will be so involved that free opening of the pleural cavity, with collapse of the lung, is inevitable. There would be no object in attacking such growths were the overlying integument so involved as to prevent its preservation for covering the defect. When, however, the tumor simply involves one or two ribs only, and is of an osseous or cartilaginous nature, it is quite possible in most cases to remove it, subperiosteally, without opening the pleura. But little danger attends such cases.

Tumors involving the contents of the thorax lie, for the most part, outside the present domain of operative surgery. Nevertheless, a few of them demand operative measures. Such, for instance, are substernal dermoid cysts, hydatid tumors of the lung, actinomycotic masses, and possibly others of non-malignant character. Most of such growths are, in the first place, difficult or impossible of diagnosis, and in the second place involve parts too vital to admit of interference.

The **diagnosis** is made largely by a process of exclusion, as well as by symptoms of pressure upon nerves and vessels and by a study of physical signs. While the future may have it in store for us, the time has hardly yet arrived when it will be considered advisable to open the thorax for purely exploratory and diagnostic purposes, although little fear may be felt about the careful use of the aspirator needle. The microscopic study of the sputum may also yield valuable evidence. If a solid tumor in any way could be recognized as involving a circumscribed part of one lung, it might be warrantable to remove the affected portion. It has very recently been suggested to open the thorax from behind by resecting ribs from a line near their angles to the inner side of the scapula, by which reasonable access is permitted to the root of the lung. Some such procedure as this may be made serviceable in selected cases by bold operators. Possibly also certain aneurysms within the thorax may be attacked in this way.

INTRA-THORACIC CYSTS.

Although in America they are very rare, the most clearly defined, and in some countries the most common, intra-thoracic cysts are hydatid or echinococcus cysts within the pleural cavities. They may develop as free cysts, or more commonly in connection with the lungs or with the thoracic wall. Those which have primarily formed within the liver sometimes perforate the diaphragm and involve the pleura or even the lungs. For the most part they contain daughter cysts within themselves, and may attain a size even as large as that of a child's head. They cause usually considerable pain, which is increased on lying upon the affected side, and are accompanied by dyspnea. Unless they suppurate, the course of the disease is feverless. The veins over the lesion are prominent, the chest-wall may be pushed forward, and the intercostal spaces widened and fluctuating; the liver and the heart may be displaced. The aspirator needle will give the most positive results, the fluid withdrawn being free from albumen and sometimes containing hooklets.

While puncture will afford temporary relief, and injection of iodine may possibly result in cure, the most satisfactory result is afforded by free incision, if necessary with resection of ribs, and packing the cavity with gauze, by which free drainage is afforded.

CONTUSIONS OF THE CHEST.

These may occur in a great variety of ways, as by the passage of vehicles over the chest, by severe blows, by being caught between cars, etc. The chest is constructed in a wonderfully elastic way, and it is surprising what contusions it will commonly resist without serious injury. Mild contusions give rise to ecchymoses and bruises from which sloughing rarely may occur. Even abscess following such injuries is rare. Fractures of ribs are the most common serious lesions; these are discussed under their own heading. The chief symptoms attendant upon such injuries are pain, which sometimes is quite severe, and such soreness as effectually for the time being to disqualify the muscles from acting. Consequently, patients insensibly adopt the abdominal method of respiration, while such involuntary efforts as coughing and sneezing give intense pain. They assume a characteristic attitude, usually on the back, lying far enough upon the injured side to rest it and give freer play to the other side.

The **treatment** of these conditions is mainly the enforcement of rest, with such compression of the chest-wall as will limit its motion. This is best carried out by a snug bandage, by a broad binder, or by a broad piece of adhesive plaster drawn nearly or quite around the thorax. This should be omitted only in case it adds to the patient's discomfort instead of relieving it. Such local treatment as may be appropriate may be instituted either by anodyne applications beneath the bandages or by hot or cold applications outside.

Contusions involving the Thoracic Viscera may be of the most complicated character. The amount of damage done within the thorax without visible external evidence in certain cases is astonishing. This includes rupture of vessels of the lung, rupture of the heart or pericardium, or such minor lacerations as lead to hemorrhagic or inflammatory results. The heart appears to experience results of concussion in many respects analogous to those from concussion of the brain; indeed, fatal results have followed such injuries where even on autopsy no alteration was discovered. In the more severe injuries blood may be thrown out in quantity beneath the pleura or into the lacerated lung substance, by which many of the signs of circumscribed pneu-

monia will be caused; in fact, also pleuritis and pneumonia of acute form are not infrequently met with and sometimes run a fatal course. One sign of rupture of the lung is the existence of emphysema, beginning either at the base of the neck or in the epigastric region and extending thence upward or downward. It is worth while to bear in mind that such emphysema may occur without any fracture of the thoracic wall.

Rupture of the lung may be quite extensive, and occurs in military as well as in civil practice, such an injury, for instance, as a blow on the chest by a spent cannon-ball having caused it. Rupture of the lung of course implies extensive hemorrhage, with expectoration of blood or bloody mucus, and effusion of blood into the chest in case the surface of the lung be torn. While recovery is not impossible, it will be accompanied by serious inflammatory disturbances, with permanent impairment of function. The heart and pericardium have been also thus ruptured, and the heart has been completely separated from its attachments, without more serious injury to the chest-wall than a trifling abrasion of the cuticle. In all cases of rupture of the pericardium the tear has been of large size, and for the most part the injury has been accompanied by fracture of the ribs or the sternum, or of both. A case is also on record where the wadding of a small cannon struck a man in the chest without injury to its wall, and the heart completely burst the pericardium.

WOUNDS OF THE CHEST.

These may be divided into the non-penetrating and the penetrating. There is practically no limit to the amount of possible laceration of the soft parts about the chest. The immediate danger attending them is from hemorrhage, while septic disturbances, including erysipelas, gangrene, and tetanus, are among their possible consequences. The possibility of pleurisy and pneumonia as immediate sequels must not be overlooked. In rare cases also peritonitis or a pericarditis or endocarditis develops in an unlooked-for manner, which is to be explained probably upon the theory of septic embolism. In such wounds, whether incised or lacerated, the routine should be as elsewhere: first hemostasis, then removal of all foreign material, and, if the parts are rudely lacerated, excision of all torn and ragged tissue, careful suture with or without drainage, and finally an antiseptic dressing.

Penetrating Wounds of the Chest.—These may be of the most varying character, from the slightest perforation with a minute instrument or weapon or the smallest bullet up to the most frightful loss of substance. They are dangerous in proportion, first, to the amount of hemorrhage which they produce, and, secondly, to the amount of air and especially of any foreign or septic material which has been introduced or permitted to enter.

The first mentioned is the most immediate danger, and its relative extent is to be judged of at the time by the direction of the penetrating substance, if known or if it can be ascertained, and by the general condition of the patient.

Inasmuch as wounds of the heart are elsewhere considered, we shall speak here for the most part of injury to the lungs. If the patient expectorates blood, the existence of a wound of the lung may be instantly recognized. If air can be heard entering the chest or if the lung on one side is evidently collapsed, it is a sign at least of perforation of the pleura upon that side. If collapse is extreme and if death rapidly ensue, in all probability a large vessel has been injured. If the diaphragm is paralyzed, it implies injury of the phrenic nerve; if the heart is tumultuous in its action, there has been injury either to it or to the pericardium, or else to its nerve-supply. If the external

wound bleeds freely, the blood probably comes from one of the intercostal or mammary arteries. If a weapon has been used, much information as to depth of perforation, etc. may be obtained by examining it.

But no such conclusions can be drawn in cases of bullet wounds unless there be a wound of entrance and none of exit, which implies of course that the bullet is somewhere within the tissues. A bullet, under these circumstances, is not likely to be arrested by the lung, although it may be by the substance of the heart. Consequently, if the lung has been thus injured it has probably been perforated. Careful search for a wound of exit should always be made, since there have been instances in which careless practitioners probed and hunted for bullets which had passed completely through the body, the wounds of exit being found upon simply turning the patient over. Nevertheless, it is necessary to ascertain, if possible, when two bullet wounds are found, whether one or two shots have been fired. It is not every bullet or stab wound of the chest that will cause perforation of the pleura. A bullet or the blade of a knife may be deflected by the ribs or the scapula in such a way as to pass perhaps a long distance through the tissues without entering the thoracic cavity.

Emphysema is another evidence of perforation, at least of the costal pleura, which will increase with time, and which may not exist at the moment of first examination if it be made immediately after injury. Hernia of the lung of course is positive evidence of perforation of the chest-wall.

The **treatment** of penetrating wounds of the chest must necessarily depend in large measure upon their character and extent. Injuries to the large vessels are usually rapidly fatal, and for these surgery as yet has little to offer; but when no such immediate danger threatens the surgeon should seek first to check hemorrhage, enlarging the wound by free incision, and ligating vessels or tissues *en masse* according to circumstances. Although intercostal vessels are protected by the groove in the lower border of the ribs in which they lie, it is nevertheless not difficult either to wound or to secure them. A bleeding internal mammary vessel is much more difficult to secure, and yet its course, parallel to the border of the sternum and a short distance from it, though inside the thorax, is well known, and should other measures fail a large stout needle carrying a strong silk ligature might be passed into the chest under it and out again in such a manner as to include it within the loop. Should other measures fail, bleeding may be checked by a compress of aseptic gauze plugged tightly into the wound.

Above all things, it is needful to warn against useless exploration, especially with the probe, in cases of bullet wound, since with the probe nothing is ascertained which could not otherwise be learned, while by its use protective blood-clot is broken up and septic matter is frequently introduced. Hemorrhage being checked and the region of the wound being thoroughly cleansed, aseptic occlusion is probably the best course, at least for the average practitioner, to pursue. The day may come when the thorax will be opened for access to the wounded lung, pericardium, and heart, and the experimental results of Block and others warrant this belief; but the time has not yet arrived when the general recommendation of this course is justifiable. Such blood as is poured into the pleural cavity ordinarily coagulates rapidly and is subsequently absorbed. If it still be fluid, or if later it should liquefy, or if serous effusion or purulent degeneration takes place, its effects may be overcome by aspiration or by incision and drainage.

COMPLICATIONS OF CHEST INJURIES AND THEIR SEQUELÆ.

These have been in the main already considered; still one or two of them deserve distinct consideration.

Pneumocele, or Hernia of the Lung, is a rare result of incised or lacerated wounds which penetrate the thorax. It may be primary or secondary. The former may occur in oblique wounds, the margins of which act as valves to prevent the ingress of air, while they permit a small portion of one lobe to be expelled by violent efforts in coughing. In another class of cases the lung may escape at the time of the infliction of the wound. The secondary herniæ of the lung are those in which the wound is of large size and the lung escapes some time after the infliction of the injury, or in which it occurs during the removal of fragments or during the cicatrization of the wound. When the protruding portion is not adherent it should be thoroughly cleansed and restored to its proper cavity; when fixed in place, ligature or excision is to be recommended.

Emphysema.—This has already several times been mentioned. By this term is meant the escape of air into the cellular tissue outside of the thorax proper. Usually, when present, emphysema extends to a distance of several inches around the wound, and sometimes involves the entire neck and trunk. After compound fracture of the ribs, for instance, it has extended as high as the scalp and as low down as the thighs. It is in no wise dangerous, except that it may be so excessive as to interfere with respiration, or that the air may be infected, in which case cellulitis, erysipelas, abscess, or even gangrene, may be the result. Ordinarily the air is taken up into the blood-vessels by osmosis and disappears within a few days. Should it give rise to great disturbance, multiple punctures in the skin will facilitate its escape.

The other sequelæ of chest injuries are mainly septic or inflammatory, and are to be dealt with according to their nature and upon generally accepted principles. Cicatricial contraction may cause deformity, or injuries of special nerves may lead to vague or peculiar muscular, sensory, or trophic disturbances, which, however, can hardly be considered here.

MEDIASTINAL ABSCESS.

This may be idiopathic, secondary, or traumatic. As a purely idiopathic condition it is extremely rare. The secondary form may be consequent upon abscess in the neck, burrowing down behind the deep cervical fascia, or upon tubercular trouble either in the neck or within the thorax. The traumatic variety may follow contusions, but has been most common after fractures of the sternum or gunshot wounds. Such abscesses are characterized by a sense of weight in this region, by pain on coughing, drinking, sneezing, etc., by a sense of being out of breath, by more or less œdema over the sternum, and by the constitutional signs of the presence of pus. When these signs are present the proper course will be to trephine the sternum, to explore carefully with the hollow needle, and, if pus be found, to open, wash out, and drain the cavity.

SURGICAL AFFECTIONS OF THE DIAPHRAGM.

This muscle constitutes the natural septum between the thorax and abdomen, and has fixed attachments to the spine and to the lower portion of the thoracic wall. It is capable of considerable displacement upward and down-

ward; in forced expiration it rises to the right third cartilage, and in forced inspiration descends to the right fifth intercostal space. On the left side it is one or two ribs lower. In cases of enormous abdominal distention it has been found as high as the second rib, and in cases of enormous pleural effusion as low as the false ribs. It, however, never loses its convexity. Most of its upper surface is covered by pleura, and most of its lower surface by peritoneum; these two membranes therefore come into very close relation here. Still, there is a small surface where the liver comes into actual contact with it, and at this point a ball penetrating from behind at about the tenth dorsal vertebra might enter the liver without wounding the peritoneum.

Congenital Defects.—The sternal portion of this muscle is sometimes wanting, and absence of other portions is occasionally seen, a case being on record of a child which lived ten days in whom the left half was entirely wanting. Through such openings the abdominal viscera, most commonly the stomach, may protrude into the thorax, constituting a *diaphragmatic hernia* (*q. v.*). Various muscular additions have also been observed, but these anomalies are rare.

Paralysis.—Paralysis of the diaphragm may occur in the course of pleurisy, diphtheria, disease of the spinal cord, or lead-poisoning; or it may be hysterical, or due to injury of one or both phrenic nerves, or to the destruction of their roots in rapidly ascending degeneration from injury to the cord in cases of fracture or dislocation of the spine. It may be unilateral or bilateral, and complete or partial. It is characterized by difficulty in breathing, the abdomen sinking during inspiration and becoming fuller in expiration, thus reversing the natural order. All efforts which require fixation or contraction of the diaphragm, such as coughing, talking, etc., are made difficult or impossible.

The **prognosis** must depend upon the cause, and **treatment** must be directed to the removal of the same. In idiopathic or non-surgical cases the faradic current, with one pole applied over the phrenic nerve in the neck, the other over the diaphragm, is said to have given good results.

Hernia.—See *Hernia.*

Wounds.—Wounds of the diaphragm are inseparable from those of the abdomen or chest, and are of importance according as the viscera on either side of it have been injured. It is occasionally torn by the jagged end of a fractured rib. Perforating wounds of the diaphragm, however, are not necessarily fatal, and many patients have recovered who have been shot in such a way that the bullet has first entered the abdominal cavity, passed through the diaphragm, and traversed the pleural cavity, or the reverse. The prognosis of such wounds, therefore, is not necessarily bad, although they are always of the most serious nature.

The diaphragm may be perforated as the result of abscess, of tumor, especially cystic, or of fatty degeneration. It is not an uncommon thing for it to give way before advancing pus in cases of abscess of the liver, profuse adhesion of the lung above it having taken place in such a way that pus is evacuated through the bronchial tubes and the mouth. The same is true of subdiaphragmatic (subphrenic) abscess.

Rupture.—This may occur as the result of contusions either of the abdomen or of the chest, and occurs more frequently upon the left side, the presence of the liver upon the right apparently affording protection. Through such ruptures diaphragmatic herniæ frequently occur. When the rent is small, it is usually the intestine which passes through; when large, the stomach, or perhaps both stomach and bowel. The consequence of this is sometimes immediate

strangulation of the bowel, at other times great embarrassment of respiration, with vomiting.

The **diagnosis** of this condition is too often only made *post-mortem*. When, however, it is made probable by the character of the injury, and when the condition of the patient will warrant it, it is proper to open the abdomen and explore. Still, in consequence of anatomical conditions this procedure, coupled with that for repair of the damage, would be so difficult and prolonged as to deter most operators, though it has been done successfully.

A question of medico-legal interest has been raised about these injuries, whether such a hernia could be proved to have resulted directly from such injury or to have antedated it. The presence or absence of a hernial sac will settle this question.

CHAPTER IV.

DISEASES AND INJURIES OF THE NECK.

A POINT in the anatomy of the neck to which too little attention is generally directed is the constitution of the so-called **branchial folds** and **clefts.** Very early in fœtal life there are found on each side of the head, behind the rudimentary aural cavity, four fissures which communicate with the upper end of the future alimentary canal. In the human embryo the third and fourth of them should have disappeared by amalgamation about the sixth week, and the second by the tenth. Only the first remains persistent, and appears as the Eustachian tube, tympanic cavity, and auditory meatus. Between these clefts develop the so-called branchial arches or folds. From the first of these is developed Meckel's cartilage, which helps to form the lower jaw; from the second, two of the small bones of the ear, the styloid process, the stylo-hyoid ligament, and the lesser cornu of the hyoid bone. Its great cornu and body develop from the third. Of the fourth branchial arch there seem to be no permanent remains. Most of the congenital tumors and fistulæ about the neck are to be explained by the persistence or defective development of these early fœtal remains. (Cf. p. 648.)

CONGENITAL MALFORMATIONS OF THE NECK.

Those which will be considered here are for the most part cysts and fistulæ. They have been termed branchial cysts, deep dermoid or deep atheromatous tumors, congenital hydrocele of the neck, hygromata, atheromatous cysts of lymph-nodes, etc. The preferable term, however, is **branchial cysts,** and they may be divided into mucous, atheromatous, serous, and sanguineous. They may be very small or may attain very large size. They are most common in the region of the second and third clefts, *i. e.* the vicinity of the pharynx and larynx, and are in intimate relation with the sheaths of the large vessels. They occur more frequently on the left side; are always globular or ovoid, and always fluctuate, fluctuation being detected by bimanual palpation. They are lined with the same epithelium which originally lined the clefts. They should not be confounded with the pure dermoid cysts, which may be found at various points on the scalp, face, or neck, and are to

be distinguished from them in that they contain only epithelial products and no hair or sebaceous or sudoriparous material, since the branchial clefts close before such material is formed.

To the first class belong many of the so-called ranulæ or cysts about the base of the tongue. The second form is most common about the region of the hyoid bone, and contains atheromatous material not of dermoid origin. The third or serous form has very thin walls, and is that sometimes known as hydrocele of the neck (Fig. 27). They may be single or multiple. The sanguineous cysts may originally have been connected with the anterior jugular vein. Their contained fluid is discolored by admixture of blood. There is but one variety of these, including those which still communicate with the interior of the cranium. This form may be emptied by pressure, but will quickly refill. They will be diagnosticated mainly by the character of the fluid withdrawn upon aspiration. All these tumors lie so near the vessels, and so transmit their pulsations, that they may be easily mistaken for aneurysms. They lack free expansile pulsation, and they are common in youth, when aneurysm is rare. No bruit is audible in them, and exploratory puncture gives widely different results. A final diagnosis of dermoid cyst is perhaps to be made only by post-operative examination, but usually a dermoid cyst will have a thicker wall. From cystic degeneration of one of the retro-tracheal lymph-glands they will be distinguished partly by position and partly by the fact that quite early in their history the latter give rise to considerable pain and difficulty in swallowing. They are to be explained as the result of renewed activity, often due to puberty, at a point where there was originally a tubular passage lined with epithelium which has failed to be completely obliterated—"obsolete canals." Concerning the causes which call into activity the inherent developmental forces remaining in these histological relics we are profoundly ignorant. For such cysts the best line of treatment practicable is their extirpation. When for any reason this is not feasible the next best method consists in antiseptic incision, packing with gauze, and drainage.

Congenital Fistulæ.—These fistulæ are due to the same primary causes as those which give rise to the branchial cysts above described, being simply persistent relics of the branchial clefts, one or both of whose extremities have failed to close. They may open interiorly into the pharynx or externally upon the neck. In the former case secretions may collect within them, causing trouble by suppuration, by producing cellulitis, or by giving rise to constant discharge. They are not to be confounded with congenital fistulæ of the trachea, which are usually found in the middle line of the neck. The former commonly open, when external, in the lower third of the neck, along the inner border of the sterno-mastoid. In rare instances the fistulæ have been complete from the neck to the pharynx. If they are capable of treatment at all, it must be by cauterization and exciting granulations, with or without division or dilatation of their external openings.

Cellulitis.—This may be primary or secondary, and superficial or deep. The primary form is usually the result of exposure to cold or to one of the infectious diseases, *e. g.* scarlatina, while the secondary form may be consequent upon trifling or severe injury, or the extension of inflammation from already affected teeth, bones, lymph-glands, etc. The general signs and symptoms of cellulitis of the neck are the same as those of cellulitis of other parts, modified, if at all, only by anatomical disposition.

Any condition of this kind which terminates by resolution is apt to be only annoying; but, on the other hand, such cases are serious just in pro-

portion as pus forms deeply and causes damage in the endeavor to evacuate itself. The presence of pus in these cases is to be made out both by local and by general signs. Of course fluctuation, when easily recognizable, will dispel all doubt. On the other hand, most cases of cellulitis will be accompanied by such brawny induration, and perhaps by such œdema, as to mask the ordinary local signs of the presence of pus. In these cases the occurrence of symptoms of embarrassment of respiration, or of extending deep pressure, or of chills or septic symptoms, will make it wise to institute a careful search even at some depth for the suspected pus. This may be done with the exploring needle, but it will be much more satisfactory and effective to anesthetize the patient and make free incisions over the suspected area, their position and direction being guided by anatomical knowledge, taking the precaution already mentioned of dissecting with extreme care and avoiding all deep small punctures for fear of displaced important vessels or nerves. When the collection of pus has been reached, the opening should be enlarged sufficiently to admit at least a finger, by which the cavity may be explored, in order to ascertain whether a counter-opening is necessary, and, if so, to indicate the point where such may be made with the greatest safety.

A special form of cellulitis is that known as *Ludwig's angina*, or *infectious submaxillary angina*, an acute form of this disease involving the areolar tissue around the submaxillary glands. After three or four days of local discomfort the neck becomes swollen and painful; the condition extends to the tongue, which becomes fixed and swollen; there is great difficulty in opening the mouth; the anterior portion of the mouth is distended; there is great salivation; and dyspnea and dysphagia are caused by pressure and fixation. The disease may be accompanied by very high temperature with septic symptoms, and frequently terminates fatally. Sometimes the disturbance to the circulation is so great that local gangrene is the result. It is an unusual form of cellulitis of the neck, but one which may assume a terrible importance.

Abscesses and Consequent Fistulæ of the neck are virtually always the result of a previous cellulitis. Abscesses have just been dealt with. Fistulæ are best treated by enlargement of their external openings and a thorough scraping of their wall with a sharp spoon, but when tortuous, or when they divide, counter-openings or perhaps extensive incision and splitting may be necessary. The majority of fistulæ of this kind will be found connected with existing tubercular foci in lymph-glands or with the incompletely healed results of operations for their removal. In either case they are to be treated after the same fashion.

Cicatrices.—These are always the result of previous lesion of the skin. They may be trifling in size, like the irregular, wrinkled scars which show where tubercular lymph-glands have broken down and have caused more or less destruction of the overlying skin, or where syphilitic disease has resulted in the same condition; or they may be extensive and disfiguring, being the result of more or less widespread burns of the parts. (See Deformities of the Mouth.)

Small and attached or depressed scars can be excised and replaced by scars which are much more presentable. For the relief of the extensive cicatrization which follows burns some one of the various plastic methods must in whole or in part be adopted. This may consist in a division of the constricting bands, or in the formation of flaps of dissected skin and their rearrangement by sliding or by transplantation, or recourse may be had to the Indian method after a fashion much like that described in the formation of a new nose, by which a flap of skin is raised from the arm to be sewed on to the

defect in the neck, while the arm is fastened to the head or thorax until the flap can be safely detached; or, lastly, one or other of these methods may be combined with Thiersch's method.

The disappointment which may ensue after these efforts comes partly from a failure of some part of the flaps to unite as we desire, and partly from the formation of keloid tissue along the lines of union. This frequently occurs in spite of all care and in consequence of unknown causes, and serves sometimes to undo half of that which we appear at first to have accomplished. When this tendency to keloid is once recognized, further efforts should usually be discontinued, since it cannot be overcome.

INJURIES OF THE NECK.

CONTUSIONS.—Contusions of the neck may be so violent as to cause insensibility, or even death. The reputation which a "blow upon the jugular" has among the laity is an evidence of the severity of many of these injuries. The results of such blows may be fracture of the hyoid or of the cartilages of the larynx, or a rupture of the mucous membrane, followed by a deep emphysema. Asphyxia may repeatedly threaten, and for this tracheotomy may be required. Aside from these lesions there may be bloody effusions or acute inflammatory swellings, with all their suppurative possibilities, while from some abrasion or eruption of the skin an erysipelas even of the phlegmonous variety may develop.

OPEN WOUNDS of the neck may be of all sizes, and be incised, punctured, or lacerated in character. A wound by which the deep fascia is divided may be called a deep wound, and will usually involve blood-vessels and nerves of importance. The frequency with which the vessels escape, especially when the trachea is divided in cases of suicidal attempt, has already been spoken of. The extent and character of these wounds when not at once apparent to sight must be recognized partly by the nature of what escapes, as air, arterial or venous blood, mucus, or possibly food, as well as by a study of impaired functions, as of respiration or deglutition, by the occurrence of emphysema, and by a consideration of whatever can be learned concerning the direction of the wound and the weapon which inflicted it. If bleeding is profuse, the natural inference is that an important vessel has been divided, although serious hemorrhage may result from wound of the thyroid body. If the carotids are wounded, death will probably ensue rapidly. Nélaton is said to have remarked that it takes four minutes for a man to bleed to death from the carotid, while two minutes are sufficient to tie it. Wounds of the large veins are dangerous, not simply from risk of loss of blood, but also of the admission of air. Bleeding here is generally favored by free anastomosis. If seen in time, compression can almost always be successfully applied to a bleeding wound in the neck, and this may be continued until means are at hand for operative relief. In case of a perforating wound into the larynx, patients may suffocate by the entrance of blood into the air-passages.

Besides bullets, foreign bodies like arrow-heads or splinters of wood are sometimes imbedded in the structures of the neck. Modern teaching with regard to bullet wounds inculcates the wisdom of primary antiseptic occlusion, without removal of the bullet, but other foreign bodies should be removed as soon as detected.

Such wounds as are not quickly fatal are usually recovered from. Danger comes from complications rather than from the injury itself. The first indication in treatment is absolute hemostasis, followed by rigid asepsis or anti-

sepsis and closure of the wound, with or without drainage according to circumstances. In case of a deep wound it would be better to close it by two or more tiers of sutures, if necessary for complete approximation. If the œsophagus be opened, it may be sutured if conveniently situated, otherwise it will be better to leave at least a portion of the wound open and pack it with gauze. Untoward results of such wounds differ in no wise from those of injuries generally, and are to be dealt with as they may arise.

Emphysema.—In deep wounds of the neck perforation of the air-passages is probable. The possible extent of this condition has been already spoken of (see Wounds of the Chest), the anatomical condition being virtually the same. If it be practicable to close the tracheal opening of an emphysematous wound, it should be done, but the external wound should not be completely closed or sealed.

TUMORS OF THE NECK.

Of tumors proper we find nearly every known variety occurring in and about the neck. The benign tumors are usually of slow growth, movable, and painless, and give rise mostly to mechanical annoyance. They may be mistaken for cysts, and indeed such tumors may be of mixed character. Malignant tumors of the neck are not infrequently of rapid growth, proceeding often to ulceration (Pl. IX, Fig. 1), and sometimes to the condition of fungus hæmatodes. In almost all instances of carcinomatous growths the lymph-glands in the vicinity will be involved. This is less likely to occur in cases of sarcoma. Malignant tumor being diagnosticated, the principal question is as to whether it can be removed, and secondly whether operation is advisable. Should the tumor extend so deeply or widely as to involve vital parts, it is unlikely that radical extirpation can be made with safety. This is especially true of tumors at the base of the neck, where the large vessels and perhaps the thoracic duct are involved. In a certain class of tumors, also, where it may seem that extirpation is still possible, yet, knowing the frequency with which they return, one may well stop to ask whether it is worth while to expose the patient to the risk of operation when the probability of recurrence amounts almost to a certainty. This is a matter which may be best submitted to an intelligent patient for his own consideration and decision. Circumstances at times make it expedient thus to gain a temporary respite, while at other times they render it more important than usual not to jeopard life. If a surgeon decides to attack such a growth, he must be prepared to sacrifice everything that is involved; otherwise it is better not to operate. Even the pneumogastric nerve under these circumstances in a few instances has had to be removed with the rest of the contents of the carotid sheath. The phrenic nerve should nevertheless be spared if possible. Death is not the inevitable, but it is the common, result of division of these nerves in the human being.

Infectious Granulomata of the Neck.—These comprise the actinomycotic, glanderous, syphilitic, leprous, and tubercular forms of infection, which nearly always are located in the lymph-glands. The actinomycotic and glanderous infections almost always first appear about the submaxillary and the cervical glands, as the reader will perceive by reference to these subjects. Leprous disease is even less common in this country than are the other two, and is marked by equally characteristic lesions in other parts of the body. The same is true to a large extent of syphilitic affections of the neck. Of these granulomata, therefore, the surgeon has to deal with two forms mainly: tubercular infection and enlargement of the lymph-glands, and syphilitic gummata,

which may develop at almost any point. This latter condition is usually characterized by such unmistakable evidences that doubt in diagnosis will scarcely arise. Unless pus be present, these cases are hardly suitable for the knife, but should be treated vigorously by anti-syphilitic remedies, operation being postponed until these have proved themselves insufficient. Should free pus be present, a simple incision of the abscess, possibly combined with scraping and cauterization of its walls, should be made at once.

Local Tubercular Disease.—The most common of all neoplasms in the neck which call for surgical measures are those produced by tubercular disease of the lymph-glands. These were formerly included under the term scrofula or scrofulous glands or swellings, but in the light of modern pathological knowledge they should always be spoken of in their true character, as tubercular. They are most common in childhood, but may occur at any age, and a distinct senile form is known. In these cases we have to deal with a true tubercular infection, either primary or, perhaps more often, secondary. In a majority of instances some port of entry for infection will be found about the head or neck of any individual thus suffering. It may be a diseased tooth, an ulcer in the mouth, nose, or oro-pharynx, a diseased tonsil, a suppurative lesion in the middle ear, a chronic eczema, ulcerative disease of the skin or scalp, chronic conjunctivitis, or something of this kind. The prime source of trouble is more often concealed from ordinary observation, but can in almost all cases be found if searched for with sufficient care. One gland or several may be involved. At times a chain of enlarged glands may be detected extending from that behind the ear to those at the root of the neck, whence the disease seems to extend into the thorax. The most common course for these lesions to pursue is slow but steady enlargement, perhaps with periods of rest, while the slow development of caseous changes is often interrupted by a sudden suppurative activity. Calcification and other changes are much more rare. As these masses become larger and press nearer the skin, they not infrequently perforate it by a process of granulomatous infiltration. On reaching the surface these break down, and we have to deal with a sluggish fungoid ulcer overlying a distinct hard mass. These changes are always accompanied by more or less periadenitis or cellulitis about the principal focus, by which masses originally quite movable become planted in their places and impossible of easy extirpation, being so fixed that it is necessary to dissect out the entire mass. Furthermore, when the masses are multiple the original chain of lymph-glands becomes altered, and merges into what is much more like a columnar mass of infected and infiltrated tissue, always lying near and often adherent to the sheaths of the large vessels, and making complete extirpation always difficult and sometimes impossible. In such a mass of tissue we usually meet with foci of softening and degeneration.

This constitutes a form of disease often met with in individuals of tubercular history and diathesis and of "scrofulous" appearance. The milder and limited manifestations of such tubercular disease sometimes fade away and disappear spontaneously, probably by atrophic processes, leaving few or no traces. Even those cases in which spontaneous perforation has occurred will sometimes slowly cicatrize, leaving unsightly and adherent scars, but the permanent and more aggressive forms are most troublesome to surgeons. Summing up in few words the results of centuries of experience with regard to their best treatment, we may say that save what may be done by general constitutional measures, and by local applications in the way of promoting absorption of the peritubercular infiltration, no treatment has proved so effective as thorough extirpation, which, as mentioned above, is often a most formidable

measure. In these cases, as well as in the so-called malignant diseases, both surgeon and patient must be prepared for recurring manifestations of the disease which may call for a second or a third operation. Such cases, however, are not so destitute of hope as are recurring cancerous cases.

The results of the injection of Koch's tuberculin are still *sub judice*. It is only just to say that in some cases the treatment has yielded very encouraging results.

The injection of a solution or emulsion of iodoform into the infected tissue is a measure which often gives more or less satisfactory results. The amount must, of course, depend upon the size of the mass into which it is injected. Most gratifying results have been obtained by the internal use of guaiacol, of which eight or ten drops in milk are given after each meal, though the more palatable form of essentially the same drug in the shape of benzosol is preferable, of which five grains are given at a dose three or four times a day. It may be put in capsule and made perfectly tasteless and inoffensive.

MALIGNANT LYMPHOMA.—Under this term are included the local manifestations of Hodgkin's disease, or malignant lympho-sarcoma (Pl. IX, Fig. 2). This is more specially a general disease, but its local manifestations sometimes cause extreme symptoms of dyspnea, dysphagia, etc. It is spoken of here only because it occasionally calls for operations on the neck, sometimes of an exacting character. In one such case where the glandular manifestations were extreme, tracheotomy was required some months before the patient finally succumbed, and toward the end the size of the glandular enlargements became a barrier against the changing of the trachea-tube, since if removed it was almost impossible to replace it. In these cases operation is advised only for relief of urgent symptoms.

LIPOMATA occur very frequently in the neck. As a rule they can be easily removed by enucleation. Sometimes they require deep and careful dissection, exposing the vessels and nerves.

THE SALIVARY GLANDS.

The **parotid gland** occupies a position where it is quite exposed to injuries, both contusions and open wounds, which are of importance not so much on account of the glandular tissue itself, as because of the vessels and nerves which pass through or near it. Septic disturbance following such wounds is not uncommon, as well as paralysis of the facial nerve, which latter may result from its division or from the pressure of inflammatory products. If it is purely from the latter cause, the prognosis is not so bad; if from division, there is little to be hoped for in the way of restoration of function. Fistulæ occasionally occur as the result of injury to the gland or to Stenson's duct. Fistulæ of this duct are usually the result of operation or accident, and are difficult to heal. A variety of plastic operations have been suggested for their closure. Perhaps the most feasible plan is that suggested by Agnew, which consists in passing from within the mouth a threaded needle around the duct posterior to the fistula, entering and emerging as nearly as possible at the same point and including the duct, but not the skin, in the loop. This ligature is tightly drawn and knotted. Its immediate effect is to produce ulceration within the cheek, while the suture, working its way loose, separates after a few days, leaving a new and artificial fistula by which saliva is again conducted into the mouth.

PAROTITIS.—While a diphtheritic form of this affection is not unknown, by far the most common form is that known generally as **mumps**, in

which one gland is affected, sometimes both, chiefly in young males and during adolescence. It should be classified with the specific infectious diseases. It may be ushered in by chills, nausea, and fever, with considerable constitutional disturbance, and causes local swelling which may be extensive, and by which mastication and deglutition are interfered with. The disease often assumes an endemic character, frequently spreading in schools. The pathology of the disease is still obscure. Metastasis from the parotid to the mammæ, ovaries, or testes occurs in perhaps 3 per cent. of cases, or often enough to deserve the recognition which it enjoys among the laity. When this occurs in the male, we have to deal with a true form of orchitis, and this form is seldom met with as a primary affection of the part under any other circumstances. Mumps is a self-limited disease, disappearing usually spontaneously, and leaving no bad results except in a very limited number of cases in which suppuration occurs. Ordinarily it needs but little treatment, saline laxatives and perhaps mild anodyne applications being usually enough. In severe cases leeches may be applied with benefit.

Suppurative Parotitis.—This may be the result of mumps, or may occur as a secondary and mixed infection in debilitated or susceptible subjects after such infectious diseases as erysipelas, typhoid, scarlatina, variola, puerperal fever, etc. Abscesses are also often found in the parotid in cases of pyemia. The parotid, being provided with a strong capsule and being contained within a firm, deep fascia, we must expect severe pain and much general disturbance when pus thus forms within it. The only exception to this rule will be found in some of the adynamic fevers. When the ordinary signs indicate the presence of pus, or even the probability of it, an incision should be made as early as possible, if necessary under an anesthetic, in order to check the course of the disease, as well as to give it a direct path toward the surface, since if left to itself it may cause disaster in various directions. Most frequently it opens into the auditory meatus, but in exceptional cases it may pass downward to the chest, or upward along the carotid sheath to the skull, or behind the pharynx, or into the neighboring maxillary joint. If the pus be superficially located, the incision should correspond with the course of the facial nerve; but if a deep incision is necessary, it should be made in front of the line of the external carotid. Often, however, it is much better to make a free incision and careful dissection without reference to future scar. In these cases we must expect involvement of the surrounding lymph-glands, along with a periadenitis or even an erysipelatoid condition. Pus from such a source often has a bad odor.

TUMORS AND OTHER AFFECTIONS OF THE PAROTID.

Salivary Concretions or Calculi may form within the parotid or obstruct its duct. They have been found as large as a hen's egg. By such obstruction they may cause retention of saliva, with inflammatory phenomena, and these latter may proceed to abscess and to spontaneous evacuation, with salivary fistula.

A positive **diagnosis** can best be made by the insertion of a probe along Stenson's duct or by puncture of a needle from without. It may be impossible to remove a small stone by dilatation of the canal. A large one must be removed by incision, always, if possible, from within the mouth under cocaïne.

Cystic Dilatation of the duct or of the gland itself may occur from simple inflammatory or cicatricial obstruction, and suppuration may finally

occur in such a sac. Incision from within the mouth, again, must be made, along with, possibly, extirpation of the sac-wall.

It is especially in the carotid region that the different blastodermic layers come into intimate relations with one another, which will account for the fact that most of the **tumors of the parotid** are of a mixed character. Among the benign forms are adenoma, chondroma, and fibroma, in which nearly always myxomatous elements will be found. Of the malignant tumors, sarcoma and carcinoma are almost equally common. Just within the parotid gland itself lies a lymphatic gland which sometimes develops into a tumor from tubercular or sarcomatous degeneration and is generally easily removed.

A **diagnosis** of tumor of the parotid is easy, but the determination of its exact character is often difficult. The distinction between the benign and malignant forms, which is the most important, is made partly by considering the age of the patient, the rapidity of the growth of the tumor, the relative fixity of the neoplasm, and the involvement of the neighboring lymphatics. Benign tumors which are causing inconvenience or worse may be excised, especially if superficial. Concerning the advisability of removing malignant tumors in this region there is room for wide differences of opinion. It is questionable whether a cancer involving all or nearly all of the gland can be so radically extirpated as not to invite speedy return of the disease. Still, in many instances operation has been followed by temporary relief, extending over such a space of time as amply to reward the patient for the suffering it has caused.

Treatment.—There are some tumors of the parotid which can be removed with but little disturbance of the facial nerve. In such cases operation should be advised without the slightest hesitation. But operation for the entire removal of the gland is always difficult, and always followed by complete paralysis of that side of the face, with accompanying inability to close the eyelid and constant irritation of the eye itself, and is not only severe for the patient, but frequently trying for the operator, that portion of the gland which is wrapped around behind and concealed by the lower jaw being very difficult of access, while the danger of recurrence comes from the inadvertent leaving of some fragment in this location rather than from any other source. The incisions for this purpose may be made parallel to the borders of the jaw, the operator being constantly on his guard against injuring the carotid sheath, and being prepared, if necessary, to tie the external, perhaps even the common, carotid.

THE SUBMAXILLARY GLAND.

This is much more protected from injury than the parotid, but resembles it in other respects. It has a complete capsule, which has the same surgical importance as that of the parotid. Its duct, named after Wharton, may be obstructed by calculi, the presence of which when large may be detected by one finger in the floor of the mouth and another beneath the jaw. The gland is sometimes inflamed, and often participates with the parotid in cases of mumps. Cysts of benign character and malignant tumors may arise primarily within it, and often it is secondarily involved, even early, in cases of cancer of the jaw. When involved in any of these affections it should be removed without hesitation, the only neighboring vessel of importance being the facial artery, which is easily tied, while the lingual, and the hypoglossal and lingual nerves, are easily avoided.

The same remarks apply to the **sublingual gland**, which, however, is seldom the seat of any primary surgical affection.

Goitre (Bronchocele).

THE THYROID BODY.

This is normally developed as a bilobed organ, the two portions of which are separated by a narrow bridge of similar tissue, called the isthmus, which lies normally near the second ring of the trachea. The lobes are of nearly the same size under ordinary circumstances, although they may vary a little within normal limits. The thyroid body is quite likely to be accompanied by accessory masses of similar tissue, which may be connected with it, or may lie behind the trachea, or beneath the base of the tongue, or elsewhere about the middle or anterior portions, and which may assume considerable surgical importance, since they seem quite likely to undergo changes that may lead to errors in diagnosis. Thus when these little masses are enlarged they may be mistaken for enlarged lymph-glands.

THYROIDITIS is a rare form of affection of this body, which when met with occurs usually during typhoid and other infectious diseases. It is accompanied by fever, pain, swelling, and perhaps serious venous obstruction, by which headache, vertigo, epistaxis, or cyanosis may be caused. It may possibly go on to suppuration. If this occurs, free incision should be made as early as possible. Its treatment is for the most part antiphlogistic. It is probably of the same general character as the *strumitis* which occurs so often in cases of goitre, and consists in more or less inflammatory disturbance in the previously diseased or enlarged thyroid tissue. Some authors have seen in such cases evidences of a constitutional predisposition. It is easy to understand how in such affected tissues hemorrhages, thrombi, and retrogressive metamorphoses, often with tissue-necrosis, may prepare the way for inflammation on slight provocation. Under these circumstances even a slight injury, or a hemorrhage, whether apoplectic or traumatic, or an irritating injection, or the introduction of an unsterilized needle, or the occurrence of some general infectious disease, may bring about an inflammation in this focus of least resistance. The symptoms of strumitis are similar to those of thyroiditis, save that they are usually more severe because of the greater size of the organ, are less quickly relieved, and often prove fatal. Free evacuation of pus, or tracheotomy, or possibly extirpation of the organ, will be called for in such cases, usually as emergency operations.

GOITRE, BRONCHOCELE, OR STRUMA (PLATE XVIII).

This is a term generally applied to an hypertrophy and hyperplasia of the thyroid body; more common on the right side than on the left; involving at times only a portion of the organ, at other times its entire mass. While it may occur anywhere, its worst forms are met with in the mountain regions and valleys of Asia and Europe, as well as in Chile and Mexico. Its hereditary character is not clearly established. Its true cause has not been discovered. Many conditions of climate and surroundings have been described as etiological, but it is not likely that they alone are sufficient to produce it. It is essentially a chronic disease. It occurs oftenest in women, and rarely before the tenth year of age. Several different forms are described. Thus we speak of hypertrophic or parenchymatous forms, in which the entire mass seems to be made up of tissue identical or nearly so with the original. The follicular form is that in which there is a minimum of stroma with a large proportion of mucinous or glandular elements. The fibrinous form is the reverse of this, may be, in a measure, of irritative or inflammatory origin, and may assume at times almost a sclerotic type. The vascular form is that in

which the normal vessels of the part are more or less dilated, and in which frequently new vessels are formed. In fact, this form often assumes such a phase as to entitle the mass to be considered as a cavernous tumor of the thyroid. The vessels thus affected are for the most part the venous, but an arterial form is known. An amyloid form has also been described, in which amyloid changes have taken place in the vessels, but it is rare and secondary.

The cystic form is the most common. It consists in the development of one or numerous small or large cysts, which may attain almost any size, and may be filled with fluid of various degrees of consistency. The fluid is always rich in soda-albumin, and may be more or less mucinous. It may also contain cholesterin in rich proportion, as well as the products of fatty metamorphosis, together with the residue of recent or old hemorrhages.

A goitre may be of any dimensions, from the slightest perceptible increase in size of the normal thyroid up to a tumor which will interfere with motions of the head, and which may even overhang the chest and reach as far as the navel. Mild forms of goitrous enlargement are met with sometimes in pregnant women, and it will often be noted that a goitre will increase in size with each succeeding pregnancy. This is but an expression of the sympathy between this organ and the female pelvic organs which in many women is shown during or succeeding each monthly period.

The goitrous tumor is usually not difficult of recognition. As a rule, it is chronic in its course; it rises and falls in the act of deglutition, is painless, is not adherent to the overlying skin, under which it moves freely, and has no attachment to the jaw or to the clavicle beneath. The larynx moves with it, but it is not adherent to any other parts in the neck. It is usually covered by prominent veins. It is often an impediment to respiration, sometimes to deglutition; when large, or when developed in the direction of the recurrent nerves, it may cause alteration or loss of voice. It may also distort the trachea or push it to one side and displace the large vessels. Its original location is almost constant, and a bilobed or symmetrical swelling of the neck is nearly always a goitre. Some of the vascular forms give rise to a murmur which upon auscultation will yield a marvellous blowing or rushing sound. About the only difficulty in diagnosis which can arise will be with reference to the innocent or malignant character of the swelling, since tumor of almost every other portion of the neck is easily excluded.

Treatment.—Internal remedies are of little or no use, save as they may serve to build up the debilitated individual. Iodine in some form has enjoyed a certain reputation in time past, but is little given at present. All kinds of local treatment have been resorted to. Iodine, again, has been the most satisfactory medicinal application. In India an ointment made of red iodide of mercury, rubbed in for ten minutes every morning, has given good results. After its application the neck is exposed to the heat of the sun. But the only treatment which can be recommended is surgical. Cysts may be tapped, and perhaps drained. This should be done with aseptic precautions. A favorite method of treatment has been the injection into the substance of the organ of a watery dilution of tincture of iodine. In the soft parenchymatous or cystic form this may be of some service, although accompanied by danger. In old or hard goitres it is useless. Electrolysis has yielded good results in many of the softer forms, one or more needles connected with the negative pole being inserted into the substance of the tumor, while the positive pole is applied by a large sponge or clay electrode in the vicinity. The current should be measured with a galvanometer, and should not be strong enough to cause severe distress. Such applications may be practised once or twice a week, and in severe cases

will often be followed by diminution in size of the mass, but scarcely ever by its total subsidence.

Of more formidable operative procedures, ligature of the thyroid arteries is perhaps the least severe, but is difficult. This, too, will sometimes give good results in the vascular and parenchymatous cases. When dyspnea is caused by pressure, a simple division of the isthmus will sometimes relieve it.

Enucleation or **Partial** or **Total Extirpation** of the mass (**thyroidectomy**) is the radical and final operation, which a few years ago was practised with extreme rarity, but which now, especially in the Swiss and German clinics, is done almost with impunity. The operation is serious mainly on account of the dangers from hemorrhage. The most successful method appears to be that of incision of the capsule, with or without previous ligation of the thyroid arteries, and a shelling out of the tumor itself from within its fibrous investment, which usually can be done without great difficulty. This method seems to be much preferable to a determined effort to remove the tumor along with all its coverings. The recurrent laryngeal nerves must be carefully avoided. Vessels must be tied as they are encountered, and the base of the growth may be ligated *en masse*. Bose and Poppert have recently practised a "bloodless" method by lifting the gland from its bed sufficiently to encircle the pedicle with elastic tubing before enucleating the cysts.

The principal danger of this operation is not so much the risk of immediate disaster as of a peculiar constitutional change which seems to be inherently connected with the loss of function of this organ; a subject concerning which we have ample clinical demonstration, with very little knowledge of its cause. It is known as **cachexia strumipriva**, and corresponds almost exactly with the idiopathic condition known as **myxœdema**. The development of this cachexia is, however, a matter of time, requiring several weeks or months. A more acute form of changes of the same general character results in the condition known as **tetany**, which is a spasmodic nervous affection, in some respects resembling tetanus, but having no infectious condition underlying it. It has been shown by recent researches, both on animals and in man, that total removal of the thyroid is very likely to bring about the acute or chronic form of cachexia strumipriva, whereas the danger of the same amounts to little or nothing when a portion of the organ, even so small as one-fourth or one-fifth of its total mass, is allowed to remain. The inference from these experiments, which is amply borne out clinically, is that the greatest, though secondary, danger of total removal of the thyroid is a series of tissue-changes throughout the organism by which the body and the mind of the patient are materially altered for the worse, while partial thyroidectomies are accompanied by little if any such danger. While, then, total extirpation is an operation to be avoided if possible, no hesitation need be felt about removing a large portion of a goitrous thyroid; in other words, so much as will afford relief from most of its unpleasant features. Especially when the condition is unilateral or largely so, no hesitation need be felt in recommending operation. Several surgeons have lately transplanted the thyroid gland of the sheep, and placed it in the connective tissues or in the abdominal cavity; others have injected hypodermatically the juice of the gland. Both methods have met with encouraging results.

The secret of these changes is very probably connected with the problem of the distribution of mucin and other waste products of the system. The reader interested in this topic is referred to the *Annals of Surgery* for August, 1891.

TUMORS OF THE THYROID.

The principal tumors proper of the thyroid are malignant, being sarcoma or carcinoma according to the tissue primarily involved. All forms of this growth are met with here, the soft forms of round-celled cancer being perhaps no more frequent than the varieties of sarcoma. They are all characterized by rapidity of growth, by great pain, by distinct pressure symptoms, by invasion of the surrounding tissues, by involvement of neighboring lymphatics and other tissues, by the general appearance of cachexia, and by the other ordinary unmistakable signs of cancers generally. They run a course by which they are soon distinguished from the innocent enlargement of the thyroid body, a course which is frequently rapidly malignant from the outset.

The **prognosis** is always bad. If the disease be apparently still limited to the thyroid proper and radical operation be not considered too formidable for the strength of the patient, it should perhaps be performed, if only for the relief of pressure symptoms; but, unfortunately, it often happens that by the time such a case reaches the surgeon's hands for any operative purpose it has exceeded the limits of legitimate hope or even perhaps of possible performance.

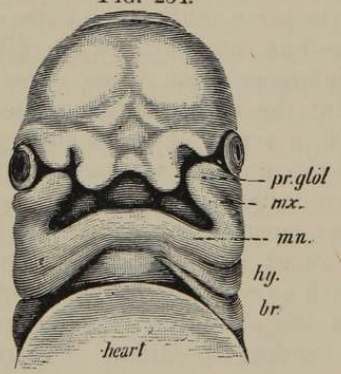
CHAPTER V.

SURGERY OF THE DIGESTIVE TRACT.

PART I.—DISEASES AND INJURIES OF THE MOUTH, TONGUE, JAWS, AND PHARYNX.

Malformations and Deformities of the Cheeks and Lips.—As many of the deformities and malformations of the cheeks and lips are due to retarded or arrested development, which a study of the embryology of these parts will alone make clear, it will be necessary in the first place to give a short account of the development of the face.

Fig. 254.



Head of an Embryo: *pr. glob.*, globular extremity of the mesial nasal process; *mx*, maxillary process; *mn*, mandibular arch; *hy*, hyoidean arch; *br'*, first branchial arch (Quain).

At a very early period of fœtal life a series of clefts appear on each side of the cephalic extremity, separated by rods of tissue called *branchial arches*. The clefts communicate with the alimentary canal.

The first branchial cleft is between the mandibular and hyoid arches. The mandibular arch, which is afterward developed largely into bone, consists of a *superior maxillary portion*, which does not unite with its fellow in the median line, but has the fronto-nasal process interposed, and *an inferior maxillary portion*, which early unites in the middle line and forms the lower jaw. Between the superior maxillary and inferior maxillary processes of the mandibular arch is the *buccal cleft*. This is closed early, except where the aperture remains for the mouth (Fig. 254). These various clefts have usually coalesced about the ninth or tenth week of fœtal life, but occasionally this coalescence fails or is incomplete. This leads to various deformities, the chief of which are cleft palate and hare-lip. In rare cases the orbital cleft remains open, and in still rarer cases the mandibular arch is undeveloped.

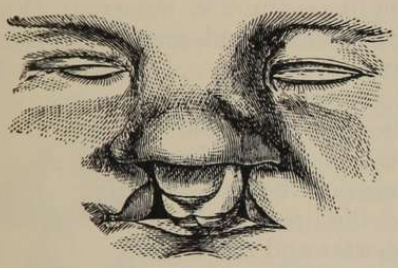
The palate, which is in two parts, is formed by the growth of a horizontal septum backward, which shuts off the nasal cavity from the mouth. This, of course, is in two parts. The median union, which commences from before backward, is not complete until the tenth week. Imperfect coalescence of the parts produces cleft palate and hare-lip.

Hare-lip is produced by the non-union of the mesial nasal process with the superior maxillary process. The non-union may involve only the soft parts or it may be complete, there being a fissure between the intermaxillary and superior maxillary bones. This may occur on one or both sides, producing the deformity of single or double hare-lip.

If the superior maxillary bones do not unite at the palatine cleft, which is in the median line, we have the deformity of *cleft palate.* Hare-lip is always to one or the other side of the median line following the direction of the naso-maxillary fissure between the superior maxillary and intermaxillary bones.

HARE-LIP.—Hare-lip may be single, double, or complicated, or may involve only the soft parts, or the hard and soft parts at the same time. In about one-tenth of the cases hare-lip is double, and when double it is not unfrequently complicated with cleft palate and failure of union of the intermaxillary bones. In such cases the intermaxillary bones will project, covered by a small portion of skin, and attached to the septum of the nose or even to the tip itself (Fig. 255). Some cases have been reported of hare-lip coexisting with congenital fissure

FIG. 255.



Double Hare-lip, with cleft of the hard palate and protruding intermaxillary bone (Koenig).

FIG. 256.

Left Hare-lip extending into the nose (Koenig).

FIG. 257.

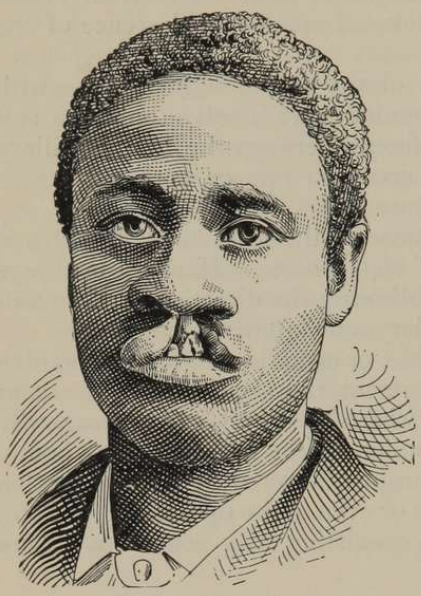
Slight Hare-lip, with fissure of the lower eyelid (Kraske).

of the cheek (Fig. 257). Single hare-lip is by far the most common defect, and is said to occur more often on the left than on the right side (Fig. 256), and more often in males than in females; the gap is usually flattened to the outer and rounded to the mesial side. It is occasionally seen in the negro (Fig. 258).

Age for Operation.—There is considerable difference of opinion as to the

proper age at which the operation should be performed; nearly all are agreed that some time previous to dentition is the best; some say between the third and sixth months; others advocate its early performance. Fergusson and others advocated performing the operation about the sixth week after birth. Probably from the sixth week to the third month is the most suitable, as the child's vitality is then usually good and operation is well borne. Of course the more severe operations are not so well borne in early infancy as those for single hare-lip, but, as Holmes remarks, simple cases cannot be operated on too early. In some cases of double hare-lip, when the child cannot take the breast and has to be fed, early operation is often desirable should the child be strong. At this early period the operation is not without danger, for very young infants bear hemorrhage very badly.

Fig. 258.



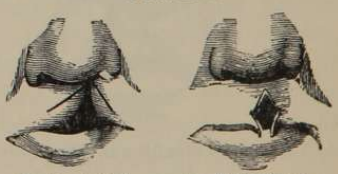
Hare-lip in a Negro.

Operation.—The operations for the cure of hare-lip are numerous (Figs. 259–262). Some are very ingenious, but very complicated, and while looking well in a diagram are not easily carried out in practice. In operating for hare-lip there are certain points to be kept in view. First, it is necessary to obtain union by first intention, and in order to accomplish this the edges of the cleft must be accurately brought together and there must be no tension of the parts. It is also of importance that the red line of the lips should be even; and when one side of the cleft is shorter and flatter than the other, this is by no means easy to accomplish. The edges of the cleft should be pared freely, and the lip separated from its attachment to the gum. This latter proceeding enables the operator to close the gap without tension. Hare-lip pins may be used, and a twisted suture applied in the usual way to bring the edges together. The pins should be introduced about a quarter of an inch from one edge of the cleft and brought out at the same distance from the opposite edge. They should be passed deeply enough to prevent hemorrhage from the coronary artery, but should not penetrate the mucous membrane. As a rule, not more than two or three are required. Deeply-placed sutures of silk or silkworm gut (preferably the latter) answer every purpose. Intermediate sutures of fine catgut may be used to bring the edges of the skin more accurately together, and, if the operator thinks fit, may also be used to unite the mucous membrane. In young infants hare-lip pins should not be left in more than forty-eight hours, when they should be removed, leaving the twisted suture, which is usually encrusted with blood, fixed to the lip to hold the parts together. If the pins are left in too long, they are apt to cause sloughs or cut through and leave ugly scars. Sutures of silkworm gut may be left

Fig. 259.

Simple Hare-lip with Equilateral Sides (Druitt).

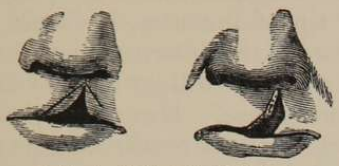
Fig. 260.



Method of Clemont or Malgaigne (Nélaton).

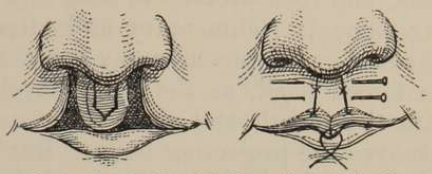
in without risk for four or five days. In order to take the tension off the stitches it is always well to apply a strip of rubber adhesive plaster to each

Fig. 261.



Method of Mirault (Nélaton).

Fig. 262.



Operation for Double Hare-lip (original).

cheek and make the ends meet over the lip. The part attached to the cheek should be broad, but the strip should narrow as it approaches the lips. The two mesial ends may be perforated, and then laced together like a shoe. By this means the cheeks are brought forward and the central parts of the lips relaxed. If such a simple arrangement be applied, there is no necessity for more complicated and expensive trusses.

To describe the operation more in detail: The child, having been etherized, is wrapped up in a towel or pillow-case to confine the arms, and is held by an assistant in a convenient position. The surgeon, with a sharp, narrow-bladed scalpel, transfixes one edge of the cleft and cuts a strip of tissue from the margin of the gap, going well up in the angle and paring freely and cleanly. Both sides should be pared, and the strips may be cut away entirely or left attached as the ingenuity of the surgeon may suggest, they being often made use of, as the accompanying figures show, to make up for deficiencies in the lip. The incision on each side should be curved, the concavity being toward the median line, so that when the two curves are brought together there will be a slight projection of the prolabium instead of a notch. The strips from the margins of the fissure may also be adjusted, so as to prevent the occurrence of the notch at the point of union of the flaps. There is much less danger of cutting too little from the edge of the cleft than of cutting too much. Should there be hemorrhage, it may be easily controlled by an ordinary pair of hemostatic forceps applied on each side of the cleft, so as to compress the whole thickness of the lip. Only sufficient pressure should be used to control hemorrhage, as too great pressure may easily cause a slough. The frænum of the lip and all connections between the lip and the gum are now freely divided. This will often cause smart hemorrhage, which soon stops when the cut edges of the cleft are brought together and strapping is applied to the cheeks. The dressing of the wound should be as simple as possible; it should be dusted over with iodoform or painted with an iodoform paint. If sutures are used, they should be removed about the fourth or fifth day, but the strapping should be left on for a week or ten days longer. As the strapping gets loose it may be tightened up by lacing the two sides together with silk or other strong material. The union should be complete at the end of the second week, and often will be so before. Should the wound fail to unite by first intention, there is nothing to do but to wait and repeat the operation later.

In **double hare-lip** the operation is the same, except that it is on both sides, and both clefts should be closed at the same operation. When the central portion is short, the portions cut from the gaps should be united in the median line below the central portion. In some cases where the central portion is narrow it is better to take it away altogether and treat the resulting fissure as a single hare-lip.

Hare-lip complicated with Protrusion of the Intermaxillary

Bone.—This is a much more difficult case to treat. In the first place, before closing the clefts it is necessary either to remove the projecting wedge of bone or forcibly bend it back into position and hold it there by sutures or strapping, and then proceed to deal with the hare-lip. In cases where the projecting bone is rudimentary and attached to the tip of the nose, it should be removed. Fergusson many years ago stated that if the intermaxillary bone be forced back, as the child develops the incisor teeth will grow backward into the mouth and thus prove a source of annoyance. Hence he always removed the projecting bone. But in many cases excellent results may be got by forcing back the projecting bone and suturing it in place after paring the edges of the gap in the gums. The bone is usually fractured, and can be replaced without the rotation spoken of by Fergusson.

AFFECTIONS OF THE LIPS.

Inflammation of the lips is quite a common affection in winter, and is due to cold. "Cracked" or "chapped" lips are troublesome and often very painful, bleeding on the slightest provocation. The fissure or crack is usually in the median line, and, if treated early by the constant application of simple or rose-water ointment and a strip of the more durable form of court-plaster on muslin, gets well quickly. Should the fissure persist, it may need cauterization with a sharp point of nitrate of silver to relieve the pain.

In early life such fissures are sometimes neglected and leave deep furrows, which are very disfiguring. These gaps can be easily remedied by paring the edges and bringing them together. Cracks may occur in the upper or lower lip; in children they are seen most frequently in the lower, and are indicative of a strumous diathesis. These children usually have enlarged lymphatic glands of the neck. Such cases must be treated by attending to the general health. If the fissures are painful, they should be brushed over with a solution of nitrate of silver. Cocaïne should be used first, so as to avoid pain. When fissures or ulcers occur about the corners of the mouth in children, they should be carefully inquired into, as they are often indicative of a syphilitic taint. They leave scars which persist throughout life.

Many severe inflammations of the lips are caused by injuries, bites of insects (bees, wasps, mosquitoes, etc.), and should be treated by the application of evaporating lotions. The inflammation usually subsides rapidly. Should it go on to suppuration, an early and free incision should be made.

Herpes of the lips occurs as "cold sores" or "fever blisters." Occasionally in weakly individuals intense inflammation accompanies herpes of the lips, and it is very apt to recur. It may be checked on its first appearance by the application of a little nitrate of mercury ointment.

TUMORS OF THE LIPS.

Epithelioma.—This form of carcinoma most frequently affects the *lower* lip, and is most common in *males*. It is essentially a disease of advanced life. As a rule, its growth is slow and the glands are not early involved. It may commence as a warty growth, as a mere excoriation, or as a fissure or ulcer which will not heal. Sometimes it commences as a small indolent tubercle, which soon ulcerates and is covered by a thick scab. This, when picked off by the patient, grows again. Soon the ulcerated surface enlarges, deepens, and is surrounded by a mass of induration: although not very painful, it is a source of great discomfort, especially when eating.

Diagnosis.—Although the diagnosis of cancer of the lip may appear very simple, yet it is occasionally mistaken for chancre, or rather chancre is mistaken for it. Chancre of the lip more frequently occurs in females, and may occur at all ages; cancer occurs in males, as a rule, and after forty-five. The lymphatic glands are involved very early in chancre, late in cancer. The progress of cancer is usually slow and lasts many months. Chancre lasts a few weeks only. Cancer never loses its hard base and never heals completely. Chancre is sooner or later accompanied by other manifestations of syphilis, as sore throat, secondary rash, etc. Cancer does not improve under treatment. Chancre improves rapidly.

Treatment.—There is but one method of treating epithelioma of the lip, and that is by early and free excision. If the growth can be excised freely before the submaxillary lymphatic glands become involved, there is a very good chance of non-recurrence—more than in any other form of cancer. Caustics should be avoided; they only temporize with the disease and delay thorough extirpation by the knife, often causing the operation to be postponed until the cervical glands are involved; the case is then comparatively hopeless and operation merely palliative. Sores on the lip which will not heal readily occurring in persons over forty-five should be excised.

Operation.—The removal of an ordinary-sized epithelioma of the lip is a simple matter. It is usual to employ a V-shaped incision with the base upward, care being taken to cut well away from the growth. The edges of the incision may be brought together with hare-lip pins or deep sutures of silkworm gut. The wound if properly closed heals by first intention within a week. When the disease is extensive the greater part or the whole of the lip may have to be sacrificed and a new lip made by a plastic operation. Should the lower jaw be involved in the disease, a portion may have to be removed. All enlarged glands should be excised.

Nævi are not infrequently seen on the lips (Fig. 29, p. 223). At first they are usually small, and may be ligatured, or treated by pin-points of the thermo-cautery or electrolysis. If the growth is deeper and larger, it may either be dissected out or the lip excised as in epithelioma. The latter proceeding is the easier, but care should be taken to cut into healthy tissue. Subcutaneous ligature may also be used with advantage in many cases.

Cysts of the Lip.—These generally occur in the lower lip, and are due to the blocking up of the mucous follicles in the inside of the lip; they often grow to a large size and appear as tense, semi-transparent, shining swellings containing a viscid or clear mucus. They are always innocent. They should be freely laid open, dried out with lint, and the inside painted with strong nitric acid or cauterized with a thermo- or electro-cautery.

Horny growths are occasionally seen on the lips, and should be excised.

Hypertrophy is commonly seen in strumous children, and may occur in one or both lips. In some cases the hypertrophy is so great that an operation is asked for to relieve the deformity. The removal of an elliptical portion of the mucous membrane and submucous tissue in a horizontal direction does much toward remedying the unsightliness of this affection.

WOUNDS OF THE LIPS.

These should be treated in the same manner as wounds of any other part. They should be thoroughly cleansed and the edges brought accurately together with deep sutures. If there is much hemorrhage from the coronary arteries, they may be tied, but, as a rule, the hemorrhage ceases on tightening the sutures, which should go down to the mucous membrane and so include the arteries.

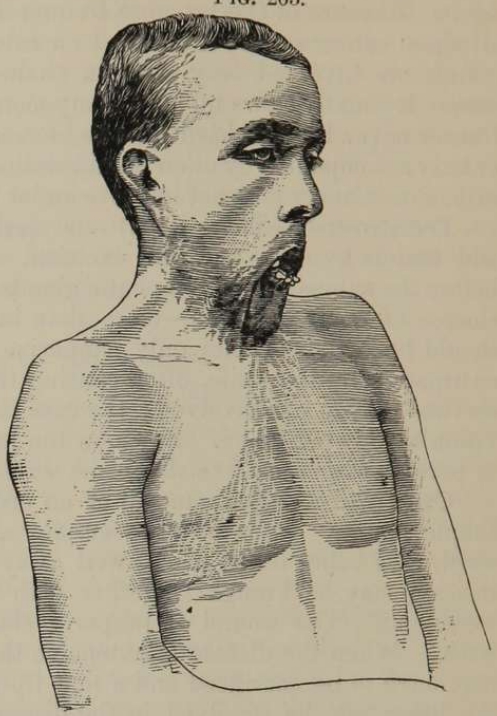
MALFORMATIONS OF THE MOUTH.

Congenital contraction or complete closure of the mouth may sometimes be seen as the result of over-closure of the buccal fissure. This is called **microstoma. Macrostoma,** or large mouth, is due to the buccal fissure not closing completely, and in such cases the mouth may actually extend to the ear.

Of course the most common malformations of the mouth are the different forms of **hare-lip,** which have already been described. Median fissure of the lower lip is a rare condition, so rare that its occurrence has been doubted, but recently cases have been reported and figured. These are easily explained by the non-union of the mandibular arch in the central line. Median fissure of the upper lip has also been occasionally seen.

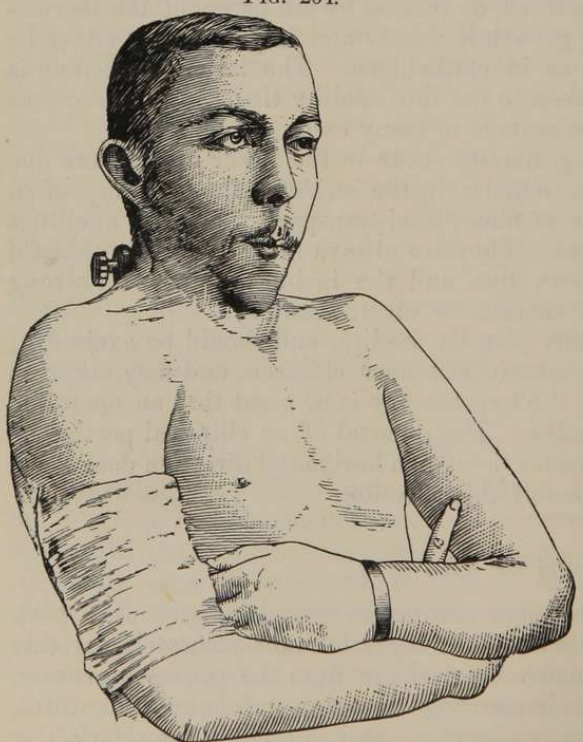
Deformities from Burns and Scalds.—Deformities of the lips the results of burns are not infrequently seen, and when severe cause frightful disfigurement. They, of course, interfere with speech, and saliva constantly dribbles from the mouth. They are usually complicated with contraction of the face and protrusion of the lower jaw. In some cases the lower lip is so much everted that its lower margin may be attached to the upper part of the sternum. A new lip may be made after the manner recommended by the late Mr. Teale of Leeds. Figs. 263 and 264, from a case recently operated on, well illustrate the deformity and the happy results of operation, the details of which are as follows:

FIG. 263.



Deformity from the Cicatrix following a Burn (original).

FIG. 264.



Results of Operation in the Same Case (original).

"The everted lip is divided into three parts by two vertical incisions three-quarters of an inch long and carried down to the bone. These incisions are

so planned that the middle portion between them occupies one-half the lip: from the inner end of each incision the knife is carried upward to a point one inch beyond the angle of the mouth. The two flaps thus marked out are freely and deeply dissected up. The lateral flaps are now raised and united by twisted sutures in the mesial line, and supported as on a base by the middle flap, to which they are also attached by a few points of suture, leaving a triangular even surface to granulate." This is a most satisfactory operation and always gives good results.

Salivary Fistula is usually seen in the line of Stenson's duct, and is the result of injury, operation, or abscess following obstruction. Should Stenson's duct from any cause be opened externally, saliva trickles out of the opening and a fistula is the result. It may follow suppuration of the parotid after injury or fever. It is one of the most troublesome of affections, causing great inconvenience to the patient during mastication, when the flow of saliva is much increased. The first point in the treatment is to establish an opening in the mouth. This may be done by passing a probe through the external fistula into the mouth in the direction of the duct, and then cutting down on it from within and passing a probe daily. As soon as a free internal opening is established, the fistula may be closed by touching it with a thermo- or electro-cautery. Another method of treatment is to pass a seton through the fistula into the mouth, bring it out of the mouth, and tie the two ends. In a few weeks a permanent internal opening is established, when the seton may be withdrawn, and the external opening will soon close (cf. p. 642). When the fistulous opening is small it may be at once closed with a fine point of an electric cautery. In certain cases plastic operation is required to close the fistula.

Cancrum Oris.—This is a form of sloughing phagedena which occurs in ill-fed, sickly children who are recovering from some of the exanthemata, especially measles and scarlet fever. A similar disease affects the pudenda of female children. It commences as a phlegmon of the cheek and lips, and is often first seen as a dusky red spot on the outer surface of the cheek. The child opens its mouth with difficulty, and if the surgeon looks in the inside he will see a deep, sloughy, unhealthy ulcer opposite the dusky spot. Large portions of the cheek and lips may become gangrenous, and the sloughing process may even extend to the bone, for it spreads with great rapidity. The disease, which is attended by considerable fever and great depression, is very fatal, the patient usually dying from exhaustion. When recovery does take place the deformity resulting from the sloughing process is great (Fig. 265).

FIG. 265.

Cancrum Oris (Albert).

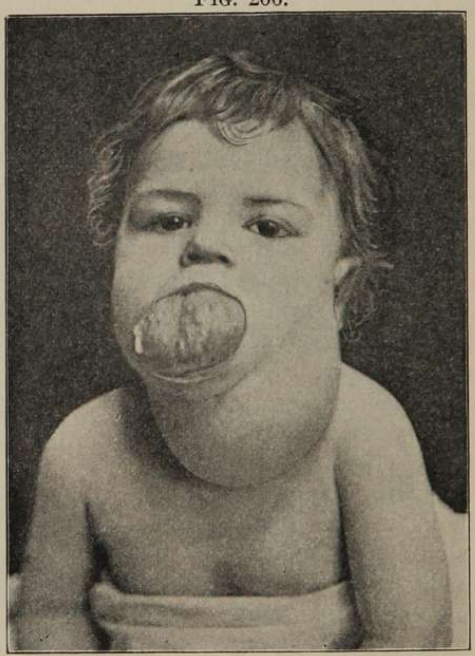
Treatment.—The food should be the most nourishing possible, and stimulants should be freely administered. When the disease is first recognized the child should be put under ether and the parts freely cauterized with strong nitric acid. Afterward they should be kept clean by antiseptic washes of Condy's fluid, creoline, etc.

Stomatitis, or inflammation of the mouth, usually occurs in the debili-

tated when the digestive organs are out of order. The simplest cases are merely an inflammation of the mucous membrane, and may be caused by any irritant, as smoking, carious teeth, hot food, etc. This condition is easily treated by a wash of borax or chlorate of potassium. In some cases the inflammation runs into aphthous ulceration. This is often painful, and has to be cauterized by the solid stick of nitrate of silver preceded by cocaïne. Where there are recurrent attacks of aphthous ulceration the general health should be improved by tonics and nourishing food.

Mercurial Stomatitis and *Mercurial Glossitis* are not uncommon in the trades in which mercury is used, and as a result of mercurial salivation from the internal administration of the drug. The cause should be removed, and potassium iodide avoided, as it increases the salivation. Ordinary washes of borax should be employed, with cooling lotions. Ice is sometimes agreeable to the patient, though it has no influence on the disease.

FIG. 266.



Macroglossia (original).

MALFORMATIONS OF THE TONGUE.

Tongue-tie, or shortness of the frænum linguæ. The tongue is bound down and cannot be protruded beyond the incisors. This is a congenital defect which is not uncommon, and when it exists to a high degree it prevents the child from suckling, and later may interfere with articulation. In such cases it is necessary to divide the tightened bands ; this should be done with a pair of scissors with blunt points. The points should be directed to the floor of the mouth to avoid wounding the ranine arteries. Cases are on record of fatal hemorrhage occurring from accidentally cutting these vessels. In dividing the frænum only a small cut is necessary, and then the rest may be torn through with the fingers. Even this is generally unnecessary, for the child, in crying, still further frees the tongue. The frænum may be congenitally too long, and cases of death from suffocation have been recorded owing to this condition, the patient "swallowing" the tongue.

Macroglossia is a congenital hypertrophy of the tongue analogous to elephantiasis. It is of slow growth, and as it enlarges causes great trouble, the mere size interfering with deglutition and speech. The tongue may protrude over the chin and reach even as far as the sternum. The subjects of this affection frequently suffer from epilepsy. The great enlargement causes deformity of the teeth and jaws, especially the lower jaw. The teeth may become carious and fall out, and the lower jaw has been known to be dislocated or distorted by the pressure. There is constant dribbling of saliva, and the protruded tongue is much altered in appearance, indurated, swollen, and purplish in color; later, nodes, irregularities, and fissures appear on its surface, and occasionally the tongue ulcerates. On puncturing it there is not much bleeding, but there is oozing of large quantities of serum. The disease is not, as a rule, noticed for the first two years, as sucking appears to delay the growth of the organ by continuous pressure. The pathology of this disease was first elucidated by Virchow: he found that there was an overgrowth of interstitial connective tissue, with a remarkable infiltration of the whole organ with white cells collected here and there in a delicate network and forming true lymphoid tissue. The disease, no doubt, is due to congenital defect aggravated by frequent attacks of glossitis.

The treatment consists in the removal of the protruded portion of the tongue. In some cases the removal of a V-shaped portion will give the best results. Ligature of the portion of tongue protruded has been successfully practised, but nothing is so safe or simple as removal with knife, galvano-cautery, or écraseur. The hemorrhage usually is not great, and the result is almost invariably satisfactory. When bleeding is feared in young children, removal by the écraseur should be preferred, but in adults the knife or scissors is better, as its use is not followed by sloughing. The tongue should be drawn forward by means of ligatures passed through its substance, and the incision should be made in such a manner that the tongue is left somewhat pointed; the bleeding vessels should be tied as cut. The after-treatment is the same as that used for partial removal of the tongue for any other cause.

TUMORS OF THE TONGUE.

Nævi are occasionally found in the tongue. If superficial, they may be treated by nitric acid or by puncture with thermo-cautery needles. When the growth is prominent and can be isolated it may be excised with scissors or treated with ligature. In excision the cut should be made all around in healthy tissue, the hemorrhage then being inconsiderable. The thermo-cautery knife also may be used. When the growth is large and more diffuse, excision by the wire écraseur is a valuable method of treatment; the écraseur should cut through healthy tissue. Ligature is seldom necessary in such cases, but when used should be passed deeply into the substance of the tongue and tied very tightly.

Papillomata, or **Warty Tumors,** occur on the dorsum of the tongue, and consist merely of hypertrophied papillæ. The diagnosis is easy when the affection occurs in early life, but when it exists in old people it is sometimes difficult to diagnosticate from epithelioma.

Treatment.—Removal by scissors is the simplest and best mode of treatment when the growths are small; when large, ligature is more satisfactory. If there be any induration at the base or the slightest suspicion of the growth being malignant, to ensure complete removal the healthy tissue around should be excised as well as the growth. Butlin rightly states that "the treatment

of the larger and doubtful warts in persons over forty years of age by caustics and other similar measures cannot be too strongly deprecated."

Ranula is a large cystic tumor which is seen under the tongue on one or the other side of the frænum linguæ. The tumor is semi-translucent, soft, and has coursing over it large dilated veins. It occurs oftener in adults than in children, and is usually painless, but the sense of fulness and the discomfort induce the patient to consult a surgeon. It contains a clear, glairy fluid, mucoid in appearance, but rarely saliva. The exact cause of the swelling has given rise to much discussion. There is no doubt that it may be due to dilatation of the ducts of the salivary glands, as well as to obstruction of those of the sublingual mucous glands.

The *treatment* is not so satisfactory as would at first sight appear. If the sac is emptied, it soon fills again, and to prevent the return of the disease it is necessary to destroy the lining membrane of the cyst by caustics, after having excised a portion of the cyst-wall. Sometimes the injection of 15 minims of a mixture of tincture of iodine 10 parts, water 10 parts, and iodide of potassium 1 part will avail. The solid stick of nitrate of silver applied to the interior of the sac gives the most satisfactory results. Butlin and Bryant recommend the old method of treatment by a seton of strong silk, left for a week. Should this fail, a flap of the cyst-wall may be stitched back.

Salivary Calculus.—A calculus may form in the ducts of the salivary glands. It has been seen in Stenson's duct and in the ducts of the sublingual glands, but Wharton's duct is its more frequent situation. The calculus is composed chiefly of calcium carbonate and phosphate, and magnesium phosphate. It forms slowly, and may have been growing for years before it gives trouble. Suddenly inflammation may be set up, and the patient consults the surgeon for a large inflammatory mass between the tongue and the floor of the mouth. The submaxillary gland is usually enlarged, and a fistula may form below the jaw. The diagnosis is not commonly difficult, for the hard mass can generally be felt with the finger. Cases are reported in which the inflammatory changes produced by the calculus have been mistaken for malignant tumor. The treatment is removal by free incision over the tumor. This is made inside the mouth. Cocaïne anesthesia is sufficient, as a rule. As soon as the cause is removed the swelling and inflammation disappear.

Sublingual Cysts.—These are usually congenital, and are rather infrequent. Being situated between the tongue and the lower gum, they are often mistaken for ranulæ. They grow slowly, and the surgeon is never consulted until they are of considerable size, and either interfere with deglutition or project externally into the submaxillary space. They are painless, and are situated between the muscles on the under surface of the tongue. They have been seen only in adults under twenty-five. These cysts contain a thick putty-like material, made up of epithelium, cholesterin, and fatty matter, and have been described by some writers as sebaceous cysts, but they are really **dermoids**, and may contain hair, teeth, and bone. The contents are sometimes semi-purulent and very offensive. They may grow to a considerable size, but generally are about the size of a small orange. The sac is often tough and fibrous, though sometimes it is very thin and easily broken, and its dissection is a matter of some difficulty.

A sublingual cyst is not difficult of *diagnosis*. It appears as a smooth, rounded swelling beneath the tongue, and often in the submaxillary space, but it has none of the translucency so characteristic of ranula. Instead of being actually fluctuating, the swelling has a doughy feel and is inelastic. They may be multiple or single, central or lateral. The explanation of their occurrence

is simple. During development a portion of the epiblast gets folded in and shut off from connection with the external surface. It remains as a sac lined with epithelium, increases with the growth of the individual, and is apt suddenly to take on rapid growth if anything stimulates the epithelial cells. The involution of the epiblast occurs between the genio-hyo-glossi muscles or between the genio-hyo-glossus and the mylo-hyoid, which explains the central and lateral situation of the cysts respectively.

The *treatment* is by excision, and this may be performed either from within the mouth or externally in the submaxillary space. The latter operation is preferable, as the region of the wound can be kept aseptic and the surgeon can more easily see what he is about. A vertical incision is made in the median line between the muscles below the chin, and when the sac of the cyst is reached it is pulled out gently and freed with occasional touches of the knife as it protrudes. If care be taken there is but little danger of hemorrhage. Should the cyst be large, the contents should first be evacuated. Many recommend the removal of these cysts through the mouth, especially in females, as thus a scar is avoided in the submaxillary space. It is simple in small cysts, but when large it will be found a difficult proceeding.

Acute Glossitis, or parenchymatous inflammation of the tongue, is a somewhat rare affection. It is much more common in adults than in children, and more frequently attacks males than females. It sometimes follows specific fevers, or may be due to injury, cold, septic conditions of the mouth, bites of insects, etc. These, however, are special forms ; ordinary spontaneous glossitis is said to be caused by cold and damp, and is looked upon by some as a catarrhal affection.

At the onset of the affection the patient complains of tenderness of the tongue while masticating solid food. The organ begins to swell rapidly, and within twenty-four hours it becomes twice its natural size and protrudes from the mouth. The portion of the tongue within the mouth is livid and shiny, but the part protruding is dry, cracked, and brown. Pressure of the teeth causes its edges to become indented, articulation is impossible, and difficulty in swallowing is always present. Frequently there is dyspnea. There is also a profuse secretion of saliva, which continually dribbles away from the mouth. The termination of the disease is usually by resolution in four or five days ; there may be small superficial sloughs on the surface which leave ulcers ; these, however, heal rapidly. Occasionally the inflammation is so acute that gangrene supervenes. One of the rare terminations of this affection is suppuration. Sometimes life is threatened by suffocation, and it may be necessary to perform tracheotomy. Constitutional symptoms, as fever, etc., are always present. Hemiglossitis is a much rarer and a much less severe form of the affection than the preceding, and usually occurs on the left side. There is not so much difficulty in deglutition, and there is never any dyspnea.

Treatment.—The majority of cases get well in five or six days without much treatment. A saline purge, a chlorate of potassium wash, and the sucking of small pieces of ice form the proper treatment in the milder cases ; but when the symptoms are urgent and the distress great, surgical interference becomes necessary. A deep and long incision should be made in each side of the raphé near the root of the tongue, and free bleeding should be encouraged. The bleeding is rarely severe, and the relief following free incision is immediate, the tongue in a few hours resuming its natural size. After incision suppuration is much less likely to occur.

Syphilis of the Tongue.—The most common manifestation of syphilis in the tongue is in the shape of *fissures.* These usually indicate a tertiary

period of the disease. Fissures are sometimes seen in the secondary stage on the side of the tongue, and are often aggravated by the sharp edge of a carious tooth. The syphilitic fissure is usually very sensitive to the touch and a source of annoyance, though not surrounded by an inflammatory condition, as other fissures are. It may be single or multiple. The diagnosis is generally easy, for there are manifestations of syphilis in other parts of the body. It should be treated by the ordinary antisyphilitic remedies; if secondary by mercury, and if tertiary by potassium iodide. Butlin recommends painting the fissures with a ten-grain solution of chromic acid, which he says, in combination with mercury, heals them with great rapidity. When healed they leave scars. Tertiary fissures may be produced by the breaking down of several small gummata, and are of some depth and length. They may plough up the dorsum of the tongue in every direction, and heal under treatment very slowly.

Ulceration commonly occurs during the secondary stage along the edges of the tongue. The ulceration is superficial, and a white patch on the mucous membrane of the cheek corresponding to the ulcer on the tongue will usually be found. *Mucous tubercles* may also appear on the tip and borders of the tongue during the secondary stage, but at the same time they are seen in other places; they are oval, grayish-colored masses covered with partly macerated epithelium. *Gummata* are seen, and may be superficial or deep, multiple or single. They may be absorbed or break down. The *deep syphilitic ulcer* is caused by the breaking down of a gumma, and is usually situated on the dorsum of the tongue. It has sharp-cut edges and an indurated base.

It must also be borne in mind that the primary lesion of syphilis—*chancre*—may occur on the tongue; it presents the appearance of primary sores in other parts, but its specific character may easily be overlooked on account of its rarity. The submaxillary lymphatic glands are usually enlarged from the first.

Tubercle of the Tongue.—When tubercle attacks the tongue it usually manifests itself in the form of an ulcer, though tubercular fissures are sometimes seen on the tip and borders. They are most often single, and may be stellate in shape.

The *tubercular ulcer* is seen most frequently on or toward the tip of the tongue, and when extensive it may be easily mistaken for cancer. The ulcer is irregular, with sharply-cut edges and pale, flabby granulations at the base; there is little surrounding induration; in its advanced stages it may eat deeply into the tongue. It is acutely painful, so much so that the lingual nerve has been divided to ease the sufferings of the patient. It may be a primary manifestation of tubercle, but this is rare. It much more commonly occurs as a secondary lesion. The diagnosis is often exceedingly difficult. The tongue has been excised for tubercular ulcer in mistake for cancer. The prognosis is quite as unfavorable as that of cancer, the patient succumbing to the disease in from a few months to two years.

Cancer of the Tongue is always of one variety, viz. **Epithelioma.** It commences as a small crack, nodule, or ulcer usually on the side of the tongue, though no part of the tongue is exempt. The posterior half is much less commonly affected than the anterior. It occurs more frequently in men than in women in the proportion of 247 to 46 (Barker). It will be found, on examining the various statistics, that cancer of the tongue occurs most frequently between the ages of forty-five and fifty-five.

There is no doubt that smoking predisposes to cancer of the tongue, as many cases are preceded by leucoma or the so-called psoriasis of the tongue. This condition may be produced by dram-drinking, smoking, and also syphilis.

In 80 cases 16 were preceded by leucoma (Butlin). The psoriasis and scars produced by syphilis, injury, or any other cause will predispose to cancer; any irritation, such as a sharp tooth, the stem of a tobacco-pipe, a badly-fitting tooth-plate, etc., will in some persons excite ulceration which may take on a cancerous action. There is no doubt, however, that cancer of the tongue may originate without any pre-existing disease or irritation, but in the majority of cases some form of irritation is the exciting cause of the disease. Many practitioners who are consulted by elderly people for ulcers of the tongue are in the habit of cauterizing the sore repeatedly with nitrate of silver or other caustic. This is a most pernicious custom, and one which, while it can do no good, may do infinite harm; for, should the ulcer be cancerous, it only aggravates it, and in an ulcer which is of a simple, non-malignant character it may excite cancer by the continued irritation. Again, it does harm in cancerous ulcers by causing operative measures to be put off until a period when operation can be of but little use, by soothing the patient with the idea that something is being done for him. Ulceration of the tongue in people over forty years of age should always be regarded with suspicion, and if there be any doubt as to its nature the ulcer and a portion of healthy tissue around it should be excised. No doubt many cases of leucoplakia terminate in epithelioma. When the cancerous ulcer is well developed or the induration at its base is marked, the diagnosis is not so difficult, but if there be any doubt a portion should be excised, and the microscope will usually establish the character of the disease.

When the ulcer commences on the border of the tongue, it rapidly infiltrates not only the tongue, but also the floor of the mouth and the gums, and finally the jaw-bone itself is affected. The tongue becomes fixed, and its motion is so limited that it cannot be protruded. Should the disease begin farther back, the ulceration or infiltration extends to the pillars of the fauces, the soft palate, and the tonsils. When the disease has advanced thus far, the glands in the neighborhood become enlarged. First, there is tenderness in the submaxillary region, with pain which shoots up to the ear; later, the glands may be felt, small and hard, but movable; as they increase in size they become fixed. If the glands are affected early, the case is unfavorable, especially so when there is early involvement of the cervical glands immediately outside the angle of the jaw. As the disease progresses, deglutition and speech become difficult, there is profuse salivation, and a horrible fetor of the breath. Patients may die from hemorrhage due to the growth ulcerating into some large vessel, or there may be frequent hemorrhages from smaller vessels, which may hasten the end. The usual mode of death, however, is from exhaustion due to pain, sleeplessness, starvation, sloughing, etc. The average duration of the disease in patients who have had no operation is from a year to eighteen months. Many cases succumb in less than a year, and few live longer than two years.

Diagnosis.—In the advanced stages of cancer of the tongue the diagnosis is not difficult; the foul, deeply excavated ulcer with everted ragged edges and widely infiltrated base, with large granulations protruding from it, the pain, the fixation of the organ, and the induration of the submaxillary glands, stamp the affection unmistakably as carcinoma. At this stage operation is not very hopeful.

The diseases with which carcinoma of the tongue are most likely to be confounded are: 1, syphilitic ulceration, primary and tertiary; 2, tubercular ulcer; and 3, simple ulcer.

From *Syphilitic Ulceration.*—The situation of the ulcer and the history of the case will enable one to form an opinion. Syphilitic ulcers are usually preceded by induration or the existence of a lump at that point. In cancerous

ulcers the induration does not precede but follows the ulcer. There may be two or more gummata on the tongue. Cancerous ulcer is always single. Cancerous ulcer occurs chiefly on the side of the tongue, syphilitic ulcer on the dorsum. In the ulcer of tertiary syphilis the lymphatic glands are rarely enlarged; in cancerous ulcer which has existed for some time they are always enlarged. Many cases occur in which the diagnosis can be satisfactorily settled only by the microscope. Even this is sometimes at fault and sometimes dangerous, for cases of rapid spread of the disease have taken place as the result of the cutting out of pieces of the growth for purposes of diagnosis.

From *Tubercular Ulcers.*—In both the lymphatic glands are involved. The age of the patient and the extensive induration would point to cancer. In cases of tubercular ulceration we can usually get a history of tubercle in the patient's family. Of course tubercle bacilli should always be sought for, and if they are found all question as to the nature of the affection is set at rest.

From *Simple Ulcer.*—If simple ulcer be suspected, a cause, such as a carious tooth, traumatism, glossitis, etc., should be looked for. Simple ulcers have rarely much induration about the base, but cancerous ulcers are remarkable for the deep infiltration of the surrounding parts. Should the ulcer not heal readily in a man over forty-five, it should be excised.

Prognosis.—Cancer of the tongue, like cancer of other parts, if not operated on, proceeds invariably to a fatal termination. It is of the utmost importance that the disease should be recognized in its early stages, when it is a purely local affection. At this period, if removal of the tongue be undertaken, the chances of the patient's remaining free from the disease are greater, and should the disease recur the interval of freedom is much increased.

Treatment.—There is but one method of treatment of epithelioma of the tongue, viz. removal by surgical operation. With regard to other methods of treatment, by caustics, pastes, etc., they are not only useless, but hurtful. It cannot be too strongly insisted on that the treatment of cancerous ulcers by caustics is bad treatment, and that the only chance the patient has of cure is early removal of the disease by surgical operation. Operation always relieves, if it does not cure. In Butlin's table of 80 cases, 70 were operated on, and 9 patients were in good health a year after the operation. (See Operations, below.)

Wounds.—Usually wounds of the tongue are not serious, but Bryant mentions a case where death followed a wound of the tongue in a small child from trickling of blood down the larynx, the child dying asphyxiated. Wickham Legg relates cases of death following biting of the tongue in persons the subjects of hemophilia. Wounds of the tongue may be produced in various ways, but most commonly the wound is caused by the teeth. Epileptics not infrequently bite the tongue during a fit. The tongue may be severely wounded by a fall on the chin or by a violent blow on the jaw when the tongue is protruded. The protruded portion of the tongue may be completely bitten off or one side only be injured.

The hemorrhage resulting from injury to the tongue is seldom dangerous, and is usually easily controlled by hot water, ice, or exposure to the air. Should the hemorrhage be profuse, its source should be sought for and the bleeding vessel, usually the ranine artery, tied. Oozing from the wound is generally arrested by bringing its edges together with sutures. In certain cases where the wound is far back, it may be necessary to pass a ligature through the tip of the tongue, draw it out, and examine the wound thoroughly; if the wound be small, it should be enlarged and the bleeding vessel secured. In some cases it may be necessary to use the cautery to arrest the hemorrhage; its use, how-

ever, interferes with primary union. Sutures are not necessary if the wound be small, but if it be large and a portion of the tongue be hanging loose, the sides of the wound should be carefully brought together with deeply-placed silk or catgut sutures. These must be tied with more than the usual care, or they will loosen from the moisture and constant movements of the tongue. The after-treatment of wounds of the tongue is similar to that of other wounds of the mouth. The mouth should be washed out frequently with weak Condy's fluid, or a paint of iodoform and alcohol may be used.

Foreign Bodies.—Wounds of the tongue may be caused by foreign bodies, such as the stem of a tobacco-pipe, crochet-needles, splinters of wood, etc. Foreign bodies are occasionally driven into the tongue in cases of gunshot wounds; these consist of teeth, portions of the jaw, etc. A bullet may also lodge in the tongue. When a wound of the tongue does not readily heal, or when there is secondary hemorrhage, or, again, if a sinus exists and an indolent swelling remains, a foreign body may be suspected. When it is removed the wound usually heals. But its removal does not always bring about so happy a result; in more than one case this procedure has been followed by hemorrhage which has caused death.

OPERATIONS ON THE TONGUE.

Removal of a Portion of the Tongue.—Should epithelioma of the tongue be confined to the tip or a very small part of the border of the anterior half of the tongue, and should the submaxillary glands not be enlarged—in other words, if the ulcer be early recognized as cancer—the removal of only a portion of the tongue is justifiable, and gives a fair chance to the patient without submitting him to the much more formidable operation of excision of the whole organ. But the complete removal of the tongue is usually the better operation, unless the ulcer is very small, for the chance of recurrence is much less than when only part of the organ is taken away. Partial removal of the tongue may be performed with galvanic écraseur, wire écraseur, knife, or scissors. The knife is to be preferred when it is necessary to remove only a small part of the tongue. The method recommended by Mr. Barker is very simple and efficacious. A gag having been introduced, the tongue is drawn out by means of two ligatures placed one on each side of the median line of the tongue near the tip. The tongue is then split down the middle, and the diseased half is freed from the floor and side of the mouth with scissors. Needles are now passed through the tongue behind the disease, and the loop of the écraseur is placed behind them, tightened, and the affected half removed. The loop of the écraseur should be of wire or whip-cord. The objection to the use of the galvano-cautery is the troublesome slough which follows.

Removal of the Entire Tongue.—In cases where the cancerous ulcer involves the posterior half of the organ or is at all extensive it is necessary to remove the whole tongue. In removing the tongue one of the chief dangers is hemorrhage, and before proceeding farther it may be well to mention a very simple and ready method of arresting hemorrhage occurring either accidentally during operation or afterward. This method was introduced by Mr. Heath of London, and has been adopted by most surgeons. It is this: "The forefinger, passed well down to the epiglottis, is made to hook forward the hyoid bone and drag it up as far as practicable toward the symphysis menti. The effect of this is to stretch the lingual arteries so as to completely control for a time the flow of blood through them, and in this way portions of the anterior part of the tongue may be cut off almost bloodlessly."

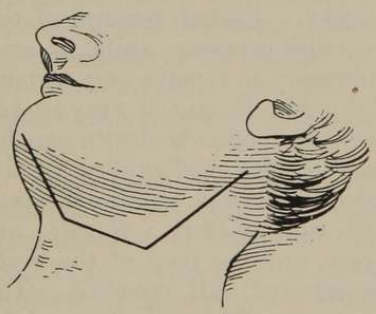
The points to be kept in view in operations on the tongue for malignant disease are: (1) The possibility of removing all the disease; (2) the prevention of hemorrhage; (3) the avoidance of the entrance of blood into the air-passages; and, after operation, (4) the preservation of an aseptic condition of the mouth and secretions until healing is complete.

The various operations which have been practised for the removal of the entire tongue are very numerous. The most popular operation with English-speaking surgeons at the present day is that known as Whitehead's, viz. removal of the tongue by scissors; this may be done with or without preliminary ligature of the lingual arteries. A few years ago nearly every surgeon employed the galvanic or wire écraseur, but the occurrence of secondary hemorrhage when the slough separated was so frequent that the écraseur has been supplanted by the scissors.

Whitehead's Operation.—The operation for the removal of the tongue is thus described by Mr. Whitehead: The head being placed in a good light and a gag introduced, the tongue is drawn well forward by a ligature through its tip: with a pair of sharp scissors the frænum is then divided, and, strong traction being made on the tongue, its attachments are gradually freed by a series of short snips carried as far back as possible. The lingual arteries may be secured as they are cut. The stump should be kept under control as regards hemorrhage by a strong silk ligature passed through the remains of the glosso-epiglottidean fold, and retained for twenty-four hours. Mr. Whitehead states that he has never seen any trouble from hemorrhage.

Kocher's Operation (Fig. 267).—Kocher has performed complete excision of the tongue 104 times, with 20 deaths. These deaths were chiefly in cases complicated with extension of the disease to the floor of the mouth, tonsil, and lower jaw. In 66 uncomplicated cases the mortality was only 3 (4.5 per cent.).

Fig. 267.



Kocher's Incision for Removal of the Tongue.

This is the only operation for the removal of the tongue which aims at preserving the parts in a thoroughly aseptic condition. Tracheotomy is first performed and a well-fitting canula introduced. The pharynx is then packed with a carbolized sponge with a cord attached, so that it can be easily removed when necessary. An incision is now made, commencing a little below the tip of the ear and extending down the anterior border of the sterno-mastoid muscle to about its middle, then forward to the body of the hyoid bone, and along the anterior belly of the digastric muscle to the jaw. The resulting flap is turned up on the cheek, and the lingual artery is ligatured as it passes under the hyoglossus muscle. The facial artery and any veins that may be in the way are also secured. Commencing from behind, all the structures in the submaxillary fossa are removed, viz. the lymphatic glands, the submaxillary, and, if necessary, the sublingual glands. The opposite lingual artery is now tied by a separate incision if the whole tongue is to be removed. The mucous membrane along the jaw and the mylo-hyoid muscle are then divided, and the tongue drawn out through the incision and removed with scissors or galvano-cautery; the latter is preferred by Kocher, as there is less liability to after-oozing. The after-treatment is most important: if the operation be an extensive one, the external wound should not be closed. Kocher's endeavor is to avoid the two great after-

dangers of excision of the tongue, pneumonia and general septicemia. To prevent the discharge from causing infection, the whole cavity of the mouth and pharynx is plugged with carbolized sponges and iodoform gauze. The patient is fed partly by the rectum, but chiefly by the throat with a tube, twice a day, when the dressings are changed. Thus, if all the minute directions are enforced, the wound remains aseptic throughout, and no food or discharge from the wound can possibly enter the air-passages. There is one thing that the operator cannot guard against, and that is vomiting: should the patient vomit, as is so often the case after the administration of anesthetics, the elaborate preparations against sepsis may come to naught. In Kocher's hands this operation has been most successful.

Removal of the Tongue after Division of the Lower Jaw.—This operation was introduced by Sédillot of Strasburg, and afterward practised by Syme of Edinburgh. It consists in making a vertical incision in the lower lip, sawing through the inferior maxilla at the symphysis, separating the two sides of the jaw, and drawing out the tongue and removing it by scissors, écraseur, or knife. The divided portions of the jaw are afterward wired together. It is best to drill the holes for the sutures before dividing the jaw. This operation answers well when the floor of the mouth is involved in the disease.

Results of Operation.—The immediate results following excision of the tongue are fairly good, considering the severity of the operation. Whatever operation is practised, the mortality in a series of cases is about the same, and the method has less influence upon the mortality than the after-treatment. In 219 cases collected by the writer from the tables of Agnew, Nunneley, Barker, Whitehead, Langenbeck, and Kocher there were 26 deaths (11.87 per cent.). The chief causes of death are septic pneumonia, pyemia, shock, and exhaustion. When the tongue alone is excised the risk is much less: the fatal cases occur most frequently when other parts are involved, as the tonsil, jaw, floor of the mouth, glands, etc., such conditions requiring more severe operations.

Operation always relieves, if it does not cure, cancer of the tongue, recurrence being the rule. Barker has collected 170 cases in which the whole or part of the tongue was removed, and in only 17 was there non-recurrence at the end of a year. The duration of life in cases not operated on is about a year, in those operated on about nineteen months, a clear gain of seven months.

Dangers of Excision.—Hemorrhage formerly was much dreaded in these operations, but with modern methods of arresting it this fear has vanished. Secondary hemorrhage also is much less frequent now that the écraseur has been almost discarded.

The greatest danger connected with excision of the tongue is without doubt septic pneumonia or other lung affections, produced by direct infection from the fetid discharges of the decomposing wound. In some cases there is gangrene of a portion of the lung or a number of small, foul, circumscribed abscesses; in others, a condition of broncho-pneumonia.

After-treatment.—The most important point in the after-treatment is to preserve a condition of asepsis in the wound, for, as has been shown above, the greatest danger is due to direct septic infection from the wound itself. Again, the swallowing of blood at the time of operation tainted with the foul discharges of the cancerous ulcer should be carefully guarded against by having the mouth thoroughly and frequently washed out with some antiseptic solution, as Condy's fluid, carbolic acid, etc., before operation, and during operation avoiding a condition of too profound anesthesia, and by posture as far as possible. After operation the wound in the mouth should be packed with sticky iodoform gauze, as recommended by Billroth, painted over with alcoholic solution of iodoform

and resin, or at least dusted with iodoform crystals. Whitehead recommends a varnish made of the ordinary constituents of Friar's balsam, substituting a saturated solution of iodoform in ether for the rectified spirit. It is well to feed the patient as freely and early as possible by the mouth: the results of this procedure are as good as, if not better than, when, as was formerly advocated, the patient is fed for the first few days by the rectum. For feeding by the mouth a very good arrangement is a soft catheter with a piece of rubber tubing attached to it, and to this again is attached a glass funnel: by pouring liquid food into the funnel the patient can be easily and comfortably fed. Should any fetor appear in the wound, the mouth should be frequently washed out with a solution of Condy's fluid, carbolic acid, or potassium chlorate. Whitehead says that instead of keeping the patient in bed he should rather be encouraged to sit up the day after the operation, or even to go out if the weather be fine; in this way discharges of blood from the wound are less liable to get into the air-passages.

DISEASES OF THE JAWS.

Congenital Deformities.—In the description of the development of the face the various deformities of the jaws have been alluded to. These include cleft palate, arrest of development of one or both sides of the lower jaw, non-union of the two halves of the lower jaw, with median fissure of the lower lip, and non-union of the premaxillaries, with median fissure of the upper lip. With arrest of development of the lower jaw is sometimes associated a congenital dislocation. All these deformities of the jaws, with the exception of cleft palate, are extremely rare.

Acquired Deformities of the jaws are not uncommon. Hypertrophy of the tongue may result in deformity by constant pressure. Chalk reports a case of dislocation produced by it. Sucking the thumb has a very marked influence on the position of the teeth, and if persisted in may cause considerable deformity of the jaw. Cicatrices outside the mouth may produce deformities. Burns in childhood may be followed by deformities, such as binding the lower lip to the sternum, and hence pulling forward the lower jaw to a considerable extent.

Abscess of the Gums and Jaw, or "gum-boil," is a very common affection, and is due to irritation from decayed teeth. Sometimes it is quite superficial and can be cured by puncture, but at other times, when connected with the diseased root of a tooth, it is much deeper and is accompanied by a considerable swelling of the face and severe pain. In such cases exit may be found for the abscess along the surface of the tooth and temporary relief be afforded, but the affection recurs, and nothing short of careful treatment by a competent dentist, and sometimes removal of the tooth, will benefit the patient. When the abscess breaks externally it may give rise to an external fistula, which will close when the offending tooth is cured by the dentist. In certain cases the abscess, when untreated, may lead to necrosis of bone. The treatment then is early and free incision of the gum and extraction of the diseased tooth, unless it can be saved by the dentist.

Necrosis of the jaw may be the result of very different causes. It may follow one of the zymotic diseases, or be produced by injury, ostitis, periostitis, exposure to the fumes of phosphorus, or mercury. A carious tooth may be the commencement of a necrosis of the jaw if not properly treated. The predisposing causes are struma, syphilis, and lowered conditions of the system from disease or from deficient food. Necrosis occurs nearly as often in the upper as in the lower jaw, and is seen at any age. It is always preceded by intense and deeply-seated pain and inflamed and swollen gums; the teeth become

loose, and soon sinuses form in every direction, giving exit to pus. On passing a probe, dead bone is easily felt. Soon the health of the patient deteriorates and a supporting treatment is necessary. The bone is bathed in pus, becomes loose, and is easily removed through an incision in the gums, followed by detergent mouth-washes, as noted above.

Phosphorus Necrosis frequently exists without the patient's at first being aware of it. It is very rapid and involves a large extent of bone. The symptoms are those of other forms of necrosis. The necrosed bone is usually porous and is of a dirty gray color.

Treatment.—The dead bone should be quite loose before removal is undertaken, as tearing out a portion not yet fully separated may lead to serious accidents, such as wounds of vessels and fracture of the new bone. It is better, if possible, to remove the sequestrum from the inside of the mouth, and where the necrosis involves the upper jaw this can usually be easily done, for, as a rule, the alveolar process only is involved. But in necrosis of the lower jaw the surgeon must be guided by the situation and direction of the sinuses, which often point externally. The necrosed bone in such cases may often be more easily removed by an incision along the line of the lower jaw.

Epulis.—This is a term which is applied to various tumors of the gums. They are really not connected with the gums at all, but with the periosteum of the alveolar process and sockets of the teeth. Two forms are usually described, viz. simple or fibrous epulis and malignant or myeloid epulis.

Simple Epulis is seen as a smooth, rounded growth, red in color, elastic, and appearing much the same as the gum. It soon ulcerates and a sero-purulent discharge exudes from its surface; or it may ossify.

Malignant or *Myeloid Epulis* is a much more serious affection, and is generally connected with the socket of the tooth. It is very vascular, of a purplish color, grows rapidly, and soon presents a large fungating mass, which protrudes between the teeth and bleeds easily; it never ossifies.

Treatment.—Early and free removal is the only treatment for both; not removal of the growth alone, but extraction of the tooth and removal of the alveolar process with the socket of the tooth. It is better to make two vertical cuts with a Hey's or other saw, and then with a strong pair of cutting forceps remove the portion of bone mapped out. In this way only will a successful result ensue. Without removal of bone the disease will nearly always return, even in simple cases.

Hyperostosis is a very rare affection. Remarkable cases have been reported from time to time. The exciting cause of this affection may be a blow on the face. When on only one side, operation has been undertaken for its relief with success.

Dentigerous Cysts are found in both the upper and the lower jaw, and usually arise from permanent teeth as a result of some form of irritation. They are frequently mistaken for solid growths. In these cysts, from some unknown cause, the teeth remain undeveloped within the jaw or may be inverted. The cyst-wall is generally very thick and lined by a vascular membrane. The tooth may or may not project through this membrane.

Diagnosis.—When a slow-growing, painless, solid tumor of the jaw is seen in a young person, the surgeon should always examine the teeth. He will probably find a tooth absent or a temporary tooth where a permanent one ought to be. Jaws have been removed for this affection under the supposition that the tumor was malignant. It is better, therefore, in a young person, even if the disease is not looked upon as a dentigerous cyst, to cut into the tumor before mutilating the patient by the removal of the whole or a portion of the jaw.

Cysts of the Lower Jaw.—A limited portion of the lower jaw may be expanded gradually by a single cystic growth. Such a cyst grows slowly, its wall becomes thinner and thinner, and the tumor distinctly fluctuates. The bone becomes so thin that it crackles on pressure. It is said that these cysts originate in connection with the teeth. Sometimes a small cyst is connected with the root of a tooth, and Powers considers that they are of inflammatory origin.

Multilocular Cysts.—These cysts are nothing but a late stage of solid tumors, this condition being due to cystic degeneration of sarcomata and epitheliomata. There is often a development of bone in the interior of the cyst. They sometimes grow to large size and are of years' growth. Frequently they are painless. Excision of the jaw is the only legitimate method of treatment.

TUMORS OF THE JAWS.

Tumors of the jaws may be divided into non-malignant and malignant.

The *non-malignant* are—(1) Fibroma; (2) Enchondroma; (3) Osteoma.

Fibroma.—Fibrous tumors of the jaws are not uncommon, and resemble other fibrous tumors as regards their clinical history and appearance. They grow from the periosteum, especially of an alveolus, and resemble epulis; or they may grow from the endosteum and expand the jaw by their growth. Such tumors usually make their way into the antrum or nasal fossæ. They may occur in early life. Their growth is slow, but they persistently increase. They seldom attain very large size nowadays, because being in an exposed part of the body they are usually removed early. They are painless and non-malignant when compared with cancer.

Treatment.—Removal of the tumor and of the entire portion of the jaw which gives attachment to it is the only form of treatment of any avail. These tumors not infrequently return after an apparently complete removal.

Enchondroma is a rather rare form of tumor of the jaw. It is sometimes of immense size, and in certain cases has killed the patient by suffocation. Enchondroma usually appears in early life as a tumor of the antrum or body of the lower jaw, is very hard, somewhat nodular, and grows more rapidly than fibroma. Occasionally it ossifies. Enchondromata are very apt to recur locally when removed.

Osteomata of the jaws are rarely met with. They may consist simply of an outgrowth from the bone or of a general thickening and enlargement of the whole bone. They are usually hard, compact, and ivory-like on section; others, again, have a more lamellated structure. The only treatment is removal.

The *malignant tumors* are—(1) Carcinoma; (2) Sarcoma.

(1) **Carcinoma.**—*Epithelioma* is the only form of cancer affecting the jaws. It is, unfortunately, by no means uncommon, and may occur in the comparatively young. It is said that the upper jaw is more frequently affected than the lower. The disease first appears in the gums, and then spreads to the bone. It rapidly infiltrates, and is thus distinguishable from tumors of the non-malignant kind. The skin becomes adherent, and has a brawny-red appearance. It is detected at an earlier stage in the lower jaw than in the upper, and soon infiltrates, ulcerates, sloughs, and involves the neighboring lymphatic glands. Its growth is usually rapid, and it is especially malignant, recurrence soon after removal being the rule. Unless removed in the earliest stages the case is hopeless.

(2) The various forms of **Sarcomata**, such as cystic, myeloid, fibrous, and

spindle-celled, attack the jaw, and should be treated by early removal. Operation is rarely permanently successful, rapid recurrence being the rule, even when the whole lower jaw is removed. They usually grow from the periosteum. In the early stages a rapidly-growing sarcoma may be mistaken for an abscess.

DISEASES OF THE TEMPORO-MAXILLARY ARTICULATION.

Tubercular disease of this joint is very rarely seen; the most common affection is **Rheumatic Arthritis,** which may affect one or both sides. It is a painful affection, and produces absorption of the interarticular cartilage and the outgrowth of bone as in other joints. The deformity produced is a protrusion of the chin forward if both joints are affected, and to one side if only one articulation is involved. It does not lead to osseous ankylosis.

Acute Arthritis may be due to injury or to the extension of inflammation from other parts, as the ear, etc. If it goes on to suppuration, the joint may be destroyed and fibrous or bony ankylosis result. The disease should be treated by the application of leeches and hot fomentations, and if pus forms it should be evacuated early.

Noisy Mastication.—This is a peculiar phenomenon met with in certain individuals, in whom some movements of the jaw during mastication are accompanied by a snapping or cracking noise. This in certain instances is so loud as to be heard even across a small room. Patients in whom this is noted are usually quite unconscious of the fact, having become so accustomed to it as not to notice it themselves. The condition which gives rise to it is one of painless relaxation of the ligaments of the temporo-maxillary joint, and seems in many instances to be of congenital origin; in others it is produced by causes which have operated so slowly as to be vague. It is a condition of no pathological significance, being simply an annoyance, and one which on account of its etiology it is almost impossible to cure. About the only hint of value which can be given to the patient is to eat very slowly and to get into the habit of keeping the muscles of the jaw in that kind of tension which will prevent the possibility of too sudden contact of articular surfaces.

Ankylosis of the Jaw is usually confined to one side, but may affect both, and may be bony or fibrous. It is not infrequently the result of suppuration. Its recognition is easy.

Operations for the relief of this affection have been devised by Humphry of Cambridge, Esmarch, Rizzoli, and others. These operations all consist in simple division of the neck of the jaw or in division with removal of a portion of bone. Esmarch advises the formation of an artificial joint by the removal of a wedge-shaped piece of bone through an incision in front of the masseter, and Rizzoli advocates cutting through the jaw with forceps introduced through the mouth. Some of these cases after operation do well and have free movement of the jaws for a time, but many relapse and movement becomes again limited.

Closure of the Jaws.—This may be merely *temporary*, due to some hysterical condition or to some reflex irritation of the muscles of mastication. The exciting cause may be the cutting of a wisdom tooth or the failure to cut one. This may be due to malposition or want of room. In such cases the patient should be put under ether, the jaw thoroughly examined, and an incision made over the affected tooth, or the next tooth extracted. Sometimes it may be necessary to extract the wisdom tooth or to chisel away the surface of bone over it.

Permanent Closure of the Jaws may be due to ankylosis, which has been described above, or more commonly to cicatricial contraction from ulceration and sloughing the result of gangrenous stomatitis in early childhood. The slough

not infrequently involves the whole thickness of the cheek, and hence the resulting cicatrix is very extensive and unyielding, and the cheeks are blended with the gums so that movement of the jaw is impossible. Division of the cicatricial bands has been followed by no good results, and plastic operations that have been devised have proved almost useless. The best treatment is division of the jaw as for ankylosis and the forming of a false joint in front of the cicatrix. Heath speaks highly of Esmarch's operation for the relief of this condition.

DISEASES OF THE TEETH.

Dental Caries.—This is a very common affection, few persons reaching adult life without having suffered from it. It is a decay on the surface of the tooth which causes the tissues slowly to soften and disintegrate until the pulp-cavity is reached. It may commence in the enamel or in the dentine beneath the enamel. When the enamel is attacked, it becomes opaque and soon is discolored; when the dentine is reached, the progress is more rapid. The diseased portion may be nearly black, but it is usually of a dark brown. The deeper the stain the slower the decay. Carious dentine has a smell peculiar to itself. The much-disputed question of the active cause of dental caries has been finally settled by Miller, an American dentist, now in Berlin, who has conclusively shown that dental caries is due to the bacteria in the mouth, of which there are a large number.

The *predisposing causes* of caries are (1) some defect in the enamel, so that the dentine is exposed to the action of decomposing food and the bacteria in the mouth; (2) injury due to the too great crowding of teeth, the pressure causing absorption of the enamel and thus exposing the dentine; (3) the accumulation of decaying substances between the teeth. In certain diseases, such as fevers, etc., decay is more liable to occur. Pregnancy and the various forms of ill health, by deranging digestion, are frequent predisposing causes. Imperfect calcification of the teeth and hereditary conditions may also predispose to caries.

The Exciting Causes of Caries.—(1) The acids which are the products of fermentation and chemical decomposition of food and other matters in the mouth, also acid mucus secreted by the gums; (2) when the dentine is exposed, certain organisms, such as the *Leptothrix buccalis*, appear and pervade the dentine and grow at its expense. When the pulp-cavity is reached, severe pain is experienced. Owing to the pulp being confined within bony walls, it cannot expand under the influence of inflammation; hence great pressure is the result, and consequently intense pain. The pulp recedes, the inner surface of the cavity is attacked, and the disease proceeds from within outward. Certain teeth are more liable to decay than others. This is particularly true of the "sixth-year molar," or the first of the permanent teeth to appear. Surgeons frequently overlook this tooth. The same tendency to decay exists in the "wisdom" teeth.

Treatment.—The treatment of caries comes more within the province of the dentist than within that of the surgeon, and consists in the removal of the decayed tissue, so that a healthy surface is left, and then filling the cavity with gold-leaf, amalgam, or other suitable material. The preventive treatment consists in preserving perfect cleanliness by toothbrush and antiseptic powders and maintaining a good condition of health.

Dental Periostitis.—The periosteum lining the sockets of the teeth is liable to become inflamed, a diseased tooth being very frequently the cause. The affection may be acute or chronic. When it goes on to suppuration an

alveolar abscess, or gum-boil, is the result. The tooth is very tender, especially on pressure, and feels as if it were too long; it afterward becomes loose and protrudes from the socket. This affection must not in its first stages be confounded with inflammation of the pulp. In this latter, although the pain is intense, still the tooth is not tender and does not feel as if it were too large for the socket. The results following a neglected alveolar abscess have been described above under Abscess of the Jaw.

Treatment.—Removal of the cause is the proper treatment, viz. extraction of the diseased tooth. If left, the inflammation recurs, and in the end the tooth has to be sacrificed.

Syphilitic Teeth.—The peculiar teeth which occur in children with inherited syphilis, first described by Mr. Hutchinson, have already been mentioned in the chapter on Syphilis.

Extraction of Teeth.—The extraction of the *temporary* teeth is a simple matter, as in the natural course of events the roots are absorbed and the crown of the tooth is shed from the gum.

The *permanent* teeth, however, frequently give some trouble, and unless the operator uses judgment and care in the extraction serious damage may be done. The surgeon must remember that skill is more requisite in the extraction of a tooth than strength. The best instrument for extraction is the forceps, of which there are many different kinds, but for all practical purposes two or three pairs are all that the surgeon will require, for the upper jaw a bayonet-shaped forceps with straight handles, and for the lower the Universal lower molar forceps. The first two molars of the upper jaw and the canines are the most difficult to extract, the easiest being the incisors and bicuspids. In extracting a tooth with a single root it may be first loosened by rotating it before pulling, but this procedure is useless in the bicuspids and molars; here the fangs are flat and cannot be rotated, but by a swaying movement, first outward, then inward, for the upper teeth, and inward and then outward for the lower molars, the tooth is loosened and comes away easily. The tooth should be seized as near to the root as possible. Care is to be taken not to break off any portion of the alveolar process, for, though serious results rarely follow, yet sometimes necrosis occurs. For the removal of stumps of teeth special forceps are required.

Irregularities of the Teeth are comparatively common, and exist usually in the permanent set alone. Thumb-sucking is a frequent source of irregularity, causing all the front teeth to protrude; crowding of the teeth also is often seen, and is relieved by extraction of one or more teeth, thus giving room for the others to develop. Too early extraction of the temporary canines of the upper jaw may cause the premolars to encroach on the territory of the permanent canines, and thus produce deformity. Teeth which when first erupted appear very irregular, as development proceeds often get into line, and are finally quite regular in appearance. Supernumerary teeth not infrequently appear. The treatment of irregularities is purely mechanical, and is fully described in works on dentistry, and surgeons would do well to refer such cases to dentists for treatment.

Toothache.—Usually this is a symptom of dental caries, the ulceration having exposed the pulp. It may also be due to inflammation of the periosteum covering the root, ossification of the pulp, or exostosis of the root. Healthy teeth may be affected with severe pain from a neighboring diseased tooth, in the same way as in some cases of hip-joint disease the pain is in the knee. In doubtful cases it is always advisable to examine the teeth very carefully in order to see which one is the source of trouble, and so to prevent

extraction of the wrong tooth. Occasionally the toothache may be due to neuralgia. In cases of exposed pulp pain may be relieved by the oil of cloves, creasote, carbolic acid, chloroform, aconite, and other remedies, applied on absorbent cotton wool. Painting the gums with equal parts of tincture of aconite and tincture of iodine sometimes affords relief. Extraction should never be undertaken except as a last resort.

Hemorrhage after Extraction of a Tooth.—Bleeding occurs in all cases, but it is generally slight, and even if the oozing goes on for some time there is usually but little danger. In cases of hemophilia or purpura hæmorrhagica the extraction of a tooth is a serious matter and may be fatal. Slight hemorrhage may be arrested by cold. In severe cases the cavity should be cleansed of the blood-clots and carefully and tightly packed with cotton or strips of lint with tannin rubbed into the meshes, and over this a plug of lint, and pressure made by closing the jaws on the plug and fixing them with a four-tailed bandage. It is only in the most severe cases that the plug has to be soaked in perchloride of iron or the cavity touched with the actual cautery.

Odontomes, or Tooth Tumors.—Broca first described these tumors in 1867. They consist of very greatly hypertrophied dental tissue. Malformed teeth and teeth with warty excrescences are sometimes included in this group. A true odontome is usually encysted, has no attachment to the surrounding structures, and rarely gives rise to much irritation. One variety occurs in the lower jaw and contains the formative elements of one or two molars. It grows irregularly and bears no resemblance to a tooth in shape. This tumor, which grows slowly and expands the bone, may be mistaken for a true tumor of the lower jaw, and portions of the jaw may be unnecessarily removed. It is important, therefore, especially in all cases of tumors of the lower jaw, that the surgeon before sacrificing a part of the jaw should bear in mind the possibility that the tumor may be an odontome. Where tooth tumors are attended by inflammation it is possible to mistake the case for one of necrosis. Some odontomes affect all the tissues of the teeth; others affect the enamel or the dentine only. Sometimes there is a fistulous communication with the external surface of the cheek. The treatment is sufficiently simple. If the growth is small and is merely unsightly, it may be removed, but in cases in which it consists of a large mass of dental tissue imbedded in the jaw an incision should be made over the growth, and then with a bone elevator or forceps the tumor can be easily enucleated without serious damage to the jaw.

DISEASES OF THE PHARYNX.

Congenital Malformations of the Pharynx.—These are not common. **Fistulæ** occur in rare cases and communicate with the pharynx, trachea, or œsophagus. They are due to persistence of the branchial clefts. Pharyngeal fistulæ usually occur as minute orifices on one or both sides of the neck below the glottis, their direction being upward to the pharynx and œsophagus. They occur in the line of the old branchial clefts, the lowest being near the sternal end of the clavicle, the next opposite the thyroid cartilage, and the highest between the thyroid cartilage and the hyoid bone (Paget). When two in number they are often symmetrical. They vary in length from half an inch to one and a half inches, and barely admit a probe, though the diameter of the fistula is always greater than that of the external opening. The internal opening of the fistula is found in the lateral wall of the pharynx, behind the cornu of the hyoid bone, or in the pharyngo-palatine side. The fistulæ are lined by

a smooth membrane, which secretes a mucous fluid. They may be cured by cauterization with the actual cautery.

Diverticula from the pharynx and œsophagus which are congenital indicate also incomplete closure of the branchial clefts and occur in the same regions as the fistulæ; occasionally they are not congenital, but acquired.

Tonsillitis (Quinsy, Cynanche tonsillaris).—Acute inflammation of the tonsils sets in very suddenly with such symptoms as severe rigor, high fever, headache, and general malaise. The tonsils soon become swollen, red, and painful, rendering swallowing difficult. The glands beneath and behind the angle of the jaw enlarge and become very tender on pressure. One tonsil is usually affected first, and in a day or two there is a fresh onset of fever and the opposite one becomes similarly inflamed. When both tonsils are simultaneously attacked it is generally an indication of septic infection. The patient has great pain during swallowing, not only in the throat, but in the ear and the side of the neck. Articulation is difficult, and both hearing and the sense of taste are impaired. The temperature may go as high as 104°–105° F. The inflammation most frequently terminates in resolution in the course of a few days, but occasionally it goes on to suppuration. When suppuration occurs the swelling in the tonsil increases rapidly and extends toward the soft palate, the tongue becomes swollen and foul, the breath fetid, and swallowing very difficult. The patient sits up in great pain and feels a sensation of suffocation. In some cases pus forms rapidly, in others slowly. Some hold that the suppuration is always peritonsillar, and that incisions are useful only when made in front of or behind the tonsil, where the pillars of the fauces are in connection with it, and where pus is formed in the connective tissue around the tonsil.

The *causes* of tonsillitis are many. A strumous diathesis predisposes to it, and also an arthritic diathesis, as well as exposure to cold, impure air, sewer gas, worry, sexual excitement, etc. One attack predisposes to subsequent ones. The tendency to tonsillitis has been considered hereditary by some. The severity of the fever, which may reach 105° F., and the great prostration often leave the patient very weak for some time, especially if the inflammation has gone on to suppuration. Some hold that all the severe forms of tonsillar inflammation are due solely to septic infection. This view has not yet been fully accepted by the profession.

Treatment.—For ordinary tonsillitis, after administering a brisk purge, nothing is better than a mixture of tincture of muriate of iron with chlorate of potassium and glycerin, taken every hour or two, with occasional applications of a paint made of sodium bicarbonate, applied with a brush. Guaiacum, salicylic acid, aconite, and many other remedies have been recommended from time to time. Ten grains of Dover's powder administered at bedtime give great relief. Should suppuration ensue, early incision is the only treatment; scarification may relieve, but will do so only temporarily. The abscess should be opened with a sharp-pointed bistoury or tenotomy knife. Incision should be from within out and a little in front of the tonsils. If a sharp-pointed bistoury is used, its edge should be guarded by wrapping plaster round it to within an inch of the point; in this way the surgeon runs no risk of wounding the mouth.

Hypertrophy of the Tonsils.—Chronic enlargement of the tonsils is a common affection in strumous children. It is caused by a chronic catarrhal inflammation or may be a simple hypertrophy without any inflammation. Repeated attacks of acute tonsillitis not infrequently lead to this condition. Boys and girls before the age of puberty are most frequently affected, but as

the patient gets older the disposition to tonsillar inflammation decreases. The enlarged tonsils appear in some cases almost entirely to fill the throat, the uvula occupying the space between them. Nasal respiration is interfered with, the child sleeps with its mouth open and its rest is broken. It is important for the surgeon to understand that enlarged tonsils are very frequently the cause of impaired general health, as nearly all the functions are interfered with. The condition is apt to be hereditary.

Treatment.—There is only one method of treating hypertrophy of the tonsils effectually, and that is by excision. It is best performed with some form of tonsillotome or guillotine, after carefully separating all adhesions to the arches of the palate, as wounds of these structures often cause severe hemorrhage. No forceps are needed. The head should be held by an assistant, who with his fingers presses in the tonsils: as much of the gland should be removed as can be pressed into the tonsillotome. The enlargement of the tonsil being usually downward, the tonsillotome should be hooked over the projecting tonsil from below up. The tonsil may also be removed with a probe-pointed bistoury, the tonsil at the same time being pulled out with a tenaculum, but the use of the guillotine is advised in preference to that of the knife, as being more expeditious, safe, and easy, when the tonsil projects well toward the median line. Jarvis' snare (Fig. 240) is also an excellent instrument. Bleeding after tonsillotomy is sometimes severe, and from time to time fatal cases have been reported, chiefly in patients suffering from hemophilia. Hemorrhage is generally easily controlled by pressure from within and from without. A piece of lint soaked in tincture of perchloride of iron, seized in a pair of artery forceps and kept pressed against the bleeding point, is very efficacious. If everything else fails, tie the carotid. The bleeding usually comes from a divided tonsillar branch of the facial.

Caseous and Calcareous Concretions may be developed in the crypts of the tonsils. They are sometimes of large size, and give rise to a considerable amount of inflammation, fetid breath, and general discomfort. Gruening states that all tonsillar concretions are of parasitic origin and composed of *leptothryx* elements. The treatment consists in removal of the concretion, and, if the tonsil is enlarged, removal of a portion of it.

Malignant Tumors.—Both *sarcoma* and *carcinoma* occur in the tonsil. The form of sarcoma is lympho-sarcoma, and that of carcinoma is epithelioma. Sarcoma is more frequent than carcinoma. Both affections are equally malignant. Sarcoma forms a distinct prominent tumor projecting into the fauces, which finally ulcerates, and if untreated usually proves fatal by hemorrhage. Sarcoma has been observed in persons under twenty. Epithelioma of the tonsil is rarely primary. The tonsil may be secondarily involved by the extension of the disease from the tongue and pillars of the fauces. Epithelioma of the tonsil rapidly ulcerates and very early infiltrates the cervical glands. It is more common in men than in women.

Treatment.—Epithelioma of the tonsils, if seen early, may be removed, but in advanced cases, with infection of the glands, removal does not give satisfactory results and is attended by not a little danger. Sarcoma of the tonsil, owing to the fact that it occurs as a prominent tumor and does not so early infiltrate or ulcerate, is more frequently attacked by the surgeon than epithelioma. The removal may be effected through the mouth, or from the outside by an incision in the neck, as recommended by Cheever of Boston.

Removal through the Mouth.—This is sometimes performed by means of the écraseur, galvano-cautery, or thermo-cautery. There is usually very little

hemorrhage. Sarcomatous tumors in their early stages are usually encapsulated, and may be cut down upon within the mouth and easily enucleated (Butlin). Unfortunately, they are very apt to recur.

Removal by Incision through the Neck.—This operation is more suitable for retro-pharyngeal than for tonsillar tumors. It consists in making an incision about three or four inches in length along the anterior border of the sterno-mastoid muscle from the ear to below the level of the tumor. A second incision, joining this, runs along the lower portion of the inferior maxilla, and a careful dissection is made down to the tumor, which is then removed (Cheever).

Czerny and Mikulicz have each devised a very radical operation for the removal of growths of the tonsils. Both these operations require a preliminary tracheotomy, and also division of the lower jaw in the region of the molar teeth. The external incision in Czerny's operation reaches from the angle of the mouth to the anterior border of the masseter muscle, and thence downward to the level of the hyoid bone, and in Mikulicz's operation it reaches from the mastoid process to the cornu of the hyoid bone.

Retro-pharyngeal Abscess.—This affection occurs chiefly in the young, and may be due to various causes. It is usually met with in strumous children, and may be an evidence of caries of the cervical vertebræ. In some cases it follows scarlatina. It may be glandular in its origin or due to extension of inflammation from other parts, or it may be idiopathic. The abscess is situated in the cellular tissue between the bag of the pharynx and the cervical vertebræ, and projects forward in the throat, causing difficulty in swallowing. In cases which have lasted some time the pus may extend laterally and cause a bulging of the neck, usually behind the sterno-mastoid muscle, or it may travel toward the posterior mediastinum. On examining the throat the diagnosis is easy: a tumor is seen projecting into the pharynx, which on palpation is distinctly fluctuating and does not disappear on pressure. The situation of the abscess is in most cases to one side of the median line.

Treatment.—As soon as diagnosticated, the pus should be evacuated by incision either in the mouth or through the neck. It may be tapped through the mouth by a large trocar and canula, and after the first evacuation of the pus, and when all danger of suffocating the patient by too free an escape of pus is past, the abscess should be freely laid open with the knife. Whilst evacuating the abscess the child's head should be held forward. The opening through the neck was first recommended by the late Mr. Hilton. He made an incision behind the sterno-mastoid through the deep fascia with a knife, and then pushed a director inward behind the vessels and bag of the pharynx until the pus was reached. The opening was then dilated with dressing forceps, and thus the cavity was freely opened. By this method the wound may be kept aseptic, and there is no danger of pus escaping into the larynx. The abscess may burst into the pharynx, and it may spread to the larynx, causing œdema. In cases where the abscess is due to disease of the cervical vertebræ large portions of bone have been discharged into the pharynx.

Tumors of the Pharynx.—These are of rare occurrence. Papillomata of small size are occasionally seen. Fatty and fibrous tumors have also been met with. Fatty tumors have been seen of large size, and are pedunculated, some being reported as hanging over the œsophagus. Fibrous tumors originate more often in the vault of the pharynx, and perhaps should be described as naso-pharyngeal tumors. When of large size they may hang down into the pharynx. Pulsating tumors of the pharynx may be due to aneurysm of the internal carotid.

Carcinoma of the pharynx is of rare occurrence.

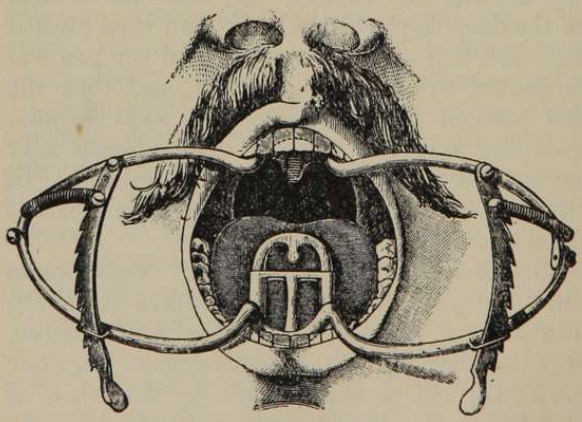
Retro-pharyngeal Tumors occur in connection with the lateral or the posterior wall of the pharynx. If left to themselves, these tumors will ulcerate and necrose, and probably the patient will ultimately die of exhaustion from repeated hemorrhages. They may in some cases be removed by incision through the mouth, but of radical operations that by external incision, with or without division of the lower jaw, as described above in the paragraph on Tumors of the Tonsils, is the best.

Congenital Deformities of the Palate may involve the uvula and the soft and hard palate. The mildest form is where the uvula is bifid. Again, the cleft may extend through the soft palate; or the soft palate and a portion of the hard palate may be fissured; or the separation may involve the whole of the soft and hard palate and extend forward between the intermaxillary bones and the superior maxilla. When this occurs the deformity is always accompanied by single or double hare-lip. In rare cases a circular or oblong opening is seen in the center of the palate, the rest being closed. In the description of the development of the face and mouth it was shown that these deformities are produced by an arrest of development of the parts and persistence of an early fœtal condition.

Cleft Palate.—When the severe forms of this malformation occur they give rise to great trouble; fluids pass freely into the nose, and unless the child is carefully fed by hand (preferably with the mother's milk) it will soon die, as it is quite unable to suck. In the less severe forms the child soon learns to swallow properly, but as he learns to speak his articulation is faulty and his voice very nasal. For this reason early operation is advisable, not so early as for hare-lip, but certainly before the child has learned to speak well, say between the ages of three and four, when faulty articulation may be overcome by successful closure of the cleft. When undertaken late, even if the operation be successful, the patient will not be able to overcome the bad habits of articulation acquired in his childhood.

Operation.—Before the days of anesthetics a patient was never operated on until he had attained a sufficient age to understand the necessity of bearing some pain and submitting to a prolonged operation by which he would be benefited if successful. Now the operation is performed under an anesthetic, with the mouth held open by a gag. Hence it is postponed to the age of three to five years; later, as a rule, in closure of the hard palate than in closure of the soft.

Fig. 268.

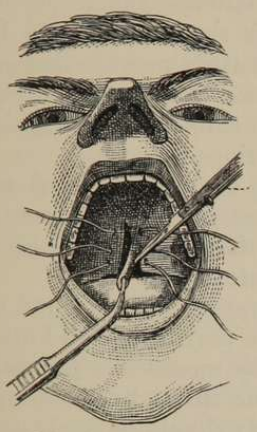


Whitehead's Gag (Koenig).

Staphylorrhaphy, or the operation for the closure of a cleft in the soft palate, has been practised for many years. To J. Mason Warren belongs the credit of improving the operation by introducing a procedure which lessened the tension on the flaps and so promoted union. This was the division of the levator and tensor palati muscles of each side. Billroth has recently introduced a new procedure, which is to chisel away the lower part of the pterygoid process, so as to relieve the tension produced by the tensor palati and palato-pharyngeus.

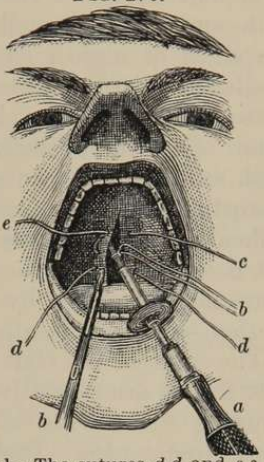
Operation.—The patient having been anesthetized and a gag introduced, the end of one half of the cleft palate is seized with a pair of tenaculum forceps and the edge freely pared with a thin-bladed knife (Fig. 269). The same is done on the other side, especial care being taken to freshen the upper angle of the cleft. The parts are now ready for the stitches. These should be of wire, horse-hair, or silkworm gut, preferably the last. All these materials may remain some days without causing trouble, as may also catgut and silk. Various methods have been devised for passing sutures, such as a needle with the

FIG. 269.



The edges of the cleft are being pared with a probe-pointed bistoury after passing the sutures. It is better to pare the edges before paring the sutures (Bernard and Huette).

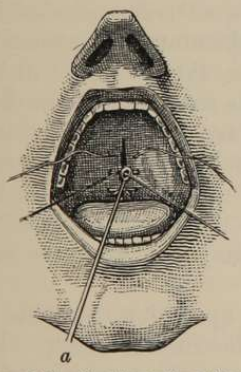
FIG. 270.



Method of Rink: The sutures *d d* and *c c* in place, the third, *b*, being inserted from behind forward by a curved needle and needle-holder, *a*: the lips are held tense with the forceps (Bernard and Huette).

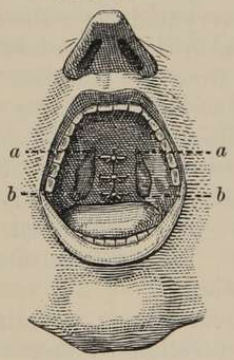
eye at the point (Fig. 270), or a tubular needle. Special needles for right and left side, in handles, are often useful. Should none of these appliances be at

FIG. 271.



Tightening of the Ligatures by a Serre-Nœud, *a* (Bernard and Huette).

FIG. 272.



The sutures being fastened, the lateral incisions *a b* are made to relieve tension by division of the tensor palati muscles (Bernard and Huette).

hand, an ordinary sharp-pointed aneurysm needle or a half-circle Hagedorn needle and a needle-holder will be sufficient. On one side the suture should be double and the other single; through the loop of the double suture the single one is passed, the loop of the double ligature withdrawn, and the stitch is *in situ*. This procedure is necessary only when the needle cannot be pushed through both sides at once. After the stitches have been tied (not too tightly) and

the wound closed (Fig. 271), the palatal muscles may be divided by pushing a tenotomy knife through the soft palate, immediately internal to the hamular process, and cutting upward until the muscles are cut through (Fig. 272). The chiselling away of the lower end of the hamular process may serve a similar purpose. Should there be very little tension this procedure may be omitted. The hemorrhage, which at first is quite brisk, soon ceases when pressure is well applied. The wound should be thoroughly irrigated with boric or salicylic acid solution, and then painted over with an iodoform paint, as described in operations about the tongue and mouth. The patient should be fed on liquid food for three or four days, and afterward on soft food until the sutures are removed; the less the mouth is opened the better. The stitches should be removed about the sixth or eighth day, and the wound by that time should be completely healed; frequently, however, a small point remains unhealed, and has afterward to be closed by touching it with the thermo-cautery or a stick of silver nitrate. Care should be taken to see that the child before operation is in good health and has not been exposed to any infectious disease.

Uranoplasty.—The operation for closure of cleft of the hard palate is one of difficulty, and in cases where the cleft is very wide it is questionable whether it is not better for the surgeon to transfer the case to a dentist, so that the aperture may be closed by some form of obturator.

Operation.—The most satisfactory mode of operating will be found to be as follows: The edges of the cleft are first pared with a narrow-bladed knife; then all the soft tissues are raised from the hard palate by means of a periosteal elevator, avoiding the tearing of the vessels which run through the anterior and posterior palatine canals. The soft palate posteriorly should be freely separated from the horizontal plate of the palate-bone by a cutting instrument, as tearing frequently causes sloughing of the parts. The sutures should now be introduced in the same way as in staphylorrhaphy, and be of silver wire, horse-hair, or silkworm gut. They should not be tied until the incisions have been made on each side midway between the alveolar border and the sutures. These incisions should be continued back into the velum. If there be much tension the muscles of the palate should be divided as described in Staphylorrhaphy, or the end of the internal pterygoid plate should be chiselled through, as recommended by Billroth. (See *ante.*) It has been held, however, that if the muco-periosteum be fully separated from the posterior edge of the palate-bone, the muscles will be paralyzed and no further cutting will be necessary. Some surgeons advise that these lateral incisions should be made first, but in some cases they are not required, and this we cannot tell until the edges are pared and sutures introduced. In this way, also, hemorrhage is postponed until all the important steps of the operation have been completed. It is a good plan to tie the sutures in the soft palate first. The first suture should be placed at the junction of the hard and the soft palate.

Free hemorrhage sometimes occurs during the operation, but this usually can be controlled by pressure made posterior to the incisor teeth. In some cases of severe hemorrhage from the palatine arteries the palatine foramina have been stopped with wooden plugs (Marsh). Secondary hemorrhage occasionally occurs. In this operation anesthetics are always used. The after-treatment is the same as after closure of the soft palate.

Ulceration of the Palate is usually the result of syphilis or of struma. *Syphilitic ulceration* may occur in the form of mucous patches with superficial ulceration or of deep ragged ulcers with sloughy bases. They generally heal under potassium iodide, but not seldom perforate the roof of the mouth. Local treatment by astringents and nitrate of silver is sometimes beneficial. *Strumous*

ulceration is seen only in the young and feeble, and should be treated by tonics and stimulants, and locally with antiseptic washes of boric acid, iodine, salicylic acid, etc.

Abscess of the Palate is a rare occurrence. When seen anteriorly it is usually connected with some disease of the teeth. Abscesses of the lateral part of the soft palate may follow tonsillitis. The proper treatment is early and free incision.

Necrosis of the Palate.—The bone exfoliates very slowly, and occasionally leaves a perforation in the hard palate. It is nearly always the result of syphilitic disease, although it may be the result of operative, gunshot, and other wounds. Plastic operations for fissures following necrosis are of little benefit, and the aperture should be closed by an accurately-fitting obturator.

Tumors of the Palate may be cystic or solid. Warty growths are occasionally seen arising from the mucous membrane; also fibro-sarcomata and cysts containing glairy fluid. Sebaceous cysts are sometimes found in the substance of the soft palate. They are recognized by their yellowish-white color. Carcinomatous tumors of the palate are always of the epitheliomatous type, and are rarely primary, usually spreading from the tonsil or the tongue. Removal of all these growths is the proper treatment.

PART II.—DISEASES AND INJURIES OF THE ŒSOPHAGUS.

Malformations.—These consist of fistulæ, diverticula, and cystic growths, such as have been described in the section on the Malformations of the Pharynx, and are due to incomplete closure of the branchial clefts. In some cases there may be a congenital thickening of the œsophagus in the situation of a branchial cleft. This may cause some narrowing. The tube may be closed by a membrane, or the whole tube may be dilated; large diverticula may proceed from it, or it may be double or absent. Its absence is incompatible with life unless gastrostomy be performed.

Dilatation and Sacculation.—Dilatation may involve a large part of the tube or may be localized. When localized it is called a sacculation or **diverticulum.** It is sometimes of immense size, but usually is small. Some form of narrowing of the œsophagus precedes dilatation, and it is this that must be treated. The dilatation (when not congenital) is usually caused by the arrest of food at the point of stricture, the continuous endeavors to force it onward producing a dilatation or pouching by putting the parts on the stretch. At the junction of the pharynx with the œsophagus a "pressure pouch" may form on the posterior aspect of the tube. This pouch or diverticulum has been successfully removed through an incision in the neck by Butlin, Bergmann, Kocher, and others. The operation appears to be neither very difficult nor dangerous. After removal of the pouch the opening in the œsophagus is closed with sutures.

Stricture.—This is the most common form of disease affecting the œsophagus, and is due to various causes. Strictures of the œsophagus may be divided into—

Organic—Cicatricial or simple; cancerous or malignant.

Non-organic—Spasmodic or hysterical.

Strictures may also be produced by the pressure of tumors, such as enlarged thyroids, aneurysms, etc.

Cicatricial Stricture.—This may be produced by any injury to the tube, such as a wound, by the swallowing of corrosive fluids, or by syphilitic ulceration. The most common cause is the swallowing of corrosive liquids, such as

lye, acids, etc., in early childhood. The stricture comes on slowly, and there is nearly always a history of injury. If the stricture occurs in a young person, it is probable that it is due to cicatricial contraction. The usual site is at the beginning of the œsophagus opposite the cricoid cartilage.

Cancerous or Malignant Stricture.—Cancerous disease is a very common cause of stricture. It may be engrafted on a simple stricture. It occurs more often in men than in women, and usually at an age over forty-five. The variety of carcinoma is nearly always epithelioma, and it most frequently attacks the lower third of the tube. The symptoms are very plain, viz. gradually increasing difficulty in swallowing, especially solid food, in individuals over forty; regurgitation of food, with sometimes a slight discharge of blood and pus, and gradually increasing emaciation.

Spasmodic Stricture.—This form is associated with a hysterical condition, and is usually seen in the young, but it may occur at any age. It is more common in women than in men. The previous history of the patient will help to diagnosticate this affection. At times swallowing is quite easy, and suddenly the patient professes to be unable to swallow anything, the attempt producing a severe spasm. The patient often complains of a constriction or the feeling of a lump in the throat (*globus hystericus*). The affection then appears suddenly and disappears as suddenly. The single passage of an œsophageal bougie often suffices to cure the stricture. When the bougie is first used considerable opposition is offered to its passage, but on continuing the pressure this soon gives way and the bougie slips easily down the tube. The condition of the lingual tonsil should always be examined.

Diagnosis of Stricture.—The fact that a person has difficulty in swallowing ordinary food and is emaciating ought to be sufficient to make one suspect stricture. The food may be retained some hours and then be regurgitated, especially if the œsophagus above the stricture be much dilated. Pain is not a prominent symptom. The most certain mode of diagnosis is the passage of the œsophageal bougie. This will locate the stricture exactly. Great delicacy of touch is required in the manipulation of the bougie. A skilful operator may learn much as to the size, length, and site of stricture. Auscultation will aid in some cases in locating the stricture, the sound of trickling of fluid through the stricture being easily recognizable. The patient rarely consults the surgeon in the early stages of the affection, and it is only as the stricture increases that spasm may suddenly be produced and cause complete obstruction. Cancerous stricture of the œsophagus is a fatal disease, death sometimes being the result of the cancerous ulceration extending into neighboring parts or vessels and causing hemorrhage; but usually the patient dies of inanition, the stricture not admitting sufficient food to keep him alive. If the disease has lasted some time, the parts become very foul and the breath has a most disagreeable smell, especially if the disease is near the pharynx.

Treatment.—In the simple or cicatricial form of stricture treatment by œsophageal bougies is fairly satisfactory. As large a bougie as the stricture will admit is passed daily and retained for some time. The size is increased every two or three days until the full caliber is reached. In this way the life of the patient may be much prolonged and made tolerably comfortable. Adults soon learn to use the bougies themselves. The patient should as far as possible take liquid food and finely-minced solid food, milk, eggs, beef tea, etc.

It is questionable whether it is advisable to pass bougies in cancerous strictures of the œsophagus, as the irritation caused by this mode of treatment only aggravates the condition and may lead to serious results. The greatest care should be exercised in passing them, as bleeding is easily caused, and the dis-

eased œsophagus is very easily perforated, cases being on record where the bougie has passed through the œsophagus into the pleura and other structures in the neighborhood. Passing a small rubber catheter once or twice a week, however, often gives relief and keeps the passage open. Careful feeding is most important, and when swallowing becomes very painful or impossible rectal feeding may be employed, or, better, gastrostomy should be done. This is a great boon, and should not be delayed until the strength of the patient is exhausted. The immediate effects are wonderful, and the patient for a time improves rapidly and is quite comfortable, suffering from neither hunger nor thirst. For Abbe's operation in stricture of the œsophagus see p. 699.

Œsophagotomy has been performed in cases where the growth was high up, and excision of the growth has been attempted in some cases.

There are several kinds of bougies used for the œsophagus—those with conical, those with round, and those with olivary ends. The last-named kind is perhaps preferable, though, as in strictures of the urethra, the same form of bougie does not suit every variety of stricture. Before introduction the bougie should be warmed and oiled; then with the left index finger the tongue should be depressed and the bougie passed in the median line, following the posterior wall of the pharynx. As a rule, there is no difficulty in reaching the œsophagus. The patient usually gags, and may vomit. To obtain a thorough examination, the patient should be anesthetized.

Permanent Tubage of Strictures.—Symonds of Guy's Hospital, London, has for some time practised a method of treating strictures which seems to have some great advantages. A flexible gum-elastic tube from four to six inches long is introduced into the stricture and permanently retained there. The upper end of the tube is expanded into a funnel which rests on the stricture. The lower end is closed somewhat like a catheter, having an eye of large size a quarter of an inch from the end, through which liquid food passes. For the purpose of withdrawing the tube, a piece of plaited silk thread is passed about three-eighths of an inch below the rim of the funnel in a single thread, and the portion inside the tube drawn out and tied to the side pieces about two inches above the funnel. After ascertaining the exact size of the stricture, the tube is placed in position by an instrument called an *introducer*, made of whalebone covered with gum-elastic. Symonds has left the tube in without removal for two months. In the 17 cases of stricture treated by this method, 9 died from the progress of the disease, but the stricture remained patent and the patient was able to swallow to the last. In some cases where there is cough on deglutition, Symonds recommends that the short tube be replaced by the long tube of Krishaber of Paris, which proceeding renders the operation of gastrostomy unnecessary; or, better still, a piece of red-rubber tubing cut obliquely at the end and sewed, an eye then being made as in a catheter, should, with the aid of the introducer, be passed through the stricture and left *in situ*.

Sir Morell Mackenzie, in his work on *Diseases of the Nose and Throat*, figures a long permanent œsophageal tube which he has used with success in cases of absolute aphagia. The tube is left in five or six days at a time. Senator of Berlin dilates the stricture with a laminaria tent attached to a string and left in for from half an hour to an hour. The most suitable strictures for this treatment are the non-malignant.

Wounds of the œsophagus are of rare occurrence. In cases of cut-throat the œsophagus may be wounded or severed, and it may be wounded by stabs of a knife or a bayonet or by a bullet. When this occurs in the thorax, the injuries to the neighboring organs are so great that this injury is

ordinarily overlooked. It is extraordinary how few cases of wound of the œsophagus are on record. But one case is noted in the *Medical and Surgical History of the Civil War*, and that was found post-mortem. Foreign bodies may wound the œsophagus from within. The passage of a bougie may wound this tube, and even perforate it, causing hemorrhage, pain, and emphysema. When the œsophagus is wounded in the neck the patient may recover. The wound should, if possible, be sutured, and the patient fed by the rectum for several days. A fistula may remain after the healing of the wound.

Foreign Bodies.—The impaction of foreign bodies in the œsophagus is of comparatively common occurrence. Food may be arrested here, viz. portions of bones, fish-bones, meat; also artificial teeth, coins, pins; in fact, nearly every imaginable substance has been found in the œsophagus. The foreign body when large is usually arrested at the narrowest part, viz. the commencement of the œsophagus opposite the upper border of the cricoid cartilage; but there are two other points at which the body may be arrested, viz. where the œsophagus is crossed by the left bronchus and where it passes through the diaphragm. Small and sharp bodies may lodge at any part of the tube. Should the foreign body be arrested high up, there will be dysphagia and pain. Some cases have died suddenly of asphyxia, so great is the spasm. After a time the patient may get used to the foreign body and the symptoms almost disappear. Should the substance swallowed be sharp, there will be more pain and sometimes hemorrhage. In these cases the diagnosis of the exact position is difficult, the sensations of the patient being a very poor guide. Even after the foreign body has been removed or has passed down, the sensation of one being lodged in the gullet remains, and it is sometimes hard to convince the patient that it is not there. Large bodies, especially when they block up the passage and prevent swallowing, if not removed within a reasonable time, are incompatible with life. If untreated, the foreign body may ulcerate into neighboring structures, such as the trachea, pleura, and pericardium. Not a few cases are on record where a foreign body has ulcerated into the aorta and has caused death by hemorrhage.

The *diagnosis* of these cases is aided, of course, greatly by the history, but this cannot be obtained from children, lunatics, or determined suicides. External palpation, or the presence of a bulging in the neck, may serve to detect a large body, but a probang catheter or an œsophageal bougie will often satisfactorily solve the problem. Small objects have been detected with the aid of the œsophagoscope.

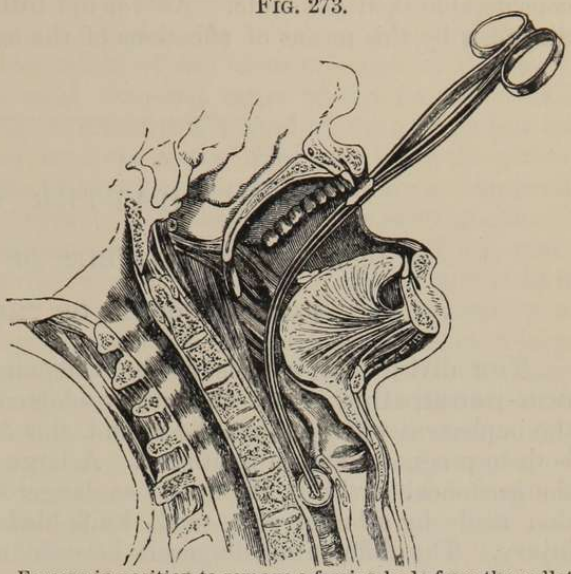
Treatment.—Should the object be round and smooth, it may be pushed down with a probang, and if high up may be grasped with a pair of œsophageal forceps (Fig. 273) and extracted. Pins, pieces of bone, etc. may be fished out with a horse-hair probang or Gräfe's coin-catcher. Vomiting will sometimes displace a foreign body.

In a certain number of cases the foreign body cannot be extracted except by cutting down on it.

Operations on the Œsophagus.—**External Œsophagotomy** is performed for the removal of foreign bodies and for cases of stricture high up in the gullet. The incision is made on the left side of the neck, on account of the inclination of the œsophagus to that side. The incision is between the larynx and trachea on the inside and the sheath of the vessels externally. For removal of foreign bodies the center of the incision should be opposite the cricoid cartilage: by pulling the trachea and thyroid gland to the inside and the vessels to the outside, and pulling aside or dividing the omohyoid muscle, the œsophagus can easily be reached and incised longitudinally. If

the operation be performed for the removal of a foreign body, this is extracted, and the wound in the œsophagus closed with catgut sutures, and the rest of the wound partly closed and packed with iodoform gauze. The patient for the first three or four days after operation should be fed by enemata, or through a small gum-elastic catheter or rubber tube passed beyond the wound before closing it. In cases where this operation is performed for relief of stricture, a permanent fistula is desired, and so a rubber tube is left in the wound. This operation is called *œsophagostomy.*

FIG. 273.



Forceps in position to remove a foreign body from the gullet (Fergusson).

Internal Œsophagotomy.—Instruments which are enlarged copies of those used in the urethra have been devised for cutting œsophageal strictures. This operation is dangerous; one-third of the cases have succumbed. It is suitable only for certain cases of annular stricture.

Strictures have been incised through the opening made in the œsophagus, and foreign bodies seized as low down as the upper part of the sternum by the œsophageal forceps.

Gastrotomy and Digital Exploration of the Œsophagus.—M. H. Richardson has devised an operation for the removal of foreign bodies impacted low down in the œsophagus. He performs gastrotomy, introduces his hand into the stomach, and with his fingers explores the lower part of the œsophagus. In this way he removed a plate containing four teeth which had been lodged in the œsophagus near the cardiac end for eleven months. The man made a perfect recovery. W. T. Bull removed by gastrotomy a peach-stone from a child's œsophagus, which was arrested some six or seven inches from the cardiac end and had failed to be dislodged by other means. In this case, a small incision having been made into the stomach, the finger was introduced, which guided a bougie through the cardiac orifice, whence it was pushed upward until it projected from the mouth. Attached to the bougie was a double silk thread to which was tied a sponge. This was drawn up through the œsophagus, and brought with it the peach-stone. The patient made a rapid recovery. In cases where foreign bodies are situated at a distance of thirteen inches and over from the teeth, from numerous experiments on the cadaver Richardson recommends searching for them from below through the stomach.

Œsophagectomy.—Excision of a portion of the œsophagus for malignant growths has been performed several times. Czerny of Heidelberg is the only surgeon who has operated with any degree of success. Five months after operation his patient was living, without return of the disease, but within a year she died of recurrence of the growth. The operation is performed in the same way as œsophagotomy, but with a larger incision. A portion of the œsophagus is resected, and the lower end fixed to the external wound.

The *œsophagoscope* is now not infrequently used for diagnosticating diseased conditions of the œsophagus and the detection of foreign bodies. It is an instrument which is illuminated by reflected light or electric light, and requires considerable skill to handle. As yet but little progress has been made in the diagnosis by this means of affections of the œsophagus.

CHAPTER VI.

DISEASES AND INJURIES OF THE ABDOMEN.

PART I.—WOUNDS OF THE ABDOMEN.

THE division of wounds of the abdominal wall into **penetrating** and **non-penetrating** is now universally adopted. Irrespective of the nature of the implement which inflicts the wound, this division is important in reference both to prognosis and to treatment. A large wound which does not implicate the peritoneal cavity is not nearly so dangerous an injury as a small perforation made by a bullet or a small knife-blade and complicated by a visceral injury. The differential diagnosis between non-penetrating and penetrating wounds of the abdomen must be made in every case in which the surgeon is called upon to treat a wound in this locality, as an approximately reliable prognosis and a rational course of treatment must necessarily rest on a correct diagnosis.

NON-PENETRATING WOUNDS.—In large incised or lacerated wounds of the abdominal wall it is not difficult to determine whether or not the peritoneum has been injured, as the deepest portion of the wound can be made accessible to visual inspection and digital exploration. A wound of the abdominal wall should never be explored for diagnostic purposes without proper antiseptic precautions, as the neglect of these is often the direct cause of the introduction of septic material into the abdominal cavity in cases in which the parietal peritoneum has been punctured, torn, or incised. The wound and its vicinity must be rendered aseptic in the usual manner, and digital or instrumental exploration must be done under the strictest antiseptic precautions. If after a careful examination it is found that the injury is limited to the tissues outside of the peritoneum, the wound is to be treated upon general principles, but with due regard to restoring the resisting capacity of the abdominal wall by accurate suturing of the incised or lacerated tissues.

A large and deep wound of the abdominal wall, unless treated with especial care, is very liable to become subsequently the seat of a **ventral hernia.** In order to prevent this later and often distressing condition, it is necessary to obtain healing of the wound by primary union and to unite the different layers by deep or buried sutures. After careful arrest of hemorrhage, and cleansing and disinfection of the wound, the divided muscular layers must be brought accurately together with a sufficient number of catgut sutures, but before these are tied the superficial silk sutures are put in place in such a manner as to embrace all the tissues, including the skin. After the margins of the wound have been carefully coaptated by the tying of all the sutures, a few superficial sutures are applied to bring the margins of the skin in accurate approximation. Tubular drains should be avoided in such cases, as the space occupied by the drain may become subsequently the starting-point of a ven-

tral hernia. If drainage is required, this can be established by the insertion at one or more points of an absorbable capillary drain composed of a small bundle of catgut threads.

External support is furnished by a compress of hygroscopic antiseptic gauze and absorbent cotton, retained in place by strips of adhesive plaster, which must embrace at least two-thirds of the circumference of the body. Next to imperfect suturing the most frequent cause of the formation of a ventral hernia after an accidental or intentional wound of the abdomen is the too early active use of the tissues involved in the injury. Hence the patient should not be allowed to leave the bed until the process of repair is completed, which will require at least from three to four weeks. If the erect position is assumed before this time, the increased tension in the abdominal wall may make such an amount of traction upon the wound that the new tissues will yield to the traction force, and give way sufficiently for the parietal peritoneum to bulge at the point offering the least resistance. In the after-treatment of large wounds of the abdominal parietes it is necessary to maintain external support by a well-fitting bandage for several months, the patient being cautioned not to engage during this time in any violent exercise which might bring about a subcutaneous separation of the different muscular layers at the line of suturing.

Penetrating Wounds.—If in cases of incised and lacerated wounds of the abdomen the peritoneum is laid open and the viscera protrude, their condition must be observed, and if they are not wounded they must be carefully cleansed with sterilized water, dried, and returned. Blood-clots and other foreign bodies when present must be removed. If, as has frequently happened, the intestines have escaped through such a wound, and have become strangulated and cannot be readily reduced, the surgeon should enlarge the wound rather than resort to any violence in perhaps fruitless attempts at reduction. In the closure of such wounds it is advisable to suture the peritoneum separately, after which they are dealt with in the same manner as non-penetrating wounds.

The penetrating wounds of the abdomen most frequently met with in practice are punctured, gunshot, and stab wounds. These must again be divided into those which have opened the peritoneal cavity without being complicated by any serious injury of the abdominal organs, and those in which the great danger consists in the fact that the missile or implement which produced the wound has caused at the same time visceral injuries of a serious character. A simple penetrating stab or gunshot wound of the abdomen is a more serious injury than a much larger non-penetrating wound, yet is frequently followed by recovery without active surgical interference ; but penetrating wounds complicated by visceral injuries with few exceptions prove fatal, unless the surgeon is able to prevent this termination by the timely treatment of the visceral lesions by operative interference.

In cases of gunshot and stab wounds of the abdomen the first duty of the surgeon is to determine whether or not the abdominal cavity has been entered. This part of the diagnosis may be easy or difficult according to circumstances. If the bullet has passed through the body and the wounds of entrance and exit occupy such positions that a direct line connecting them will necessarily pass through the abdominal cavity, there can be but little doubt that the bullet has traversed that part of the peritoneal cavity interposed between them, and consequently that there has been injury of the viscera occupying that locality. In fat persons the exact outlines of the peritoneal cavity cannot be located with absolute accuracy, and on this account some doubt may remain, in case two bullet wounds, made by a single bullet, are found over the anterior or lateral

aspect of the pendulous abdomen, whether the peritoneal cavity falls in the track made by the bullet. The existence of emphysema in the tissues around the track of a bullet or stab wound is not positive evidence that penetration has taken place, as it may be caused by the entrance of air from without. In stab wounds prolapse of the omentum into the wound is of frequent occurrence, and when this condition is present it is a positive evidence that the knife has penetrated the abdominal cavity. If a large bullet has entered the peritoneal cavity by the shortest possible route through a thin portion of the abdominal wall, the fact that penetration has taken place often becomes evident in the same manner.

In the majority of cases of penetrating wounds exploration of the wound by a careful dissection is the only positive and reliable procedure in determining that the bullet or knife-blade has entered the peritoneal cavity. Digital exploration of small wounds should never be relied upon in ascertaining the depth and course of the wound, as this measure is not infallible in making a correct diagnosis, and in case the bullet has penetrated the abdominal cavity the finger may push before it and into the peritoneal cavity infected foreign substances. The use of the probe should be discarded in the examination of punctured and gunshot wounds of the abdomen for diagnostic purposes. The wound-canal is often so tortuous from displacement of the tissues forming its walls that it cannot be followed with a probe without risk of making false passages—an occurrence which could not fail to lead to erroneous conclusions in reference to the extent and course of the wound and in regard to the presence of visceral complications which might demand prompt operative interference. The only safe plan to pursue is to enlarge the wound by an incision at least two inches in length, which should intersect the external opening through its center and in the direction of the principal muscle involved by the injury. Before this is done all the preparations for a laparotomy should have been completed, everything required in the treatment of visceral wounds should be on hand, and the consent of the patient and his friends obtained to do whatever may become necessary in case it is found that the peritoneal cavity has been invaded and that visceral injuries demand surgical interference.

It is often a difficult task to follow the track of a bullet with the scalpel through a thick abdominal wall. The best method of procedure is to insert a grooved director as far as it will pass without resistance, and then divide the tissues layer after layer, catching bleeding vessels with hemostatic forceps as fast as they are cut, in order to keep the field of operation as nearly as possible in a bloodless condition. The bullet frequently discolors the tissues, and these discolorations are often important landmarks in following the wound. When the point of the director is reached, it becomes necessary to make a close inspection, and under no circumstances should the knife be used until the wound-canal can again be identified and followed with the eye or the director. The dissection is to be made carefully and slowly until the opening in the peritoneum is reached, which alone establishes beyond a doubt the existence of penetration.

Quite recently the assertion has been made by several prominent surgeons that laparotomy should be done in all cases where it can be shown that a punctured wound extends into the abdominal cavity, for the purpose of treating intra-abdominal lesions. It must, however, be admitted that, in the absence of serious visceral lesions, penetrating wounds of the abdomen are injuries from which the patients are very likely to recover without operative treatment, and that when such patients are subjected to laparotomy death may occur solely in consequence of the operation. It is undoubtedly true that in most cases of spontaneous recovery after punctured wounds of the abdomen the favorable

termination has been due to the absence of serious visceral lesions, which some hold to be invariably present in such cases. In two out of six cases of penetrating gunshot wounds of the abdomen which came under the observation of Senn the absence of visceral injuries of the gastro-intestinal canal was demonstrated by the use of the hydrogen-gas test, and both of these patients recovered without resort to laparotomy. The same absence of visceral lesions has been also demonstrated during an operation or at the post-mortem. Clinical experience and the result of experiments show conclusively that laparotomy should not be performed simply because a bullet or a knife-blade has entered the abdominal cavity, but that its performance should be limited to the treatment of intra-abdominal lesions which, without operative interference, would tend to destroy life. Stab wounds are not as often complicated by visceral injuries as are bullet wounds. A bullet which passes through the lower part of the abdomen from side to side or obliquely is almost sure to produce from four to fourteen perforations of the intestines, while absence of dangerous visceral wounds may be inferred with some degree of probability if it crosses the abdominal cavity in an antero-posterior direction at or a little above the umbilical level.

Symptoms.—The *general symptoms* in cases of penetrating punctured wounds of the abdomen, with the exception of those due to profuse hemorrhage, furnish absolutely no reliable information in the differentiation between simple penetrating wounds and penetrating wounds complicated by visceral injuries. Severe shock may attend even a non-penetrating wound, and it may be absent, or at least not well marked, in cases of multiple perforations of the intestines. It is not an uncommon occurrence for a patient who has received a penetrating wound of the abdomen to walk several blocks, or even a number of miles, without a great deal of suffering and without showing any symptoms of shock, and yet for a number of intestinal perforations to be revealed at a subsequent operation or post-mortem. Vomiting takes place as frequently in wounds of the abdominal parietes and in simple penetrating wounds as when the viscera have been injured. Vomiting of blood indicates the existence of a wound of the stomach.

Pallor is present in all penetrating wounds of the abdomen soon after the receipt of the injury, and it is only more pronounced when produced, at least in part, by sudden and severe internal hemorrhage. Pain is a very unreliable and often misleading symptom, as it may be moderate or almost completely absent soon after the injury has been inflicted, even when multiple perforations are present. The pulse at first is slow and compressible in all cases, and nothing characteristic in its qualities is observed even if the stomach or intestines have been injured. Hemorrhage caused by wounds of any of the large organs, as the spleen, liver, or kidneys, gives rise to progressive acute anemia, small, rapid pulse, cold, clammy perspiration, dilated pupils, yawning, vomiting, and, in extreme cases, syncope and convulsions.

The *local symptoms* are of no more value in determining the existence of visceral injuries in penetrating wounds of the abdomen than are the general symptoms just enumerated. External hemorrhage is slight or entirely wanting unless an artery or a vein in the abdominal wall has been injured. The bleeding from visceral wounds gives rise to accumulation of blood in the peritoneal cavity: this can be recognized by physical signs which denote the presence of fluid in the free abdominal cavity and by the general symptoms indicating progressive anemia: increasing pallor of the face and of the visible mucous membranes, small, feeble pulse, and dilated pupils. Wounds of the stomach often give rise to hemorrhage into this organ and hematemesis. Blood in the stools

seldom follows hemorrhage into the bowels from intestinal wounds sufficiently early to be of any diagnostic value.

Circumscribed emphysema in the tissues around the track made by a bullet has been regarded as an important sign of the existence of intestinal perforation. This symptom is misleading and absolutely devoid of diagnostic value, as this condition has frequently been observed in non-penetrating wounds of the abdominal wall.

The accumulation of any considerable quantity of gas in the peritoneal cavity sometimes can be recognized by the disappearance of the normal liver dulness, caused by the presence of gas between the surface of the liver and the chest-wall. This condition has been sought for in cases of perforating wounds of the abdomen as a diagnostic point, and if found has been laid down as a sure indication of the existence of visceral wounds of the gastro-intestinal canal. This is not, however, always the case. In connection with the employment of the hydrogen-gas test, however, the presence or absence of this sign becomes of great diagnostic value.

The escape of the contents of the stomach or intestines through the external wound is a rare occurrence, and is possible only when the external wound is sufficiently large and straight and when it is located directly opposite the visceral wound. It occurs more frequently in wounds of the large than of the small intestine. When this symptom is present it is conclusive proof of the existence of a visceral wound of the gastro-intestinal canal, and the character of the material which escapes will furnish a reliable indication as to what part of this tract has been injured. With the exception of the last-mentioned symptom and the indication pointing to the necessity of arresting internal hemorrhage, there is nothing about the local or general symptoms in cases of penetrating wounds of the abdomen that would enable the surgeon to decide with any degree of positiveness whether visceral injuries existed or not, and, consequently, whether laparotomy should or should not be performed.

Diagnosis.—It has already been urged that the fact that the abdominal cavity has been opened should rest upon unmistakable evidence, such as prolapse of the omentum or intestines, or the escape of the contents of the gastro-intestinal canal, and in the absence of such evidence it must be established by following the track of the wound down to the opening in the parietal peritoneum. After it has been ascertained that the wound is a penetrating one, the course to be pursued must vary according to circumstances. If the local signs and general symptoms point to the existence of dangerous internal hemorrhage, *no time should be lost in further efforts to make an accurate anatomical diagnosis*, as sufficient evidence has been obtained to warrant a laparotomy for the purpose of preventing death from hemorrhage by the direct surgical treatment of the visceral injuries. If no such urgent indication presents itself, it is desirable that the existence of visceral lesions demanding surgical interference should be ascertained before the patient is subjected to the additional risks incident to a laparotomy. Since a simple penetrating wound of the abdomen is an injury from which a large majority of patients recover without operative treatment, and since visceral wounds of the gastro-intestinal canal are attended by such frightful mortality without surgical interference, the practical value and importance of a correct diagnosis before deciding upon a definite plan of treatment become obvious. It is apparent that if some reliable diagnostic test could be applied in cases of penetrating wounds of the abdomen which would indicate to the surgeon the presence or absence of visceral lesions of the gastro-intestinal canal, the indications for aggressive or conservative treatment would become clear.

Senn has shown by his experiments on animals, and later by his clinical experience in the treatment of six cases of gunshot wounds of the abdomen, that *rectal insufflation of hydrogen gas* can be for the most part relied upon in demonstrating the existence of intestinal perforations before opening the abdomen. He has demonstrated conclusively that if the abdominal muscles are completely relaxed under the influence of an anesthetic, hydrogen gas can be forced from the anus to the mouth if no perforations exist, and if such are present the gas as a rule will escape into the peritoneal cavity, where its presence can be easily ascertained by the physical symptoms characteristic of a free tympanites, or by the escape of the gas through the external opening, where its presence can be demonstrated by igniting it. Hydrogen gas is a non-toxic substance endowed with valuable inhibitory antiseptic properties, and is absorbed from all the large serous cavities and the connective tissue within a few hours. Pure zinc and sulphuric acid should be employed in the generation of the gas, which is collected in a rubber balloon holding at least four gallons. The rubber balloon is connected with the rectal tip by means of rubber tubing which is supplied with a stopcock. In applying the gas test an assistant presses the margins of the anus against the rectal tip, so as to prevent the escape of the gas, while another assistant forces the gas along the intestinal tube by pressing on the rubber balloon. The passage of the gas through the ileo-cæcal opening is announced by a distinct gurgling sound which can always be heard by applying the ear or stethoscope over that region. As soon as the gas reaches a perforation large enough to permit its escape, it will enter the peritoneal cavity and escape through the external wound if this has been freely laid open down to the peritoneum. If the external wound is in a location which points to injury of the stomach, this organ should be insufflated through a rubber stomach-tube, and if this test proves negative, it is to be followed by rectal insufflation.

The use of hydrogen, while it has failed in a few cases, and in others has made the return of the bowels into the abdominal cavity more difficult, is nevertheless occasionally a valuable addition to our means of diagnosis and treatment. Many, perhaps the majority of, surgeons, however, hold that the difficulties and possible dangers it creates more than offset its apparent advantages.

Prognosis.—Penetrating wounds of the abdomen without serious visceral injuries and without the presence of a septic foreign body in the abdominal cavity are frequently followed by recovery without resort to intra-abdominal treatment. Penetrating wounds complicated by visceral injuries giving rise to profuse internal hemorrhage are serious injuries and call for prompt surgical interference. Penetrating wounds complicated by wounds of the stomach or of any portion of the intestinal tube large enough to permit the escape of the contents of the injured organ must practically be regarded as mortal injuries. In the former instance death usually follows in a short time from hemorrhage; in the latter, from septic peritonitis. In exceptional cases, where all the conditions are favorable for such a termination, a spontaneous recovery may take place by the wounded portion of the stomach or intestine forming speedy adhesions with adjacent serous surfaces, thus protecting the peritoneal cavity against infection. One of the most important conditions for such a favorable termination to take place is that the wounded organ should be empty at the time the injury is inflicted and should remain so until the peritoneal cavity has been shut off by adhesions. These cases, however, are exceptional; extravasation, septic peritonitis, and death are the usual results of such injuries.

Treatment.—The propriety of surgical interference in cases of penetrating wounds of the abdomen will depend on one of two things:

1. Dangerous internal hemorrhage.

2. Wounds of the stomach or intestines large enough to permit of extravasation.

The rational treatment of penetrating wounds of the abdomen originated in this country, and its development to a life-saving and legitimate surgical procedure has been brought about almost exclusively by the researches and clinical work of American surgeons. Among those who contributed most toward the advancement of this branch of abdominal surgery may be mentioned Gross, Sims, Kinloch, McGuire, Parkes, McGraw, Bull, Dalton, Bernays, Cabot, Barrows, Keen, Stimson, and Senn. The most recent statistics show that about 30 per cent. of the cases operated on have recovered, thus fully sustaining the expectations of those who urge not only the propriety but also the necessity of treatment by laparotomy in all cases in which penetrating wounds of the abdomen are complicated by serious visceral injuries.

1. *Preparation of the Patient.*—A patient suffering from a perforating wound of the abdomen should be properly prepared before he is subjected to laparotomy. If the stomach is filled with food, a salt-water emetic should be given for the purpose of evacuating the stomach, or, better still, it may be emptied by a stomach tube. The rectum and colon should be emptied by a copious enema of lukewarm water to which may be added a tablespoonful of common salt. A hypodermatic injection of gr. $\frac{1}{4}$ of morphia and gr. $\frac{1}{30}$ of strychnine should be given shortly before the anesthetic is administered, as these drugs in the doses specified assist the action of the anesthetic, secure rest for the intestines, and sustain the action of the heart. If the patient is much prostrated, two ounces of whiskey diluted with four ounces of warm water should be given by the rectum. The external wound and the whole abdomen must be thoroughly disinfected.

2. *Operating Room.*—The room in which the examination is to be made, and possibly laparotomy performed, should be prepared as directed in the section on Operative Surgery.

3. *Incision.*—Great diversity of opinion still prevails in regard to where the incision should be made. In the majority of cases the median incision affords advantages which give it the preference. It should always be selected in cases of gunshot wounds of the stomach, and where the wound of entrance is located near the median line, and where it is known that the bullet has taken an antero-posterior course. A median incision affords most ready access in the treatment of wounds of the small intestine.

If the hydrogen-gas test is used, it may sometimes prove of value in deciding the location of the incision. If in gunshot wounds of the upper portion of the abdomen direct inflation of the stomach through an elastic tube reveals the existence of perforation of this organ, the median incision should be selected. If rectal insufflation yields a positive result before the gas has passed the ileo-cæcal valve, the incision should be made over the wounded portion of the colon, which is usually indicated by the course of the bullet. A wound in the transverse colon can be found and dealt with most efficiently through a median incision, perforation of the cæcum or of the ascending colon calls for a lateral incision directly over the wounded organ, while a lateral incision on the left side is indicated if from the direction of the bullet it is evident or probable that the colon below the splenic flexure is the seat of the visceral injury. In the treatment of gunshot wound of the colon a lateral incision should be made sufficiently long to facilitate the finding and suturing of the perforation and to

enable the surgeon to search for and treat additional injuries. The external wound is closed with several rows of buried sutures: there is but little danger of the occurrence of a ventral hernia.

Laparotomy performed for the arrest of dangerous hemorrhage should always be done by making a long median incision, which will afford the most direct access to the different sources of hemorrhage. Very often it will be advisable to make the incision in the line of the wound of entrance, more especially in cases where a lateral incision is indicated from the location of the wound, from the course of the bullet, and perhaps from the results obtained by application of the hydrogen-gas test.

4. *Arrest of Hemorrhage.*—In penetrating wounds of the abdomen profuse hemorrhage is more frequently of parenchymatous and venous than of arterial origin. Gunshot wounds of the liver, spleen, kidneys, and mesentery give rise to profuse and often fatal hemorrhage. After opening the peritoneal cavity it is often very difficult to find the bleeding points, as the blood accumulates as rapidly as it is sponged out, and it becomes necessary to resort to special means in order to arrest the profuse bleeding sufficiently to find the source of hemorrhage.

One of two means should be employed: (1) digital compression of the aorta; (2) packing the abdominal cavity with a number of large sponges. Digital compression of the aorta below the diaphragm can be readily made by an assistant introducing his hand through the abdominal incision, which in such a case must be larger than under ordinary circumstances. Compression of the abdominal aorta immediately below the diaphragm will promptly arrest the hemorrhage from any of the abdominal organs for a sufficient length of time to enable the surgeon to find the source of hemorrhage and carry out the necessary treatment for its permanent arrest.

Hemorrhage from a perforated, lacerated kidney may demand a nephrectomy. A similar wound of the liver is sutured with catgut, cauterized with the actual cautery, or tamponed with a long strip of iodoform gauze, one end of which is brought out of the external wound. A wound of the spleen, if the hemorrhage cannot be arrested by the antiseptic tampon, necessitates splenectomy. Very troublesome hemorrhage is often met with from wounds of the mesenteric vessels.

When multiple perforations of the mesentery and visceral wounds of the stomach or intestines are the source of hemorrhage, it is a good plan to pack the abdominal cavity with a number of large sponges to each of which a long strip of iodoform gauze is securely tied, these strips being allowed to hang out of the wound in order that none of the sponges may be lost or forgotten in the abdominal cavity after the completion of the operation. The sponges make sufficient pressure to arrest parenchymatous oozing as well as venous hemorrhage if they are placed at different points against the mesentery and between the intestinal coils. The sponges are removed one by one from below upward, and the bleeding points secured as fast as they are uncovered.

The ligation of mesenteric vessels, both arteries and veins, should be done by applying the ligature *en masse*. Thornton's curved hemostatic forceps is the most useful instrument for this purpose. Catgut should never be relied upon in tying a mesenteric vessel, as it is greatly inferior to fine silk. Troublesome hemorrhage from a large visceral wound of the stomach and intestines is best controlled by hemming the margin of the wound with fine silk. If hemorrhage is profuse, this must be attended to before anything is done in the way of finding or suturing the visceral wounds.

5. *Search for Perforations.*—If the hydrogen-gas test has been employed

with a positive result before the abdomen was opened, there will be no difficulty experienced in finding the first opening. If the stomach was inflated directly through an elastic tube, and the test has shown the presence of a perforation, a median incision is made from the tip of the ensiform cartilage to the umbilicus and the stomach drawn forward into the wound. If no perforation is found in the anterior wall, the insufflation is repeated, and the escaping gas will direct the surgeon to the perforation. After closing the perforation the stomach is again inflated, and if a second perforation exists it is readily detected by this test. The possibility of the existence of a third perforation should be remembered; consequently a third inflation may become necessary. A second and a possible third perforation can also be detected by inflating the stomach directly through the first or second perforation.

If the wound is situated in the abdominal cavity below the stomach, the hydrogen-gas test is applied by insufflation by the rectum. If the test has yielded a positive result, the lowest perforation is readily found by examining the intestine at a point where the distended and empty portions join, as the leakage of gas through the perforation prevents inflation higher up.

If the intestine is found distended below the first-discovered perforation, it is an indication that no perforations exist lower down in the intestinal canal, and hence that it is unnecessary to lose any time in a further search in that direction.

As soon as the lowest perforation has been found, rectal insufflation should be suspended. If possible, the perforated portion of the intestine should now be brought forward into the wound, and after emptying the intestine below the perforation as far as possible of its gas, the bowel is compressed below the perforation by an assistant and the intestine higher up is inflated through the wound. As a matter of course, a perfectly aseptic glass tube should be inserted into the rubber tube in place of employing the tube which was used in the rectum. The inflation is now carried as far as the second opening, when the first opening is sutured, and after disinfection and emptying the intervening portion of its gas the intestine is replaced in the abdominal cavity. Further inflation is now made through the second opening, and if a third one is found the second is sutured, and so on until the entire intestinal canal has been thoroughly subjected to the test. By following this plan extensive eventration is rendered superfluous and the overlooking of a perforation is made absolutely impossible. Such eventration in the search for perforations and undiscovered perforations figure largely as the causes of death in gunshot wounds of the abdomen treated by laparotomy, and both of these sources of danger are avoided by a thorough and systematic employment of the hydrogen-gas test.

There is good reason to think that quite as many lives have been lost by prolongation of the search for perforations as by overlooked perforations, and most surgeons now hold that the search should be made with the aid of inflation and by rapidly running over the movable portion of the intestines, and only so much of the fixed portion as lies in the track of the bullet.

6. *Suturing of Wounds of the Stomach and Intestine.*—Trimming the margins of the visceral wounds is not only superfluous, but absolutely harmful, as it requires a useless expenditure of time and may become an additional source of hemorrhage. The same can be said of the Czerny-Lembert suture. All that is required in the treatment of a visceral wound of the stomach and intestine is to turn the margins of the wound inward and bring into apposition healthy serous surfaces by the continuous Lembert or by interrupted sero-muscular sutures, which should always be made to include fibers of the submucosa.

Fine aseptic silk should be used, and from four to six sutures to an inch are sufficient. If possible, wounds of the stomach should be sutured in a line parallel with the long axis of the organ, and wounds of the intestine should be closed transversely, with a view of preventing constriction of the lumen. Defects an inch and a half in length on the convex border can be closed in this manner without fear of causing intestinal obstruction, while much smaller defects on the mesenteric side often necessitate a resection, not only because the vascular supply in the corresponding portion of the intestine would be inadequate, but also because a sufficiently sharp flexion might be produced at the seat of suturing to become a source of intestinal obstruction.

7. *Enterectomy.*—Enterectomy is often indicated in cases of double perforation and in marginal wounds of the mesenteric border. If in cases of multiple perforations it becomes necessary to make a double enterectomy, and the intervening portion of the small intestine is not more than two or three feet in length, it is best to resect the intervening portion itself, as the immediate effect of the single operation will be less severe than that of a double resection with a corresponding double enterorrhaphy. The mesentery corresponding to the portion of intestine to be removed should be tied in small sections with fine silk before the bowel is excised.

8. *Omental Grafting.*—If the bowel at the seat of suturing shows evidences of contusion, the line of suturing and the damaged portion of the bowel should be covered by an omental graft, which is fastened in its place on the mesenteric side by passing two catgut sutures in the line of the mesenteric vessels through both ends of the graft and the mesentery and tying them loosely. Before the graft is planted the surface of the bowel and the surface of the graft which is to be brought in contact with it are scarified with the point of an aseptic needle.

9. *Irrigation of the Abdominal Cavity.*—This is necessary only if fecal extravasation or escape of stomach contents has taken place, an accident which, if it has not occurred before the abdomen was opened, should be carefully avoided during the manipulation of the wounded intestines. Flushing the peritoneal cavity with warm sterilized water not only clears it of infectious material, but acts at the same time as a stimulant to the flagging circulation. After completion of the irrigation the patient is placed on his side, and in this manner the fluid contents of the abdominal cavity are poured out. The cavity is then rapidly dried with large sponges wrung out of a weak sublimate solution (1 : 10,000). Some surgeons have practically abandoned flushing of the abdominal cavity, and rely almost exclusively on sponging in removing pus and extravasated fecal material.

10. *Drainage.*—Cases which require irrigation usually require drainage. Other indications for drainage are visceral wounds of the liver and wounds of the pancreas, spleen, and kidneys, where extirpation of the wounded part of the organ or of the whole organ is deemed unnecessary, and the existence of parenchymatous hemorrhage which cannot be remedied by any of the different hemostatic measures. A combination of a tubular and capillary drain is most advantageous. A glass drain reaching to the bottom of the pelvis loosely packed with a strip of iodoform gauze answers an excellent purpose.

11. *Closure of the External Incision.*—Incisions through the median line are rapidly closed by one row of silk sutures which include all the tissues of the margins of the wound. Incisions made in any other place are to be closed in the same manner, or by two or three rows of buried catgut sutures and a superficial row of silkworm-gut sutures including all the tissues except the peritoneum.

12. *After-treatment.*—Absolute rest must be strictly enforced. Opiates must be given in doses sufficient to quiet the peristaltic action of the intestines. No food should be given by the stomach for at least forty-eight hours. During this time a mixture of brandy and water, in small doses frequently repeated, is agreeable to the patient, as it quenches thirst and exerts a favorable influence upon the circulation. If more active stimulation is required to overcome shock and the effects of hemorrhage, whiskey, strychnine, ether, musk, or camphor can be injected subcutaneously or by the rectum, while the peripheral circulation is restored by applying dry heat to the extremities and trunk. Should symptoms of peritonitis set in, a brisk saline cathartic should be given at the end of forty-eight hours, as at this time the intestinal wounds will have become sufficiently united to resist the peristalsis provoked by the cathartic, while the removal of the intestinal contents and the absorption of septic material from the peritoneal cavity thus attained are not only the most efficient means of averting a fatal disease, but also of placing the wounds in the most favorable condition for rapid repair.

If the case progresses favorably, liquid food by the stomach can be allowed at the end of the second day, and digestible solid food at the end of the first week. Under ordinary circumstances no effort is made to move the bowels until the end of the third or fourth day. If early feeding becomes necessary in marasmic or exsanguine patients, this can be done by rectal alimentation. Patients should not be allowed to leave the bed until the external wound has firmly united throughout, as any imprudence in this direction is liable to be followed by the formation of a ventral hernia. The sutures are removed on the eighth day, and the patient is directed to wear an abdominal supporter for several months after he has left his bed.

PART II.—DISEASES AND INJURIES OF THE STOMACH.

Wounds and Contusions.—The stomach, when of normal size and in its natural location, is so well protected by the chest-wall and the surrounding organs that it seldom becomes the seat of injury from blunt force. Contusion, partial laceration, and complete rupture may occur from a severe blow or kick applied over the organ when distended with food. A partial laceration and contusion will give rise to circumscribed pain at the seat of injury, followed by a limited inflammation which usually results in the formation of adhesions between the injured part and the adjacent surface. Evidences of circumscribed peritonitis in the region of the stomach after an injury are suggestive of the existence of a traumatic lesion of this organ, and should warn the surgeon to secure rest for the injured part by placing the patient on an absolute diet for four or five days, withholding indigestible food until all danger of perforation has passed.

As the peritoneal investment is less elastic than the muscular and mucous coats, partial rupture of the organ necessarily implicates most frequently the external or peritoneal coat. In *complete* ruptures and in lacerations involving the mucous coat hemorrhage takes place into the stomach; and if the patient vomits blood, the existence of a serious injury of this viscus may be fairly assumed. A rupture of the stomach large enough to permit the escape of its contents into the peritoneal cavity is usually attended by additional serious injuries which still further complicate the case. Extravasation of food into the peritoneal cavity causes severe pain and symptoms of shock, which, if the patient rallies, is followed by diffuse septic peritonitis and death within forty-eight hours. In cases of this kind the existence of a complete rupture can be

readily demonstrated by inflating the organ with hydrogen gas through an elastic stomach-tube. If the rupture is *incomplete*, the stomach will be dilated and its contour can be mapped out on the surface of the abdomen by inspection and percussion; if a complete rupture has taken place, the organ cannot be distended, as the gas will escape through the visceral wound into the abdominal cavity, where its presence can be recognized by the physical signs which characterize a free tympanites.

In the **treatment** of a complete rupture of the stomach no time should be lost. The abdomen should be opened by an incision from the xiphoid cartilage to the umbilicus. If the visceral wound is located where it cannot be readily found, it can be quickly pointed out by repeating the inflation. If extravasation has taken place, the peritoneal cavity should be carefully cleansed by flushing with warm sterilized water and mopping with a soft aseptic sponge. If the stomach has not been emptied by vomiting or by the escape of its contents through the rupture, it should be evacuated completely through the wound before this is closed with sutures. After careful arrest of hemorrhage the rent in the stomach is closed by applying two rows of silk sutures: the first row, to embrace the muscular and mucous coats, is cut short, and buried by the second row, which is made to include the peritoneum and enough of the muscular coat to give each suture a firm hold. Some surgeons employ only a single row. If the peritoneal cavity has been contaminated by extravasation for a considerable length of time, it is advisable to resort to drainage. As an operation for such an injury necessarily requires a considerable length of time, the circulation should be maintained by a judicious use of external heat and of stimulants administered by subcutaneous and rectal injections. As heart stimulants, camphorated oil, digitalis, and strychnia, injected subcutaneously, are to be relied upon. Whiskey or brandy diluted with warm water should be given by the rectum. The patient is to be nourished exclusively by rectal alimentation for at least three or four days.

Gunshot and Stab Wounds of the Stomach are much more frequent than lacerated wounds. The existence of a visceral wound of this organ in connection with penetrating wounds of the abdomen is often made evident by hematemesis, and less frequently by the escape of the contents of the stomach through the external wound. If such positive indications are wanting, as is usually the case in gunshot wounds, the diagnosis may be made by resorting to insufflation with hydrogen gas.

A number of cases have been reported where the stomach had been perforated by a small bullet, and recovery followed without operative interference. Such a favorable termination can be hoped for if the visceral wound is small and if the organ was empty at the time the injury was inflicted. Under such circumstances the wound is temporarily closed by the bulging of the mucous membrane, which forms a perfect plug until by a speedy process of repair the wound on the peritoneal side is permanently sealed by new tissue.

In the surgical **treatment** of wounds of the stomach it is important to remember that if the wound is located near the cardiac orifice of the organ or in the posterior wall, it is difficult of detection and not readily accessible to direct treatment. In gunshot wounds of the stomach, unless the bullet grazes one of the borders, it is the rule that the organ is perforated at two points. If only one perforation is found, this should never be closed until search has been made for additional perforations by inflating the organ through the perforation. This diagnostic test prevents the possibility of leaving an undiscovered and unsutured perforation. Two cases may be mentioned, in each of which one perforation was overlooked and the patient died of peritonitis which could be

traced to the unsutured wound. In one of the cases the bullet passed through the cardiac extremity of the stomach in an antero-posterior direction. The perforation in the anterior wall was readily found and sutured, and, as no other visceral injuries could be found, the operation was terminated. The patient died of septic peritonitis on the second day. The necropsy revealed a second perforation in the posterior wall of the stomach and a septic peritonitis which had plainly developed from this source, as the large opening had remained patent, establishing a free communication between the interior of the stomach and the peritoneal cavity. The second case is of great interest, as it shows that one bullet can produce three perforations in the stomach. The bullet passed transversely through the upper part of the abdominal cavity. Abdominal section was made, and two perforations in the stomach, one near the cardiac extremity, the other near the pylorus, were easily found and sutured. The surgeon had every reason to believe that he had found and treated all the perforations. The patient died of septic peritonitis, which, as the post-mortem showed, was caused by an overlooked perforation in the small curvature of the stomach. Gunshot and stab wounds of the stomach are sutured in the same manner as lacerated wounds, care being taken to cover the perforation some distance beyond the margins of the wound by applying the superficial or Lembert sutures at least half an inch beyond the margins on each side. The same care must be exercised in the after-treatment of such cases as has been detailed in describing the treatment of lacerated and ruptured wounds of this organ.

Foreign Bodies.—Foreign bodies which traverse the pharynx and œsophagus usually pass through the entire length of the gastro-intestinal canal and escape in a day or two with the fecal evacuation. Coins, buttons, fragments of bone, pins, and other small foreign bodies are usually disposed of in this manner. The popular belief that the passage of a foreign body through the alimentary canal is facilitated by the administration of purgatives is erroneous, as every measure directed toward increasing peristalsis will tend to increase the risk of its arrest and impaction. It has been advised to restrict such patients to an exclusive diet of bread and milk for a number of days, to be followed by a gentle laxative. Quite recently the so-called "Vienna treatment," consisting in an exclusive diet of mashed potatoes, has received a great deal of attention and has been employed to good advantage in such cases.

The **dietetic treatment of foreign bodies** in the alimentary canal is founded upon the fact that during appropriate feeding the foreign body becomes, as it were, encrusted or buried, and is thus rendered less dangerous, and its passage through the pyloric orifice of the stomach and along the intestinal canal is facilitated. If the foreign body, such as a knife, fork, etc., either from its great size or on account of its shape, cannot pass through the pyloric orifice, it acts as an irritant to the walls of the stomach, causing catarrhal inflammation, ulceration, and even perforation. Under such circumstances it becomes the duty of the surgeon to resort to the operative removal of the for eign body before it has inflicted irreparable damage.

Gastrotomy for the removal of foreign bodies is one of the oldest and most successful of all abdominal operations. The first operation of this kind was performed by Florian Mathias of Prague in 1602. The stomach is reached through a median incision, and, if possible, the foreign body is located before the incision for its removal is made. If this cannot be done, the anterior wall of the stomach is brought forward into the wound and retained in this location with volsellum forceps, and a vertical incision made large enough to admit one or two fingers for digital exploration of the interior of the vis-

cus. After the foreign body has been located, it is grasped with a pair of strong polypus forceps in such a manner as to extract it without inflicting additional violence. The visceral wound is closed in the usual manner with Czerny-Lembert sutures, and after carefully cleansing the exposed parts the organ is replaced and the external wound sutured. Absolute diet must be enforced for at least three or four days after the operation, the time required for the formation of firm adhesions between the margins of the visceral wound.

Ulcer.—Until recently ulcer of the stomach had no interest for the surgeon, as treatment for this affection was regarded as the exclusive province of the physician. Recurring hemorrhages from an ulcer of this organ have brought many patients to the brink of the grave, and not infrequently death has resulted from this cause alone, while in many other cases the cicatricial contraction occurring during the healing of an ulcer has given rise to remote evil consequences beyond the range of successful treatment by internal medication. For these reasons during the last few years ulcer of the stomach has become the subject of surgical interest and operative interference. Perforating ulcer of the stomach and duodenum follows circumscribed necrosis of the wall of these organs caused by a diminished arterial blood-supply of a limited vascular district. That many of these ulcers are of vascular origin is shown by their shape and their direct relation to a terminal artery. The defect is in the form of a cone, of which the base is directed toward the lumen of the viscus, and the apex corresponds with a small artery which must have been partially or completely obstructed before the necrosis occurred. These ulcers are sometimes multiple, and in the stomach they are found by preference along the lesser curvature. After interruption of the arterial circulation the wedge-shaped, ischemic, necrosed portion is removed by the action of the gastric juice and the ulcer is formed. As perforating ulcer of the stomach or duodenum never occurs in cases of ulcerative endocarditis, and as it selects in preference young females, the causes of vascular obstruction must be of a local nature. The sphacelus shows molecular decay, but no trace of inflammation. The more frequent occurrence of perforation is prevented by circumscribed plastic peritonitis, which seals the defect or establishes permanent adhesion between the affected portion of the organ and an adjacent serous surface.

The principal **symptoms** of ulcer of the stomach are a fixed pain, a circumscribed area of tenderness, and vomiting soon after eating. If in the absence of the usual symptoms of carcinoma the patient vomits blood, the diagnosis is almost positive.

The surgical **treatment** of ulcer of the stomach has for its object one of three things: (1) arrest of hemorrhage; (2) excision of the ulcer; (3) suturing of a perforation. If a positive diagnosis of the existence of an ulcer of the stomach, which threatens life from recurring attacks of hemorrhage or which has resulted in perforation, can be made, treatment by laparotomy should be resorted to without delay. The stomach is reached by a median incision. The existence of a perforation, if not easily seen, can be readily demonstrated by insufflation with hydrogen gas through an elastic œsophageal tube. If no perforation is present, the seat of the ulcer can sometimes be located by a circumscribed patch of peritonitis which corresponds with the location of the ulcer within the viscus. As ulcers are most frequently found in the smaller curvature and in the region of the cardiac and pyloric orifices, these localities should be carefully inspected. If the ulcer involves the posterior wall of the stomach, it can be found and treated only through an incision in the anterior wall. If the ulcer is located in the

anterior wall, it can be readily excised and the resulting wound united in the usual manner. The closure of the wound made by excision of an ulcer of the posterior wall must be done in such a manner that the superficial or Lembert sutures are inserted and tied before the deep stitches are made, which are tied last and cut short. The wound in the anterior wall is then closed in the ordinary manner. As in all other operations on the stomach, the patient is placed on an absolute diet for a number of days. Rydygier was the first to subject an ulcer of the stomach to surgical treatment, and since his time a number of successful cases have been reported. Excision of an ulcer followed by gastrorrhaphy will undoubtedly prevent the remote consequences which would follow the cicatrization and spontaneous healing if the disease were allowed to pursue its own course.

Cicatricial Stenosis.—Cicatricial stenosis of either of the two orifices of the stomach, the cardiac and the pyloric, frequently follows as a remote sequel the healing of an ulcer or a traumatic defect in these localities. If it is located at the cardiac orifice, the stricture interferes with the introduction of food into the stomach; if it involves the pyloric orifice, it interferes with the escape of chyme into the intestinal canal. The development of the stenosis is a slow process, as it depends upon the formation and contraction of cicatricial tissue which is formed at the site of the former trauma or ulcer. The formation of an excessive amount of granulation-tissue in a surface wound or ulcer of the stomach takes place in consequence of the continual irritation caused by the food and digestive fluids; and it is on this account that cicatricial contraction so often follows the healing of a wound of the mucous membrane or ulcer of this organ.

Diagnosis.—At the *cardiac orifice* a cicatricial stricture develops most frequently after destruction of the mucous membrane by the action of caustics or through the injury caused by the lodgment of a foreign body or by rude attempts to remove it, whereas ulcer constitutes the most frequent cause of cicatricial stenosis at the *pyloric orifice*. A cicatricial stricture at the cardiac orifice of the stomach may be suspected if the patient has experienced a gradually increasing difficulty in swallowing solid food. As the stricture grows narrower, the œsophagus above it becomes dilated and solid food is regurgitated soon after it is swallowed, while liquids still enter the stomach through the constricted orifice. If the patient has not reached the age at which carcinoma may be suspected, and if the clinical history points to an antecedent pathological condition which is known to produce a stricture, it is almost certain that a stenosis of a benign nature exists. The presence of the stricture and its exact location are determined by the use of an olive-pointed œsophageal bougie (p. 680). A cicatricial stenosis of the pyloric orifice of the stomach gives rise to obstruction at this point, retention of food, and dilatation of the stomach. Such patients are usually treated for months or years for dyspepsia or indigestion, until finally a careful examination of the stomach reveals the existence of the obstruction and great distention of the organ.

The diagnosis of stricture of the *pylorus* must be based on the history of the case, the use of the siphon stomach-tube, and inflation of the organ. The clinical history will usually reveal the existence of disturbed digestion for years previously, incident to the presence of an unhealed ulcer, and more recently caused by the obstruction. For a time compensatory hypertrophy balances the mechanical difficulties caused by the stricture, but when this is no longer possible the walls of the stomach become attenuated and the cavity of the organ is enormously increased in size, containing remnants of food which have been retained for days and often for weeks. Through the elastic siphon tube the

stomach is evacuated and irrigated, and the quantity of fluid which it holds furnishes important information in reference to the size of the organ. Air can be forced through the stomach-tube after the organ has been thoroughly emptied and irrigated, and the contour of the stomach then becomes visible externally and its outlines can be accurately fixed by percussion. Seidlitz powder can be used for the same purpose, the two portions being dissolved separately, the bicarbonate solution being swallowed at once, the tartaric acid in divided doses. It is not uncommon to find the greater curvature of the stomach considerably below the umbilicus if dilatation has progressed to any considerable extent. The absence of a tumor in the pyloric region is indicative of a cicatricial stenosis, but does not preclude the possibility of malignant disease. A cicatricial stricture of either orifice of the stomach is certain to lead to a fatal termination from marasmus unless the mechanical difficulty is remedied by surgical interference, as a patient suffering from a stricture of the cardiac orifice dies from starvation on account of his inability to introduce food into the stomach, and a pyloric stricture leads to permanent and complete obstruction to the passage of food, the patient finally succumbing to the combined effects of inanition and the retention of putrefying and fermented food in the stomach.

Treatment.—Cicatricial stenosis of the *cardiac orifice* of the stomach should be treated by gradual dilatation in all cases where it is possible to pass even the finest filiform bougie through the stricture. The different kinds of urethral bougies answer often an excellent purpose in the early treatment of narrow strictures. Dilatation should be carried out gradually, but persistently, until the normal size of the lumen of the orifice has been restored, and the largest dilating instrument used should be employed every week or two for a long time subsequently, in order to prevent recurrence of the stricture. If the stricture proves impermeable to the different kinds of dilating instruments, the only course left is to resort to a gastrostomy, both for the purpose of establishing a new route for the introduction of food into the stomach and in order to afford another opportunity to make an attempt to dilate the stricture from below. Abbe has recently devised a new method of treatment in cases of œsophageal stricture. After opening the stomach through an external incision, he passes with an instrument a string through the stricture, and, bringing one end out through the mouth and the other through the opening in the stomach, divides the stricture by placing the string on the stretch and moving it rapidly upward and downward until the stricture is divided. After the œsophagus has been rendered permeable in this manner the visceral and external incisions are closed, and recurrence of the stricture prevented by the frequent introduction of œsophageal bougies.

The operative treatment of a cicatricial stricture at the *pyloric end* of the stomach consists in dilating the stricture forcibly through a wound in the stomach, or through a gastric fistula (Treves), in the formation of a partly new pylorus by the Heineke-Mikulicz pyloro-plastic operation, or in establishing a new outlet from the stomach into the upper portion of the small intestine by making a gastro-enterostomy. (See Operations, p. 706.)

Dilatation of the Stomach without Mechanical Obstruction.—As a rare pathological condition we occasionally find an enormously dilated stomach without a mechanical obstruction at the pyloric orifice. The cause of dilatation in such cases is a chronic catarrhal inflammation of the mucous membrane, which results in a weakening and attenuation of the muscular coat and gradual yielding of all the tunics. If under dietetic and appropriate medical treatment, including systematic evacuation of the stomach through the rubber siphon tube and the application of the galvanic current directly to the interior

surface of the stomach through an insulated œsophageal tube, the function and normal size of the organ cannot be restored, a "tuck" may be taken in the stomach by sewing the greater curvature to the lesser by several rows of stitches, as Bircher and Weir have done in four cases; or a new outlet from the stomach into the small intestine, and may be made by a gastro-enterostomy (p. 706). Bircher has recently recommended in such cases reduplication of the anterior wall of the stomach, with suturing of the fold by numerous catgut sutures, and has reported several successful cases. Weir and others have resorted to this procedure with satisfactory results.

CARCINOMA.—Myo-fibroma and other benign tumors of the stomach are extremely rare, and when present seldom necessitate surgical interference. Sarcoma as compared with carcinoma is so extremely rare that it is necessary only to speak briefly of carcinoma as a tumor of the stomach which interests the surgeon. It appears that in the stomach the general law is observed that this disease develops in preference at points where two kinds of epithelial cells meet. It is a well-known clinical fact that in the stomach the disease has its primary starting-point most frequently at the pyloric or the cardiac orifice, and of these two regions the pyloric is the more frequently affected.

Carcinoma in either of these localities gives rise to a combination of clinical **symptoms** which suggest the existence of ulcer and stricture. As soon as the surface of the carcinoma ulcerates, hemorrhage into the stomach is of frequent occurrence, and the tumor, by narrowing the orifice, at the same time gives rise to obstruction in the same manner as a simple stricture. It is not always easy or even possible to ascertain the existence or exact location of a carcinoma of the stomach by any of the known physical signs. A carcinoma at the cardiac orifice, from its deep location, may attain a considerable size before its presence can be demonstrated by palpation or percussion. In the majority of advanced cases of carcinoma of the pylorus, however, a distinct tumor can be felt in the pyloric region, but often the weight of the tumor has carried that part of the stomach in a downward direction, and the tumor may be found as low as the level of the umbilicus. The size of the stomach is greatly diminished in carcinoma at the cardiac orifice, while if the disease is located in the opposite extremity the organ is often found enormously distended in consequence of the long-standing obstruction. It is sometimes not easy to differentiate between a carcinoma of the pyloric extremity of the stomach and a retro-peritoneal tumor in that locality. Inflation of the stomach is the most reliable diagnostic procedure in such cases. If the tumor is retro-peritoneal, it becomes covered by the distended stomach; if it belongs to the stomach, though it may be displaced downward, its position relative to the anterior wall of the abdomen remains unchanged by the inflation. The existence of a carcinoma at the cardiac orifice can be shown by the œsophageal bougie, and the degree of contraction at this point is ascertained in the same manner. A carcinoma of the stomach may be suspected if a patient more than forty years of age gives a history of disturbed digestion dating back for several months or a year, combined with evidences of cardiac or pyloric stenosis. The chemical examination of the contents of the stomach, so much relied upon during the last few years in making a differential diagnosis between benign and malignant affections of this organ, is not always reliable, but will often yield valuable diagnostic information. Hematemesis in persons beyond middle age, and enlargement of the cervical glands, indicate malignant disease.

The surgical **treatment** of carcinoma of the stomach consists either in the removal of the mechanical obstacle which interferes with the introduction of food into the stomach or with its escape from it, according to the location of the

tumor, or in the removal of the disease. In carcinoma of the cardiac orifice life can be prolonged by keeping the strictured portion patent by the careful introduction of œsophageal tubes. Liquid and finely divided food can be introduced in this manner. If the stenosis has reached such an extent that it is difficult to introduce stomach-tubes, a small rubber tube should be passed through one of the nasal passages and into the stomach, to be retained in place, and through this liquid food can be injected into the stomach. If this method of feeding is no longer possible, a gastrostomy is indicated. A limited carcinoma of the pylorus, if it has not resulted in secondary infiltration of the lymphatic glands behind it, furnishes a legitimate indication for a radical operation. (See Operations, p. 708.) If, however, the disease has extended beyond the walls of the stomach, pylorectomy is contraindicated, and the surgeon must be content to establish a new outlet from the stomach into the upper portion of the small intestine. In pyloric carcinoma life is greatly prolonged and much suffering prevented by placing the patient on a carefully selected diet and by resorting to irrigation of the stomach as often as the retention of the undigested food may render it necessary.

Gastric Fistula.—An external gastric fistula may form as one of the results of a perforating ulcer of the stomach if adhesions between the anterior surface of the stomach and the abdominal wall have shut out the peritoneal cavity before perforation occurred. It may also develop after a perforating wound of the stomach if peritonitis is prevented by a speedy union between the margins of the visceral and parietal wounds. An intentional gastric fistula may require surgical treatment for its closure if the object for which the fistula was made has been accomplished, as when it has been undertaken with a view of dilating a cicatricial stricture of the cardiac orifice or the lower portion of the œsophagus.

Treatment.—If the fistula is short and leads directly into the stomach, an effort should be made to close it without opening the peritoneal cavity. The abdominal wall should be incised to the extent of at least two inches down to, but not through, the peritoneum. This will expose the opening in the stomach. The lining of the fistulous track is now freely excised, special care being taken to vivify that portion of the fistula which corresponds to the wall of the stomach. In closing the fistula the line of sutures must be applied in the direction offering the least traction. The first row of sutures is made with fine silk, and should embrace the mucous and submucous coats. The remaining coats of the stomach are brought together with strong catgut sutures. The margins of the wound corresponding to the abdominal wall are united with a deep row of catgut and a superficial row of silk sutures. An antiseptic compress retained with long strips of adhesive plaster constitutes the dressing. Nothing should be given by the stomach for at least four or five days. Thirst is quenched with fragments of ice, and food is administered exclusively by the rectum. If this operation should fail, and in cases where it is not applicable, the abdomen must be opened, the stomach separated from the abdominal wall, and the fistulous opening closed in the same manner as a visceral wound of this organ. Wherever it is possible to cover with peritoneum that part of the wall of the stomach which has been separated, this should be done, as this will secure a more speedy and certain union of the sutured parts. As an additional precaution it might be advisable to fasten the sutured part of the stomach to the inner surface of the abdominal wound with a few catgut sutures, and drain the external wound with an iodoform gauze tampon down to this point, which would effectually protect the peritoneal cavity against extravasation should the visceral wound fail in healing by primary intention.

OPERATIONS ON THE STOMACH.

GASTROTOMY.—The term gastrotomy was used for a long time synonymously with abdominal section or laparotomy, as well as to designate the operation of temporarily opening the stomach for the removal of a foreign body, etc., but is now restricted to the latter operation, while the opening of the peritoneal cavity is designated as abdominal section, laparotomy, or, as has recently been proposed by Harris, cœliotomy. As compared with the operation which will be described as gastrostomy, the wound in the stomach, irrespective of its purpose, is always closed; that is to say, gastrotomy is always followed by gastrorrhaphy. Gastrotomy is performed for the removal of foreign bodies which have become lodged in the stomach, or for the removal of a gastrolith (Thornton, Schonborn), or for the purpose of treating lesions within the stomach. Under the last heading may be mentioned the localization and direct treatment by excision of ulcers, the digital divulsion of cicatricial strictures of the pyloric or the cardiac orifice, and, as has recently been done by Bernays, the temporary removal of the obstruction by scraping out the carcinomatous tissue in cases of malignant disease of the pylorus. The stomach should be washed out with a weak antiseptic solution, such as salicylated water or boric-acid solution, immediately before the anesthetic is administered, in order to prevent extravasation in the vicinity of the wound after making the incision.

In the majority of cases it will suffice to make an incision through the abdominal wall from the ensiform cartilage to the umbilicus, and if more room is required a small transverse incision can be added on the side of the median line where it will be most needed. The anterior wall of the stomach is now brought well forward into the wound, which, if the organ is normal in size, can readily be accomplished without inflation. The peritoneal cavity is then protected by packing antiseptic gauze around the exposed portion of the stomach. The incision is always to be made transversely to its long axis. The best method of opening the stomach is to cut down to the mucous membrane with a sharp scalpel, and then open the organ between two catch-tooth forceps and enlarge the incision to the requisite extent with blunt-pointed scissors. After the foreign body has been extracted or the visceral lesion remedied, the wound is to be closed in the manner described below. Stomach-feeding should not be commenced for at least four days, when small quantities of liquid food are to be given at short intervals. Up to this time thirst is allayed by allowing small fragments of ice to dissolve in the mouth, and the strength of the patient is sustained by rectal alimentation.

GASTRORRHAPHY.—Gastrorrhaphy signifies the closure of a wound of the stomach by suturing. It is done in the same manner as in enterorrhaphy. After careful hemostasis, the deep or buried sutures are first applied. These should consist of fine aseptic silk, which are made to include all the coats of the stomach with the exception of the peritoneum and are cut close to the knot. About four sutures to an inch will be required. The superficial sutures of fine silk should include the peritoneum and enough of the subjacent tissue to give them a firm hold. The needle is inserted about a quarter of an inch from the margin of the wound, and is brought out near, but not at, the margin, re-entered on the opposite side at a similar point, and brought out at the same distance from the wound on the opposite side. As the superficial sutures are being tied the peritoneum is gently inverted. It is thought by some surgeons (Senn) that slight scarification of the peritoneum hastens the process of repair; and on this account they deem it advisable before the superficial sutures are tied, to subject the peritoneal surfaces which are to be brought into apposition to this

treatment. Others are of the opinion that scarification adds nothing to the rapidity of union between such opposed serous surfaces.

GASTROSTOMY.—Gastrostomy is an operation for establishing a fistulous opening in the stomach through the anterior abdominal wall. A resort to this operation is indicated in cases of malignant or cicatricial stenosis of the œsophagus or cardiac orifice of the stomach advanced to such an extent that the introduction of food *per viam naturalem* or by the use of tubes is no longer possible. The results of this operation in malignant disease have thus far not proved very satisfactory, as it has seldom been performed before the patient had reached an extreme degree of marasmus which in itself proved the greatest source of danger. As the object of the operation is to establish a gastric fistula through which food can be introduced into the stomach, it is evident that the opening in the stomach should be made as near as possible to the cardiac orifice. In all instances in which the patient's strength warrants the performance of the operation in two stages, as was first suggested by Mr. Howse, this method should be practised, as it is much safer than that by which the stomach is opened at once.

Forster, Durham, and Verneuil made the abdominal incision in the line of the left linea semilunaris. Fenger's incision is the one which has been employed most frequently. This incision, from three to four inches in length, is made to the left of the rectus muscle, a little below and parallel to the left costal arch. The tissues are divided, layer after layer, with a sharp scalpel until the peritoneum is reached. This is incised between two forceps and the opening enlarged to each angle of the wound. It is essential to protect the muscular and connective tissues of the belly-wall against the action of microorganisms and the gastric juice; hence the first thing to be done after opening the abdominal cavity is to suture the parietal peritoneum to the skin with fine silk or catgut stitches. If it is difficult to find the empty and contracted stomach, the next step of the operation is to inflate the organ, which will bring its anterior wall into sight, when it can be drawn into the wound. By this procedure the operation is greatly facilitated and the surgeon will avoid the error of opening the colon in place of the stomach, as was done by Maunder. The stomach should be drawn forward sufficiently to make a small cone, and in this position it is fastened by suturing it to the sides of the wound. Langenbeck made use of two long steel needles in anchoring the stomach more securely in the wound, the needles transfixing both margins of the wound and the wall of the stomach. Krönlein transfixes the wall of the stomach without entering its lumen, which is much preferable to Langenbeck's method, as the latter has given rise to unpleasant complications, in several cases the tracks of the needles in the abdominal wall becoming the seat of a diffuse phlegmonous inflammation.

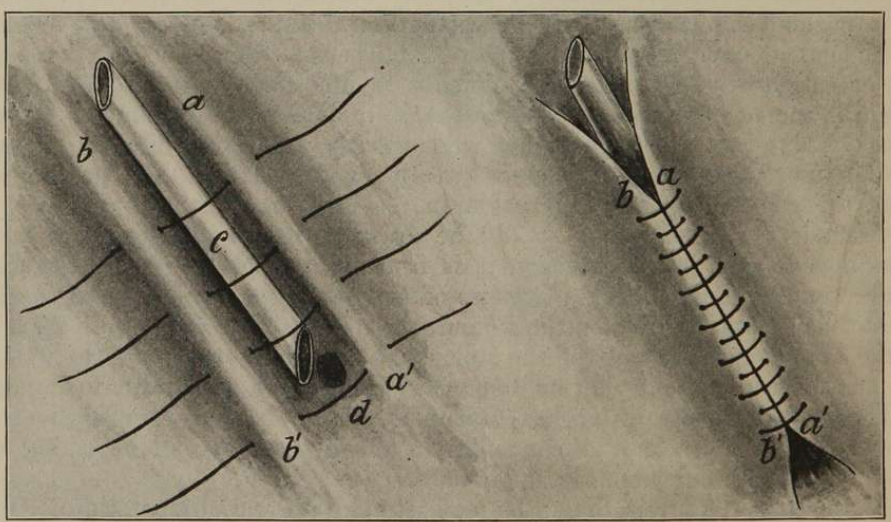
If the patient's strength can be maintained by rectal alimentation for four or five days, the opening of the stomach should be postponed until that time, as then the organ will have become firmly adherent to the abdominal wound. If, however, the symptoms are very urgent and the delay of stomach-feeding might endanger the life of the patient, a small incision is made at once in the stomach, into which a small rubber tube is fixed, and through this at short intervals liquid food and stimulants are injected. The opening in the stomach should never be large, as there is nearly always a tendency to the escape of food from the fistulous opening. That even five days will not always suffice to prevent separation of the stomach from the abdominal wound is shown by a case in which the needles were removed on the fifth day, and as the stomach appeared to be firmly adherent it was opened and stomach-feeding commenced.

Two days later the stomach was found completely separated, and its contents escaped into the peritoneal cavity, causing a rapidly fatal peritonitis.

Quite recently Hahn has devised a new incision for gastrostomy for the purpose of making the opening in the stomach nearer the cardiac orifice than has been done heretofore, thereby bringing the fistula in a place where the food could not so readily escape. He makes the external incision through the eighth intercostal space on the left side. The stomach is exposed first by Fenger's incision, after which the skin and fascia in the intercostal space mentioned are incised with a scalpel close to the costal cartilages: the remaining structures are then perforated with a sharp-pointed hemostatic forceps, which is made to seize the proper point of the stomach by directing it with eye and finger through the first wound. With the forceps the stomach is drawn forward into the wound, when it is attached to the skin with sutures.

Witzel has proposed a new method of performing gastrostomy which has yielded excellent results, and has been quite generally adopted by the profession. The external incision is made to the left of the median line through the rectus muscle. After bringing the stomach forward into the wound, an opening is made at the desirable point in the anterior wall large enough to permit the insertion of a rubber tube a little larger than an ordinary lead-pencil (Fig. 274 A, *c*). After the introduction of the tube two vertical folds, one on each side of the opening, are made (*a*, *a'*, *b*, *b'*), which are united over the tube by a number of muscular sutures to a distance of at least two inches (Fig. 274 B). The distal end of the tube is brought out through the upper angle

A FIG. 274. B



Witzel's Method of Gastrostomy: A, first stage—*c*, the rubber tube; *a*, *a'*, *b*, *b'*, two folds of the wall of stomach with threads inserted; *d*, hole in stomach for insertion of tube. B, second stage—tube buried by tying the stitches, thus approximating *a* to *b*, and *a'* to *b'*.

of the external incision, to which the stomach is securely fastened with a number of sutures, after which the balance of the external wound is closed. Food can be introduced at once through the tube. The tube may sometimes be removed after a permanent channel has been established, and reinserted only for feeding purposes. The valvular construction of the internal opening effectually prevents the escape of food. Keen and others have reported successful cases by this method.

After the fistula has been well established the stomach-feeding is to be

managed in such a manner that the patient masticates all solid food, which is then injected through a rubber tube, or, if the opening and tube are large enough, it is poured in through a funnel. The act of mastication satisfies at least in part the sensation of hunger, which is not always the case if stomach-feeding is exclusively relied on. Gross and Zesas have collected respectively 207 and 162 cases, with surprisingly different rates of mortality; that of Gross being only 29.47 per cent., while Zesas' mortality was 60 per cent. for cicatricial stenosis and 84 per cent. for malignant cases. The operation should not be made responsible for this bad showing, however, because we have reason to believe that in most cases the disease would have proved fatal in a short time without it. These unfortunate results should only remind us not to postpone the operation until the patient has not sufficient recuperative powers left to rally from its immediate effects and to secure satisfactory repair. If gastrostomy is undertaken as a preliminary step in the treatment of impermeable cicatricial strictures of the cardiac orifice or of the lower portion of the œsophagus, the fistula is closed as soon as the patency of the normal channel has been restored by rapid or gradual dilatation.

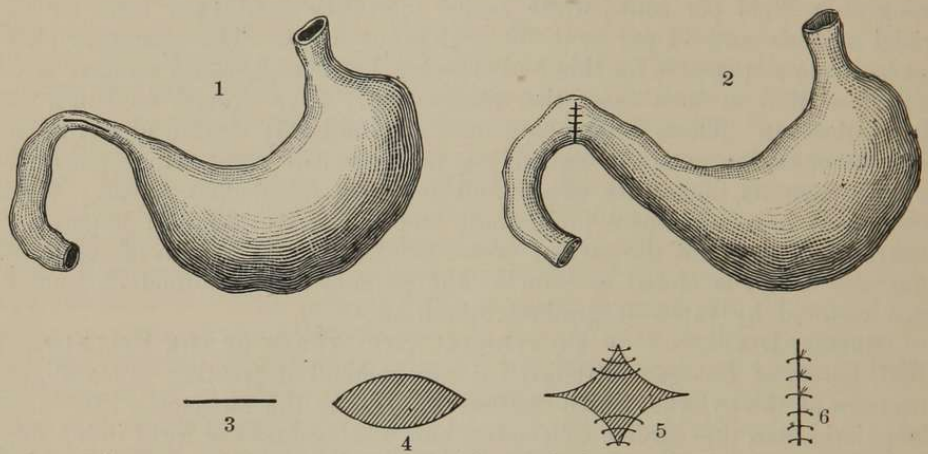
Digital Divulsion of Cicatricial Strictures of the Pylorus.—In 1883, Loreta of Bologna introduced a new method of treating non-malignant strictures of the pylorus, which consists in opening the stomach a little nearer the pyloric than the cardiac extremity, and passing first the right index finger through the strictured portion, and later also the left, and then separating them, as he did in the first case, more than three inches. Considerable force is usually required in dilating the stricture to this extent, and during such forcible stretching there is always danger of tearing through the entire thickness of the wall of the pylorus. The wound of the stomach is closed in the same manner as after gastrotomy for other purposes. The stomach should be thoroughly emptied by irrigation with a boric-acid solution before the operation, and during the stretching process the visceral wound should be drawn well into the abdominal incision. Notwithstanding the fact that a number of successful operations of this kind have been reported, it is more dangerous and uncertain in its results than the pyloro-plastic operation of Heineke-Mikulicz (see below). To the immediate risks of Loreta's operation, rupture of the pylorus and hemorrhage, must be added recurrence of the stricture, which is certainly one of the most common remote consequences following the treatment of cicatricial stenosis by rapid or slow dilatation, wherever the stricture may be located. In this particular it can hardly be assumed that stricture of the pylorus constitutes the sole exception. The same distinguished surgeon resorted to instrumental divulsion of cicatricial stenosis of the cardiac orifice through an incision of the stomach, and the two cases which he treated by this method were reported as cured. The dilatation was made with an instrument resembling that of Dupuytren for lithotomy.

Forcible dilatation of strictures of the cardiac orifice is a far more difficult operation than stretching of the pylorus, but, as from the inaccessibility of this region no plastic operation can be performed, the operation will have a limited field of usefulness in the surgery of this part of the stomach.

Pyloroplasty.—The operation for cicatricial stenosis of the pylorus well deserves the name pyloroplasty, as it not only removes the mechanical obstruction, but at the same time creates a new pylorus. This operation was first devised by Heineke of Erlangen, and eleven months later Mikulicz, ignorant of Heineke's work, did the operation in exactly the same manner. The operation is done by cutting through the anterior wall of the pylorus and extending the incision about an inch toward the stomach and the same

distance in the direction of the duodenum, as is shown in Fig. 275. This incision divides the stricture, and the contracted pylorus becomes the posterior wall of the new pylorus by retracting the margins of the wound on each side at the center with a tenaculum and suturing the wound trans-

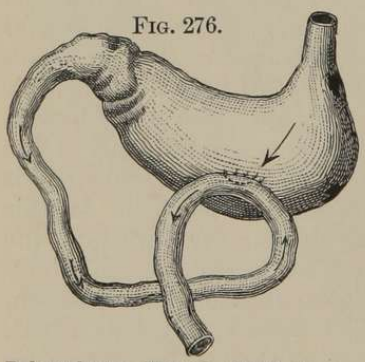
FIG. 275.



Pyloroplasty (Heineke and Mikulicz): 1, linear incision: 2, the final result. The lower series of figures show (3) the transformation of the horizontal linear incision into the oval (4), the sutures (5) converting it finally into (6) a vertical linear incision (Esmarch and Kowalzig).

versely to the long axis of the stomach, as represented in Fig. 275. The new pylorus is made up of tissue taken partly from the duodenum, the posterior wall being composed of the narrow, contracted pylorus. In suturing the wound it is advisable to tie first from each angle of the wound, tying the central sutures last (Fig. 275). Two rows of sutures are employed, the same as in closing a wound of the stomach. Recurrence of the stricture is a physical impossibility, as the new pylorus is composed mostly of healthy tissue, and the danger attending the operation is not greater than that which accompanies an ordinary wound of the stomach. The results of this operation, obtained in eight cases which have so far been reported, have been very satisfactory, and it is almost certain that it will take the place of all other operations in the surgical treatment of cicatricial pyloric stenosis.

FIG. 276.



Pyloroplasty: Wound closed in a transverse direction.

GASTRO-ENTEROSTOMY.—This operation is intended to establish an anastomotic opening between the stomach and upper portion of the small intestine in cases of malignant stenosis of the pylorus. It was devised and first practised by Wölfler. He made an incision about three inches in length in the anterior wall of the stomach at a safe distance from the carcinoma and near the great curvature, and a similar incision in the convex side of the intestines about thirty inches below the plica duodeno-jejunalis, and united these two visceral wounds with sutures, thus establishing a direct communication between the stomach and the small intestine. In uniting the posterior margins of the wounds the serous or superficial sutures should be first inserted and tied, and then the inner or second row of sutures are tied and cut short to the

knot. Silk should be used exclusively as suturing material. It is advisable to insert and to tie securely the posterior row of Lembert's sutures before the visceral incisions are made. In Wölfler's operation the movements of the intestine at the point of puncture are in a direction opposite to the peristaltic action of the stomach, a condition which must be unfavorable to the easy escape of the stomach contents into the intestinal canal—a circumstance which led Rockwitz so to modify the operation that he turns the intestinal loop one-half around its axis and unites it with the stomach in this position, and thus brings the two organs in such a relative position that the peristaltic wave of both is in the same direction. Von Hacker has modified the operation still further, and establishes the communicating opening in the posterior instead of the anterior wall of the stomach. The portion of intestine which should be united with the stomach is that which lies from twenty-four to thirty inches below the pylorus. Operators have experienced a great deal of difficulty in finding this place without too great loss of time and unnecessary handling of the intestines. Luecke advises to seize and unite with the stomach the first intestinal loop that presents itself in the wound, and gives it as his opinion and the result of his experience that in doing so the anastomotic opening will invariably be made near the desirable point not distant from the duodenum. This advice has led to serious mistakes. In one case in which this direction was followed, the post-mortem revealed that the opening had been made eight feet below the pylorus, and in one of Lauenstein's cases the opening was found near the ileo-cæcal region, consequently nearly the entire length of the small intestine had been excluded from participation in the processes of digestion and absorption.

In searching for the upper portion of the small intestine it is not always easy to find the plica duodeno-jejunalis. The following plan of search may be recommended. The first loop that presents itself is brought forward into the wound, and is held in this position by an assistant, while the surgeon follows the intestine in one direction, observing carefully its color and the thickness of its walls as loop after loop is examined. If the intestine leads in an upward direction, the color becomes paler and the walls thicker, and the duodenum will soon be reached. If he is tracing the bowel in an opposite direction, the intestine becomes gradually smaller, its walls thinner, and the color is more of a bright red. Should this be the case, the loops of the intestines are returned, and the examination is made from the loop held by the assistant in an opposite direction, which will soon lead to the part that it is intended to unite with the stomach. As soon as the desirable loop is reached, it should be turned around, and held in this position by an assistant until the anastomosis has been completed (Fig. 276). Of 21 gastro-enterostomies collected by Rockwitz made for malignant and cicatricial stenosis of the pylorus the immediate mortality is represented by 57.2 per cent. This great mortality is due to the debilitated condition of the patients operated on and to the great length of time required in uniting the visceral wounds. Unnecessary loss of time is a great source of danger in the class of cases in which it becomes necessary to make a gastro-enterostomy.

Senn has modified Wölfler's operation by securing apposition between the stomach and the intestine by means of perforated decalcified bone plates, which he asserts greatly shortens the operation and brings the parts into a more favorable condition for speedy union. This procedure and its modifications are fully described in the chapter on Intestinal Obstruction. The approximation plates are reinforced by a number of superficial sutures in the same manner as in establishing an intestinal anastomosis. The serous sur-

faces interposed between the plates must be scarified. As the mucous membrane of the stomach shows a great tendency to turn out, it should be fastened in the middle of the wound on each side with a fine catgut suture before the viscera are approximated. A gastro-enterostomy with the aid of approximation plates can be completed in half an hour.

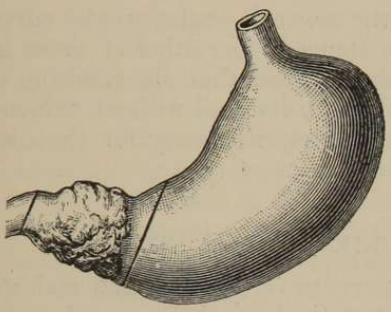
Patients with carcinoma of the pylorus who survive a gastro-enterostomy are relieved of much suffering and live in comparative comfort for from three months to a year. The operation proves most beneficial in circular carcinoma of the pylorus with great distention of the stomach. It is contraindicated if the disease has become diffuse and the organ is not much dilated. The operation is also not applicable if the general strength of the patient is so much reduced that death is likely to result from the immediate effects of the procedure, or if the disease has extended to other important organs and death would ensue in a short time from this cause. In well-selected cases gastro-enterostomy is a legitimate operation which is destined to relieve suffering, prolong life, and reflect credit on the achievements of modern surgery.

Pylorectomy.—Excision of the diseased pylorus is called pylorectomy. This operation, first done on animals, was suggested by Winiwarter and Gussenbauer as a remedy for carcinoma of the pyloric end of the stomach, but the first operation on the human subject was done by Billroth. According to Bramer, who collected 72 cases of pylorectomy for carcinoma, the mortality is about 76 per cent. Winslow in a smaller number of cases gives about the same mortality. Of those that survived the immediate effects of the operation, all but one died in a period varying from four to eighteen months. Gastro-enterostomy can show a much lower mortality and a prolongation of life of the survivors of from two months to a year and more. Pylorectomy should be limited to cases of circumscribed annular carcinoma of the pylorus in which the disease has not extended beyond the wall of the viscus. Adhesions of the pylorus to other organs and the presence of infected lymphatic glands are absolute contraindications. As a positive diagnosis of carcinoma of the pylorus cannot usually be made sufficiently early to justify this operation, the surgeon will generally find, after he has opened the abdomen and ascertained by direct inspection and palpation the extent of the disease, that he is forced to abandon the original intention, and will complete the operation by making a gastro-enterostomy. In the absence of regional metastasis and extension of the disease by contiguity to adjacent organs, a radical operation is indicated, provided the patient's strength is sufficient to warrant its performance. It is to be hoped that future research will enable physicians to make a sufficiently early diagnosis to bring all cases of pyloric carcinoma within the reach of successful radical surgical treatment.

Preparatory to the operation the stomach should be placed in a condition of absolute physiological rest for at least two days, during which time it should be washed out daily through an elastic siphon tube with a weak antiseptic solution, such as salicylated water or a solution of boric acid, and for the last time this should be done immediately before the anesthetic is given. If no contraindications are present, chloroform should be given in preference to ether, as it is less liable to be followed by retching and vomiting. In opening the abdomen Billroth prefers a transverse incision made over the middle of the tumor, if such is present, and sufficiently long to secure ready access to the seat of operation. Bleeding must be carefully arrested before the peritoneal cavity is opened. The pylorus is now brought well forward into the wound with vol-sellum forceps, and the peritoneal cavity is protected against infection during the operation by packing aseptic or iodoform gauze around the parts to be

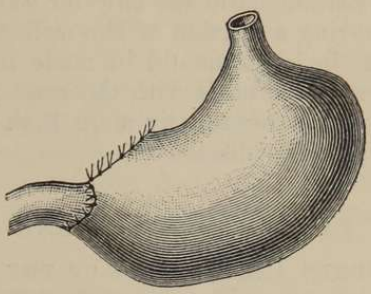
excised. The omentum below the pylorus is tied in small sections and divided between two silk ligatures. The other connections are dealt with in a similar manner. As soon as the pylorus is isolated it can be drawn farther forward into the wound, and a small compress of gauze or a sponge is placed underneath it; in either case the precaution should be taken to attach a forceps to guard against losing the compress or sponge in the abdominal cavity. If the stomach has been washed out thoroughly, there is no danger of peritonitis from extravasation, as the small quantity of fluid which it contains can be removed with a sponge as it escapes when the organ is incised, or it is taken up by the underlying gauze. The incision through the duodenum and stomach should be made at least an inch from the border of the tumor (Fig. 277). As the

FIG. 277.



Oblique Division of the Stomach and Duodenum in Pylorectomy (Esmarch and Kowalzig).

FIG. 278.



Duodenum united to the Greater Curvature: upper portion of incision through the stomach sutured before the section was completed (Esmarch and Kowalzig).

incision through the stomach will be much larger than that through the duodenum, Billroth commences at the upper border, and follows the knife by suturing until the remaining length of the incision will correspond with the section through the duodenum, when the section is completed, the duodenum divided, and the part removed. The duodenum should always be attached to the larger curvature of the stomach, as shown in Fig. 278.

In uniting the duodenum with the stomach fine aseptic silk sutures are inserted by a round needle in a holder, first at the cut edge of the stomach between the mucous and muscular coats, so as to include the muscular coat and the peritoneum; then inversely through the same layers of the duodenum; and finally brought out between these layers and the mucous membrane at the cut edge of the duodenum. After tying the posterior sutures the anterior portion of the wound is closed in the usual manner. In bringing the cut surfaces together, care must be taken to avoid the formation of folds. Billroth warns not to attach the duodenum to the lesser curvature of the stomach, as the location of the new pylorus in that locality is unfavorably situated for the free escape of the contents of the stomach into the duodenum. Any weak points in the line of suturing should be reinforced by superficial sutures. In some cases Billroth sutured the incision in the stomach completely, and implanted the duodenum into a slit in the anterior wall of the stomach near the greater curvature. In some instances it may be found advantageous to close both incisions and follow the pylorectomy by a gastro-enterostomy, a method of operating which has recently been brought prominently to the attention of the medical profession by Bull of New York and Tuholske of St. Louis, the first of whom reports two successful cases. The abdominal incision must be carefully closed by several rows of buried sutures and by superficial sutures, and tension relieved by at least two button sutures. The after-treatment, as

in all other operations on the stomach, consists in withholding food by the stomach for several days, relying during this time exclusively on rectal feeding and, if need be, on the hypodermatic administration of stimulants. After two or three days small quantities of liquid food frequently repeated are allowed, but solid food must be strictly excluded from the diet until the visceral wound is completely healed. Should flatulency occur, it is relieved by a turpentine enema.

Gastrectomy.—Gastrectomy literally signifies excision of the entire stomach, but as the term is used in surgery it means the removal of only a part of this organ. In pylorectomy a partial gastrectomy is always made, but if a portion of the stomach is removed without excision of the pylorus the operation is to be designated as a gastrectomy. In the surgery of the stomach this operation may come into use in the excision of an ulcer or the removal of a limited carcinoma in the anterior wall of the stomach or the greater curvature. In removing a portion of the wall of the stomach for either of these indications the incisions should be made in such a manner that the resulting wound can be safely sutured with the least possible tension and without reducing the lumen of the organ any more than is absolutely necessary for the complete removal of the disease.

PART III.—DISEASES AND INJURIES OF THE INTESTINES.

Wounds and Rupture of the Intestines.—Gunshot and stab wounds of the intestines have been described in a previous chapter, and it is only necessary here to refer very briefly to the subject of contused and lacerated wounds caused by external violence, but not attended by a perforating wound of the abdomen. Contused and lacerated wounds of the intestine result usually from a kick or blow or from the passage of a carriage-wheel over the abdomen.

In a **contusion** of the intestine all the coats may be injured without fecal extravasation taking place. Such an injury is followed by more or less inflammation of the injured part and circumscribed peritonitis. If the injury is not extensive, adhesion to an adjacent serous surface takes place, and the patient recovers. If, however, the inflammation is severe, gangrene, perforative peritonitis, and death are almost sure to follow. **Rupture** of the intestine varies in extent from a few lines to complete division of the bowel. The size of the wound in partial rupture and of the lumen of the intestine in complete laceration is diminished by bulging of the mucous membrane. As in cases of stab and gunshot wounds of the intestines, contusion and laceration of the intestines are injuries which are seldom diagnosticated before the abdomen is opened or before the diseases to which they give rise make their appearance. In rupture of the intestine extravasation and hemorrhage often cause symptoms resembling shock, but these are not invariably present and are by no means pathognomonic. It is possible that in the future the hydrogen-gas test will yield valuable diagnostic information in the differentiation between contused and lacerated wounds. If there be an opening in the intestine, the gas will escape through it and produce a well-marked free tympanites. The probable diagnosis must rest on the manner in which the injury was inflicted, the degree of force applied, and a careful study of the local and general symptoms.

Treatment.—Patients who have received an injury of the abdomen should be kept in bed on an absolute diet for several days if the symptoms are such as to make a rupture of the intestine improbable. Under this treatment a contusion of the intestine will be followed by recovery, as a rule. If the symptoms point to the probability of a rupture of the intestine, immediate

laparotomy should be performed, as by following this course the chances for a favorable result are much better than if the operation is postponed until symptoms of peritonitis set in.

The external incision should be made through the linea alba. If intraperitoneal hemorrhage has taken place, this demands the first attention. If the laceration is not readily found, rectal insufflation of hydrogen gas or filtered air will point out and locate the visceral injury at once. Immediate enterorrhaphy deserves the preference over the formation of an artificial anus, as it is not attended by any greater immediate risk to life and does away with the remote dangers incident to a secondary operation. Lacerated wounds of the intestine are closed in the same manner as incised wounds, only that perhaps the margins of the wound should be more inverted, in order to secure apposition between healthy serous surfaces. If the lacerated wound presents contused margins, it may become necessary to cover the contused area with an omental graft in order more effectually to guard against the occurrence of subsequent perforation. If the mesentery is torn it also must be sutured. As some extravasation always takes place in lacerated wounds of the intestines, it is necessary to flush the abdominal cavity with warm sterilized water before the external wound is closed, and to make ample provision for drainage. The after-treatment consists in stimulation to counteract shock and in securing rest for the injured intestine by withholding food by the stomach for several days and by the administration of opiates.

INTESTINAL OBSTRUCTION.

DEFINITION AND CLASSIFICATION.—Intestinal obstruction, occlusion, strangulation, and ileus have been used as synonymous terms. Some authors wish to draw a line of distinction between cases of intestinal obstruction and intestinal strangulation upon an etiological basis, including under the former term all instances where the obstruction is caused by a tumor, enterolith, or intussusception, while internal hernia, volvulus, and constriction by a band are included under the head of strangulation. For practical purposes such a distinction is superfluous, as any cause which mechanically interferes with the passage of intestinal contents produces the symptoms characteristic of intestinal obstruction, and if it cannot be removed by ordinary means should be treated by abdominal section. The classification into true and false obstruction, from a surgical standpoint, should also be abandoned, as operative interference is indicated only in cases of obstruction due to the presence of mechanical obstacles, such as foreign bodies, tumors, intussusception, or to compression of the lumen by tumors, flexion, twisting, and bands of constriction. Inflammation of the tunics of the bowel and diffuse peritonitis may give rise to symptoms resembling those of obstruction, and the indications for treatment are to combat the inflammation and to restore peristaltic action, combined with mechanical means to relieve the abdominal distention.

A more important classification remains to be mentioned, in which all cases of true intestinal obstruction are divided into *acute* and *chronic*. This distinction must be maintained for many reasons. In chronic obstruction the symptoms usually develop very slowly as the occlusion becomes more complete. During the early part of the affection the intestinal wall above the seat of obstruction undergoes compensatory hypertrophy, dilatation taking place very slowly unless the chronic suddenly merges into the acute form—an event which is always announced by a complexus of symptoms characteristic of acute or subacute obstruction. Chronic obstruction is more frequently met with in persons advanced in years, and the seat of the obstruction is usually located

in some part of the large intestine. The acute form is caused by pathological conditions which suddenly narrow or obliterate the lumen of some portion of the intestine, usually above the ileo-cæcal valve, and often, without any premonitory symptoms, give rise to a group of acute symptoms almost pathognomonic of this affection. The sudden arrest of the fecal circulation is followed by violent peristaltic action of the bowel above the seat of obstruction in a vain attempt to clear the intestinal tract, which, from muscular exhaustion and the increased pressure from within due to the accumulation of intestinal contents, finally gives rise to paresis and the textural changes which accompany great congestion in relaxed and exhausted tissues. In the treatment of such acute cases prompt action constitutes an essential element of success, as in a few hours or days the patient becomes utterly prostrated, and the bowel at and above the seat of obstruction will have undergone irreparable pathological changes.

Surgical Resources in the Treatment of Intestinal Obstruction.

Evacuation and Irrigation or Lavage of the Stomach.—Accumulation of intestinal contents above the seat of obstruction acts deleteriously in several ways: 1. It causes violent peristaltic action of the intestine above the seat of obstruction; 2. It exhausts the patient's strength by causing persistent retching and vomiting; 3. It is one of the causes which produce distention of the intestine above the obstruction; 4. It favors fermentative and putrefactive changes in the intestinal contents.

Kussmaul has introduced a new and exceedingly valuable measure in the treatment of intestinal obstruction by the use of the soft-rubber stomach-tube. By the siphon action of the tube, gas and the fluid contents of the stomach and upper portion of the intestinal canal are evacuated, and thus abdominal distention is relieved and the hydrostatic pressure in the intestine above the obstruction diminished. In inserting the tube into the stomach the patient should be asked to make swallowing movements, which will convey the tube along the œsophagus without causing much gagging, which often prevents the forcible introduction of the tube. After the stomach has been evacuated it should be washed out with a weak solution of salicylic or boric acid, a procedure which cannot fail to diminish the fermentative and putrefactive processes in the retained intestinal contents.

Distention of the Colon with Fluids.—For evacuation of the colon copious rectal injections are resorted to almost instinctively in every case of intestinal obstruction. This procedure has also been employed quite extensively with the intention of utilizing the hydrostatic pressure as a means for the correction of the mechanical difficulties which have given rise to the obstruction. For the former purpose they should never be omitted; for the latter indication they should never be used, as fluids cannot usually be forced beyond the ileo-cæcal valve, and in the treatment of mechanical obstruction below this point it is far inferior to insufflation of air or gas.

Rectal Insufflation of Hydrogen Gas or Filtered Air.—This procedure has been fully described in the chapter on Wounds of the Abdomen (p. 689). Its employment in the diagnosis and treatment of some forms of intestinal obstruction is valuable. The inflation is made in the same manner as in the diagnosis of intestinal wounds. By its use the seat of obstruction below the ileo-cæcal valve can be located with accuracy, and above this point at least approximately. The inflation will distend the bowel below the obstruction, and the air or gas will not pass beyond it. It is an extremely use-

ful resource in the treatment of invagination, and in describing this form of intestinal obstruction it will again be referred to as a therapeutic measure.

Tubage of the Colon.—This surgical resource in the treatment of intestinal obstruction has been greatly abused ever since it was first introduced by O'Bierne. The idea has been entertained that an elastic tube could be inserted the whole length of the colon, but such a statement was never made by O'Bierne, as he insisted that the tube could not be passed beyond the sigmoid flexure. Experiments on the cadaver have shown conclusively that when the tube is introduced to a depth of twenty to thirty inches the tip of the instrument remains in contact with the intestinal wall, and that this portion of the bowel is pushed forward when the end of the instrument can be felt through the abdominal wall at a higher point. In the administration of a large enema to wash out the colon the long rectal tube is superfluous, as, especially in Hegar's knee-chest position, the fluid from an ordinary fountain syringe and short nozzle will follow the course of the colon and advance as far as the cæcum. The legitimate indications for tubage of the colon are—1. To detect and locate an obstruction below the sigmoid flexure; 2. To relieve gaseous distention of the colon; 3. To administer high nutrient enemata in cases where it becomes necessary to maintain the strength of the patient by this method of alimentation.

Manual Exploration by the Rectum.—The introduction of the whole hand into the rectum as a means of diagnosis was devised and first practised by Simon. He and his many followers maintain that the hand can be introduced sufficiently far to enable the surgeon to palpate most of the abdominal organs. Nussbaum assures us that he has felt more than once the tip of the sternum with the hand employed in the manual exploration by the rectum. This method of examination should be employed only when the patient is an adult, and should be done only by surgeons with small slender hands (seven inches or less in circumference), as rupture of the rectum and permanent incontinence of the sphincter are some of the incidents which have been reported as having been produced by this method of exploring the rectum. As a therapeutic measure this procedure can be employed in the removal of foreign bodies or an enterolith within reach of the hand, and in the reduction of an invagination if the intussusceptum has passed beyond the sigmoid flexure.

Taxis and Massage.—Abdominal taxis, so much lauded by Mr. Hutchinson as a means of treating intestinal obstruction, is not only unscientific and useless for this purpose, but is attended by great risk to life. Taxis and massage, scientifically practised, have a limited range of application in the treatment of intestinal obstruction, but they are applicable only to cases where the obstruction is due to the presence of a foreign body, a fecal accumulation, or an enterolith, and should only be resorted to before these causes have developed inflammatory changes at the seat of impaction.

Uniform and Uninterrupted Compression of the Abdomen.—In all cases of intestinal obstruction, but more particularly in the chronic form, uniform support of the abdomen affords relief to the patient, and is one of the best means of preventing rapid distention of the intestine above the seat of obstruction. Fixation and equable compression are resorted to in other parts of the body as the best known means of controlling muscular spasms. Uniform compression of the abdomen is best secured by padding the iliac regions with absorbent cotton and then enveloping the body from the pubes to the tip of the sternum with broad strips of adhesive plaster, which should be made to overlap one another.

Puncture of the Intestine.—Advanced cases of intestinal obstruction

are always attended by great distention of the bowel above the obstruction, a condition which causes increased intra-abdominal pressure. The distention may be so great as to destroy life by the suspension of important functions from mechanical pressure. It also aggravates the mechanical difficulties which interfere with the passage of intestinal contents, as the distended bowel under such circumstances forms numerous flexions which constitute additional obstructions. If life is threatened by the distention, and *more efficient surgical aid, for any reason, cannot be rendered*, puncture of the intestine may prove beneficial. Puncture of a distended paretic intestine is always attended by some risk of extravasation, and on this account the needle puncture should be made obliquely through the wall of the intestine, in order to reduce this source of danger to a minimum. The best instrument for this purpose is one of the smaller needles of an aspirator. Care should be taken to render the needle aseptic before it is used. The puncture should be made at the most prominent point, and the instrument pushed boldly forward in an oblique direction until resistance ceases.

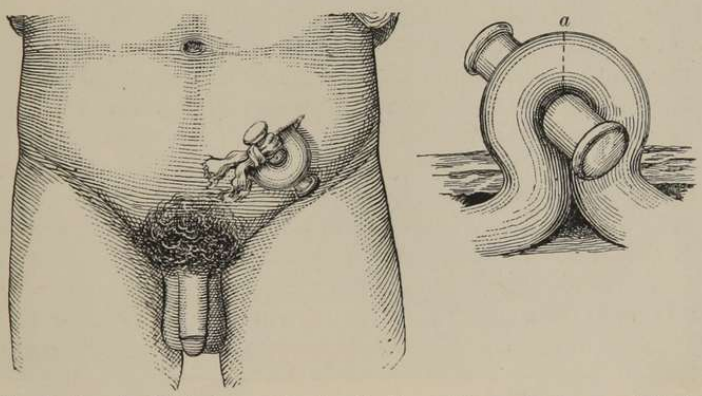
Enterostomy.—The formation of a fecal fistula above the ileo-cæcal valve by operation should be called enterostomy, and not enterotomy. This operation was done by Nélaton for the first time in 1840. The mortality of the operation has been nearly as great as that of laparotomy with removal of the cause of obstruction, and on this score alone its further application should be limited to exceptional cases where a radical operation is inadmissible on account of the nature of the obstruction or the enfeebled condition of the patient. The operation, which can be made without anesthesia, is performed by making an incision not more than two and a half inches in length in the right iliac region, above and parallel to the outer half of Poupart's ligament, and all hemorrhage should be arrested before the peritoneal cavity is opened. The parietal peritoneum is now sutured to the skin. Almost without exception a distended knuckle of intestine, readily recognized by its size and color, presents itself in the wound, and is drawn forward sufficiently for a surface the size of a quarter of a dollar to be united with the margins of the wound with fine silk sutures closely placed. An incision large enough to admit the tip of the index finger is now made in the center of the united part transversely to the long axis of the bowel, and after the escape of intestinal contents and disinfection of the surface of the wound the margins of the visceral wound are separately stitched to the skin by a single suture on each side, in order to secure patency of the opening. On incising the bowel the surgeon is often disappointed at the small amount of gas and fluid which escapes, and it is frequently several hours before a free escape takes place and the abdominal distention begins to diminish. In exceptional cases an enterostomy is followed by a permanent cure by the spontaneous correction of the mechanical difficulties which caused the obstruction; in other cases a radical operation is to be done later; while in a third class the fistula is allowed to remain permanently in case the cause of the obstruction cannot be removed.

Colostomy.—The term *colotomy* has been used to designate the operation of forming a fistulous opening in any part of the colon. But this word, literally, only means cutting into or incising the colon for the purpose of making a temporary opening, as in gastrotomy, enterotomy, etc. Hence the operation of making a more or less permanent fistula in the colon should be known and described as *colostomy*, corresponding to *gastrostomy*, *enterostomy*, etc. This operation will always retain its place in operative surgery as a palliative and life-prolonging procedure in the treatment of carcinomatous stenosis of the lower portion of the colon and in cases of inoperable carcinoma of the rec-

tum. The modern operation of colostomy is made by opening the peritoneal cavity in the right or left iliac region according to the location of the obstruction, and one of its principal objects is to interrupt the fecal circulation *completely* at the artificial anus, so as to procure absolute physiological rest for the portion of bowel below it—a condition not attainable by the lumbar operation. Inguinal colostomy was first practised by Littré. In early times the mortality was even higher than in lumbar colostomy, being from 46 to 53 per cent. This was the consequence of opening the peritoneal cavity without antiseptic precautions. The introduction of antiseptic methods here, as in all other intra-abdominal operations, reduced the mortality to the neighborhood of 5 per cent. König reports 20 cases with only 1 death from peritonitis; Cripps, 26 cases with only 1 death.

A number of operations have been described for making an inguinal colostomy. The one devised by Maydl is done as follows: He makes an incision about four inches in length over the portion of the colon which is to be opened, and in the direction of the fibers of the external oblique muscle, and draws the bowel forward until its mesenteric attachment is on a level with the external incision. Through a slit in the mesocolon close to the gut is inserted a glass rod with a flange at each end, iodoform gauze being wrapped around the ends to prevent displacement (Fig. 279). The rod prevents the return of

FIG. 279.



Maydl's Operation for Inguinal Colostomy, showing the flanged bar, and at one end the iodoform gauze: *a* is the line of the later incision (modified from Esmarch and Kowalzig).

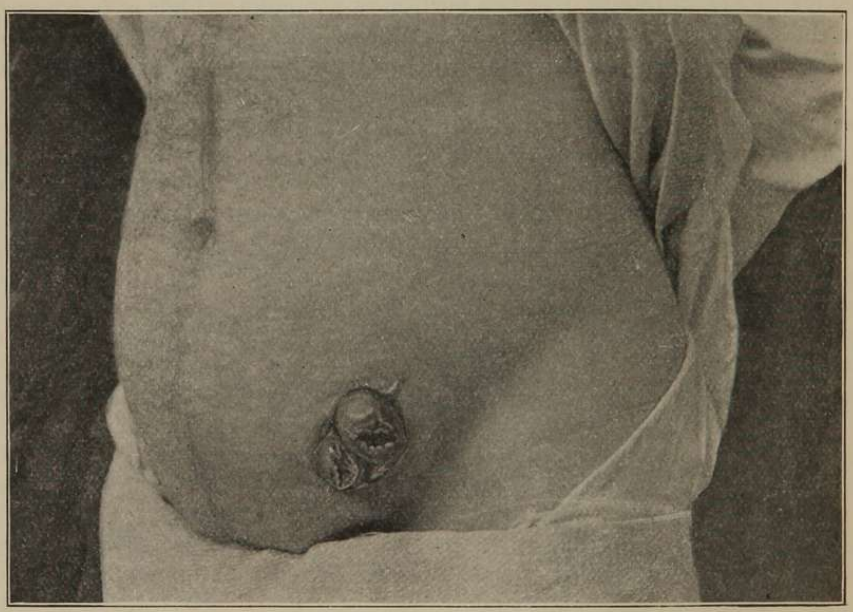
the bowel into the abdominal cavity before adhesions have formed. By means of a row of sutures placed on each side of the prolapsed gut, including the serous and muscular coats, the two limbs of the flexure, so far as they lie in the abdominal wound, are stitched together beneath the support. If the intestine is to be opened immediately, which should be done only when the symptoms are such as to demand prompt relief, it is stitched to the parietal peritoneum of the abdominal incision, and the latter is protected by iodoform collodion. If incision of the bowel can be postponed for a few days until firm adhesions are formed, the intestine is stitched to the peritoneum and surrounded by iodoform-gauze packing around and beneath the support. If the artificial anus is made for lesions incapable of subsequent removal, a transverse opening, including one-third of the periphery of the bowel, is made by the thermo-cautery, drainage-tubes are inserted into the two lumina, and the intestine is carefully washed out.

If it is the intention to establish a *permanent* artificial anus and the progress of the case is satisfactory, the bowel is cut through completely in two

or three weeks, the support serving a useful purpose as a guide in making this incision. A few sutures will serve to secure the cut ends to the skin. If the direction of muscles has been regarded in making the abdominal incision, the patient is provided with so efficient a sphincter that a large drainage-tube is required to keep the opening patulous. Should the artificial anus be only a *temporary* one, the incision in the intestine is made in a longitudinal direction. When it has become desirable to close the artificial opening, the rubber support is removed, after which the bowel retracts, and the opening often closes without any further treatment. If the adhesions are too firm for this, they are removed, the bowel is sutured and returned into the peritoneal cavity, and the external wound is closed.

The modern operation of inguinal colostomy is indicated in cases of congenital atresia of the rectum when the blind end of the bowel cannot be

FIG. 280.



Artificial Anus after the Maydl Operation (from a photograph): the patient has excellent control of the bowels.

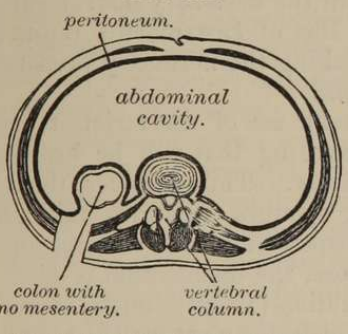
readily reached through the perineum; also in cases of carcinoma of any portion of the colon and rectum not amenable to a radical operation. Finally, the operation might become necessary in irreducible invagination of the colon in which, for anatomical reasons, resection or anastomosis cannot be done.

The operation of lumbar colostomy has by some surgeons been entirely abandoned in favor of the above, on the ground that it is not especially dangerous in these days to open the peritoneal cavity; that the colon is often very hard to find in the loin; and that the kidney in the first procedure may interfere with our manipulations. Many operators, however, still believe that lumbar colostomy possesses a definite field of great usefulness. The peritoneum may generally be avoided, and in cases of malignant disease of the sigmoid flexure or rectum the operation gives about four inches more space between the growth and the artificial anus than could be obtained by the inguinal operation. Lumbar colostomy is usually done on the left side, as obstructions in the colon are generally in the sigmoid flexure or the rectum. The patient is laid upon his right side, a firm pillow being pushed under the opposite loin, and

the lower border and tip of the last rib are marked with an aniline pencil, and a point one-half inch behind the center of the iliac crest. A line drawn from this point vertically upward to the last rib indicates the normal position of the colon. The best incision is Bryant's oblique, modified by him from Amussat's transverse. Begin the incision at the edge of the erector spinæ, just below the border of the last rib, and run it downward and forward toward the anterior superior spine. The first cut goes down to the muscles, the next into the muscles; now by means of cutting or tearing with forceps we reach the lumbar fascia, open it, tear through a mass of fat, and reach the transversalis fascia. A distended bowel will now bulge into the opening, and the operation is easily ended. If the bowel is empty, the transversalis fascia is torn through with forceps; the lower end of the kidney is felt, and the colon, which rests upon it, is recognized. The bowel is drawn into the wound, and, if the case be not urgent, held there by two large hare-lip pins, which are passed through the bowel and rest on the edges of the wound, a pad of iodoform gauze being interposed. The margins of the wound are brought together with silk sutures. About the fourth day the bowel is to be opened by cutting between the pins. In an urgent case, after finding the bowel, it should be drawn up into the wound and some silk stitches inserted to prevent fecal infiltration of the adjacent cellular area. The bowel is then opened. The circumference of the opening in the bowel is stitched to the margin of the wound. The rest of the wound is closed by silk sutures.

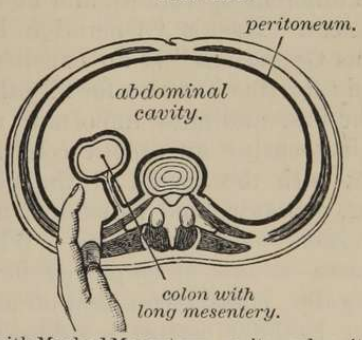
In cases where the mesentery is short or absent, this operation will not open the peritoneal cavity. Fig. 281 shows a case where the colon has no mesentery. Fig. 282 shows a colon with a long mesentery in which a lumbar

FIG. 281.



Colon without Mesentery: peritoneum not opened in lumbar colostomy (Allingham).

FIG. 282.



Colon with Marked Mesentery: peritoneal cavity of necessity opened in lumbar colostomy (Allingham).

colostomy cannot be extra-peritoneal. If the colon cannot be found after careful search, Allingham incises the peritoneum and hooks up the colon with his finger.

ABDOMINAL SECTION, or CŒLIOTOMY.—In making an enterostomy or colostomy the abdominal cavity is opened, but these two palliative operations are not classed under abdominal section in the treatment of intestinal obstruction, as this expression in this connection is reserved for those cases in which the abdominal cavity is freely opened for the purpose of finding and removing the cause of the obstruction. A radical operation in the treatment of intestinal obstruction embraces—1. The detection and removal or rendering harmless the cause of the obstruction; 2. The immediate restoration of the continuity of the intestinal canal.

To meet the first indication the cause of obstruction must be found, its

nature determined, and, whenever advisable or practicable, removed—a step in the operation which may be very easy or may be a most formidable and serious undertaking, more especially in cases where the pathological conditions which have given rise to the obstruction are of such a nature as to constitute in themselves an imminent or remote source of danger, as, for instance, malignant disease or gangrene of the bowel from constriction. Abdominal section in the treatment of intestinal obstruction has so far been attended by a fearful mortality, owing to the fact that most operations were performed at a time when the patients were in collapse or when the parts involved in the obstruction had undergone advanced and often irreparable pathological changes.

Schramm has collected 190 cases of intestinal obstruction treated by laparotomy, and of this number 64.2 per cent. died, the mortality before antiseptics were employed being 73 per cent., and since that time 58 per cent. Curtis has collected the cases of intestinal obstruction treated by abdominal section since the year 1873, consequently since the antiseptic treatment of wounds was introduced; the whole number of cases, 328, show a mortality of 68.9 per cent. A more careful study of these statistics shows the value and importance of early operations, as sometimes delay of only a few hours will bring complications which not only necessitate more time in their removal, but will at the same time necessitate a resection or anastomosis which, had the operation been performed earlier, might have been avoided. Abdominal section in the treatment of intestinal obstruction, both acute and chronic, is one of the most formidable operations in surgery. The surgeon who undertakes it should be perfectly familiar with the anatomy of the abdominal cavity and its contents, and conversant with all the pathological conditions which may give rise to obstruction; at the same time he should have a full knowledge of the technical details of the different operations, and be supplied with the necessary instruments and appliances. Keen's "Operation Blank and List of Instruments required in Various Operations" is an excellent aid in making the necessary preparation, not only for this but also for all other operations.

The first and most important rule is to make use of the strictest precautions in securing an aseptic condition of everything that will be brought in contact with the wound or the peritoneal cavity. This includes the room, patient, operator, and assistants, instruments, sponges, ligatures, table, blankets, towels, wash-basins, etc. Where the cheapest and most efficient antiseptic—heat—cannot be employed for this purpose, the disinfection is done with warm water, potash soap, and an antiseptic solution (1 : 20 solution of carbolic acid or 1 : 2000 corrosive sublimate). The operator must satisfy himself of the aseptic nature of everything which is used inside of the peritoneal cavity. As soon as the abdomen is opened, boiled water is substituted for the antiseptic solutions. To secure the proper temperature, boiling water is cooled by cool preboiled water, not by freshly-drawn cold water.

If the patient is much prostrated, $\frac{1}{30}$ of a grain of strychnine and $\frac{1}{4}$ of a grain of morphia should be given subcutaneously, and four tablespoonfuls of brandy in four ounces of warm water by the rectum, before the anesthetic is given. Irrigation of the stomach should always precede inhalation of the anesthetic. If no contraindications are present, chloroform should be given until the patient is fully under its influence, when the narcosis can be continued with ether.

If the obstruction has been located beforehand, the abdominal incision should be made as near it as possible: when it is in the cæcum or the ascending colon, it is to be made on the right side; when in the descending colon, on the left side; in all other cases, and in all instances where the seat of the obstruc-

tion cannot be determined beforehand, a median incision is indicated. The first incision should at least be large enough to admit the hand. It may be stated as a rule that the ease of diagnosis increases with the size of the incision, and the danger which attends searching in the dark for the obstruction more than overbalances the slight increase of risk incident to a large incision. It must be borne in mind that in nine out of ten cases the obstruction is located in the lower portion of the abdominal cavity, below the umbilicus, and that in the great majority of these cases it will be found in one or the other of the inguinal regions. If evisceration is not decided upon, the best plan to pursue is to explore first the lower segment of the abdomen, more especially the ileocæcal region, the sigmoid flexure, and the pelvis, and if the obstruction cannot be detected, a systematic search for it must be instituted. Any distended loop of the intestine that may present itself in the wound is an evidence that the obstruction is located lower down. The loop is withdrawn and is held by an assistant while the operator examines in one direction, and if this does not lead to the obstruction, the portion examined is returned, and the bowel is then explored in the opposite direction. As a rule, the intestine is more dilated and congested the nearer the obstruction. If the assistant's hands are too much in the way, the bowel can be fixed in place with a strip of gauze passed through a slit in the mesentery, which can be held by an assistant until the obstruction is found.

If a long median incision is made, the small intestines will escape at once; these should be caught in warm, moist, aseptic compresses, supported in this position by the hands of one or two assistants, and kept warm by pouring on warm boiled water from time to time. The surgeon is now able to examine rapidly and accurately every portion of the intestinal canal with a view of locating the obstruction, with little or no risk of inflicting injury during the examination. The greatest objection that has been urged against this method is the difficulty of replacing the distended intestines; but the proper way to effect this is, instead of making direct compression, to resort to protection of the intestines by covering the whole mass with a warm, moist, aseptic compress, the margins of which are tucked in under the abdominal incision. In this way the bowels are protected against the injurious effects of irregular direct pressure, and are guided back into the abdominal cavity as the wound is closed by tying the sutures, already in place, from above downward. If uniform, diffuse, gentle pressure fails in replacing the intestines, the margins of the abdominal incision should be lifted with blunt hooks and the pelvis raised (Trendelenburg's position)—expedients which render material aid in effecting replacement. Should the obstacles be so great as to frustrate all gentle attempts at reduction, it is better to resort to incision and evacuation of the most distended portion of the prolapsed bowel. In cases where after evisceration it is not possible to find the obstruction by examination of the distended visible portion of the intestine, the contracted empty portion below the obstruction can be brought into sight by rectal insufflation of hydrogen gas or filtered air, and a search made for the obstruction from below upward by examining the bowel as it becomes inflated until the seat of obstruction is reached. This method of examination will also reveal additional obstruction should such exist below the one which has arrested the passage of intestinal contents.

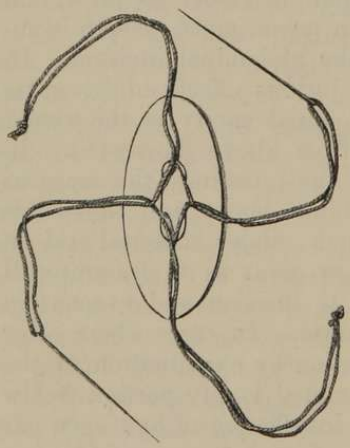
Operative Treatment of the Obstruction.—**Intestinal Anastomosis.**—This operation consists in establishing a communication between the intestine above and that below the obstruction, thereby permanently excluding from the fecal circulation the portion of the bowel which has become impermeable. The idea of making such an anastomosis originated with Maisonneuve, and the

procedure was studied experimentally by Von Hacken. Billroth resorted to it, and Senn modified it by substituting for the sutures perforated decalcified bone plates. Various substitutes have been proposed for the latter. Senn made numerous experiments on animals, and he and others have repeatedly performed the operation on the human subject with results that have proved most satisfactory.

In suturing the two visceral wounds together in establishing an intestinal anastomosis by the old end-to-end method, a great deal of valuable time is lost and only very limited areas of serous surfaces are brought in contact. Lateral anastomosis by absorbable perforated plates can be made in a much shorter time, and large areas of serous surface are interposed between the clamps, and, being held in uninterrupted contact, soon become firmly adherent.

The plates are now made and used in three sizes, according to the age of the patient and the part of the intestinal canal to be operated upon. They are made of decalcified bone, are oval in shape, and the central perforation should correspond in size with the opening that is to be established. The plates are to be kept ready for use fastened between two pieces of glass and immersed in a solution composed of equal parts of water, glycerin, and alcohol. To the margins of the perforation are fastened four double silk sutures; the lateral or fixation sutures are armed with round needles; these strings are fastened to the plate with a lock stitch (Fig. 283). As substitutes for the bone plates, catgut rings and mats have been devised by Abbe, Matas, Davis, and Brokaw. Robinson uses untanned leather as material for the plates, and Stamm has had good results with cartilage-plates made of the scapulæ of calves. Baracz has substituted for the absorbable animal substances plates made of the Swedish turnip, and Dawbarn uses plates made of raw potato. The portions of the intestine between which it is intended to establish a communication should be brought well forward into the wound and surrounded on the sides with aseptic gauze. The incision is made on the convex surface of the bowel opposite the mesenteric attachment and in the direction of its long axis. In length it must correspond with the greatest diameter of the plate. The plate is inserted endwise, and as soon as it is in the lumen of the bowel it is brought into proper position by making traction on the four strings. The serous surfaces corresponding to the size of the plate are freely scarified. In operating for intestinal obstruction the proximal part of the bowel will be found distended, and its contents must be freely emptied through the incision before the plate is inserted. After thorough evacuation and irrigation of the interior of the bowel, further extravasation is prevented by an assistant, who compresses the bowel above the place where the incision is to be made. This can also be done by passing a rubber band or strip of gauze through a slit in the mesentery and tying it over the bowel, or by catching it with a pair of lock forceps at the point of crossing after tightening it. The lateral sutures are now passed through the margins of the wound near the border and equidistant from its angles (Fig. 284).

Fig. 283.

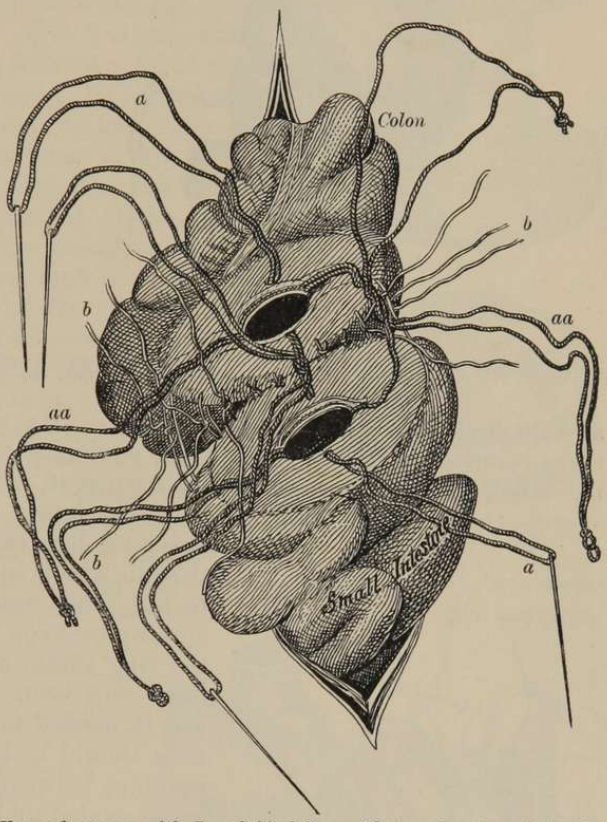


Senn's Decalcified Bone Plate.

Before approximating the parts, the surfaces are well cleansed, and if neces-

sary disinfected. The superficial sutures behind the plates are inserted and tied before the plate-sutures are tied (Fig. 284, *b*). An assistant now holds the intestine in such a manner that the two visceral wounds are brought together when the surgeon approximates the visceral wounds by tying the plate-sutures. In tying the threads attached to the plates the posterior pair of the middle or fixation sutures are tied first, and the threads cut short to the knot. During the tying of all the sutures the plates are to be held in apposition. The tying is done with sufficient firmness to bring the parts in accurate apposition, without endangering the tissues interposed between the plates. After tying the first pair of sutures the end or apposition sutures are tied, and finally the anterior pair of fixation sutures. Care must be exercised to interpose the margins of the visceral wounds accurately between the plates. After this has been done, a few stitches of the continued suture are made at the border of the plates anteriorly, in order to reinforce the plates and bring in apposition a maximum area of serous surfaces (Fig. 285).

FIG. 284.



Ileo-colostomy with Decalcified Bone Plates, showing plates in position, one in the ileum, the other in the colon: *a*, lateral or fixation sutures passed through the margins of the wound; *aa*, end or apposition sutures hanging out of the wound; *b*, posterior or sero-muscular sutures (Senn).

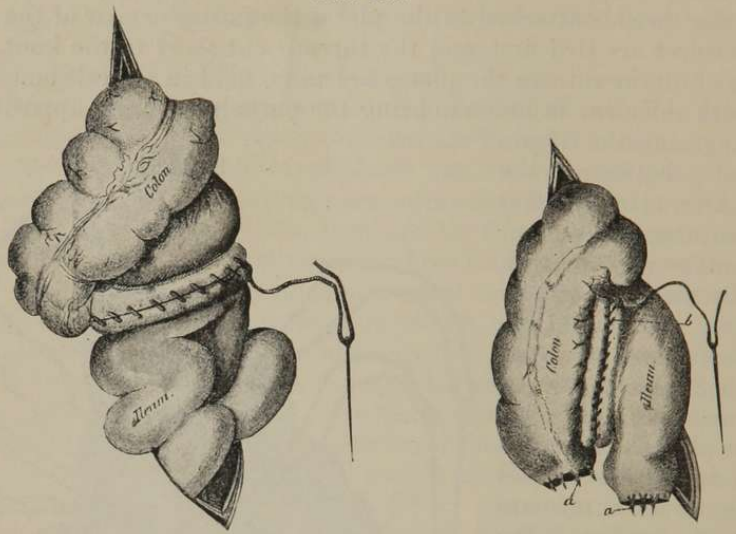
Intestinal anastomosis should take the place of an artificial anus in all cases where the patient's strength warrants the procedure and a radical operation is contraindicated by the general condition of the patient or by the character and extent of the local disease which has caused the obstruction.

Figure 286 shows the use of the catgut rings of Abbe of New York in the performance of intestinal anastomosis. Dr. Abbe's description of their preparation is as follows: "A moderately heavy catgut is chosen, taken from alcohol or juniper oil: it is wound loosely on a test-tube and soaked in hot water. It soon kinks up, and were it not on a tube could hardly be unravelled. After a while it is straightened out, allowed to untwist, wound again loosely, and soaked in hot water once more until it ceases to twist. It is then ready to make up into rings, which will lie perfectly flat. Eight or ten turns over two pins stuck in a cork two inches apart will make a bundle somewhat smaller than a lead-pencil. These may be tied at four places with fine silk, to secure the strands parallel while being wound round like a cable with a continuous piece of the same catgut. The end of the piece is secured by threading into a Hagedorn needle and transfixing the whole bundle obliquely

with it at the place of finishing. Thus there are no knots, and it is difficult to find the point of beginning.

"The ring is now a long oval, with an inside diameter of two inches

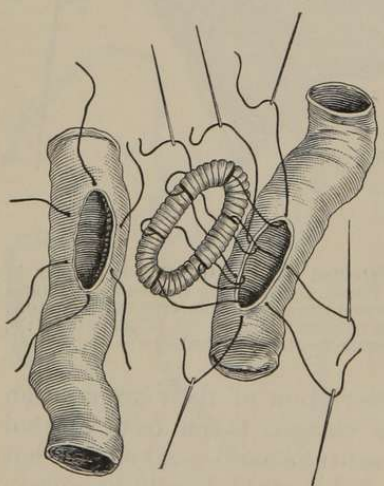
Fig. 285.



Restoration of Continuity of Bowel after resection of carcinomatous cæcum, with the aid of perforated decalcified bone plate (Senn).

and in thickness smaller than a pencil. Six strong but small braided silk threads are now fixed to each ring, equidistant, on the face looking toward the other ring, which is to be laid against it.

Fig. 286.



Method of passing the Silk Sutures in inserting the Rings of Abbe.

"No knots are used. A needle pierces the ring between the strands, carrying the thread, which is drawn through, all but eight inches, and wound once and a half round, sinking between the encircling catgut, piercing the ring again, and cut off. The rings, which have now been water soaked, are ready for use if needed for emergency; but if possible they should be kept a while in alcohol under pressure between two glass slides, the threads being curled up within the oval, and the sides being pressed as the glasses are tightly tied together. The ring thus becomes a long oval with parallel sides, and soon becomes harder and flattened on its faces. Moreover, it shrinks a trifle in alcohol, to swell again in situ and give additional security." Fig. 286 shows the method of passing the silk sutures in inserting the rings.

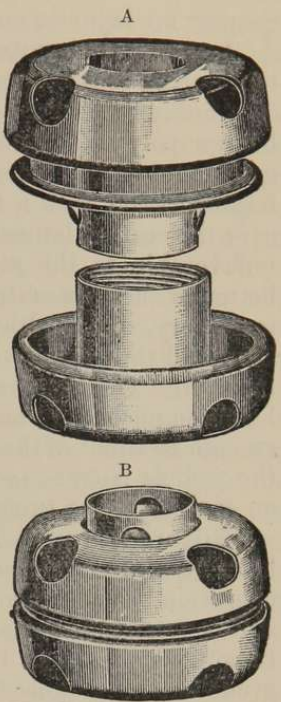
Dr. Abbe threads every piece of silk with its own needle before beginning to operate. Other surgeons prefer a calyx-eyed needle, which is threaded by being pushed down upon the ligature.

The ring of Brokaw is made by covering pieces of catgut with segments of rubber tubing, the anchor ligatures being fastened to the catgut between the rubber segments. This ring has the disadvantage of being apt to twist.

Recently, the Murphy button (Fig. 287) has been used quite extensively

as a means of approximation in anastomosis. While this button has been very successfully used in a large number of cases, its employment is attended with several dangers in that part of the intestinal canal above the ileo-cæcal valve. The orifice of the button may become plugged; the button itself has fallen into the stomach, has been retained in the intestinal canal, and the opening in the latter has been known to contract to a dangerous extent soon after its use.

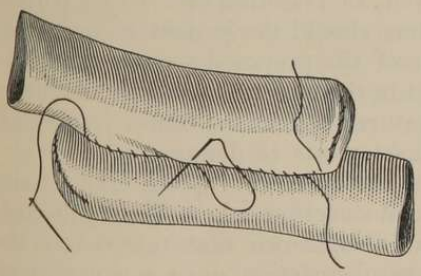
FIG. 287.



Murphy's Button (enlarged): A, open; B, closed.

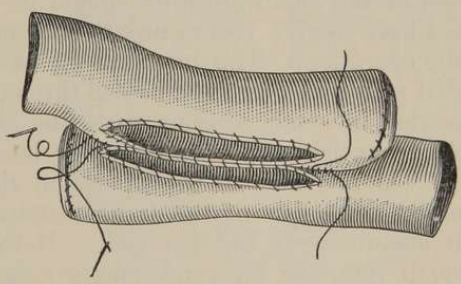
The use of all artificial aids to anastomosis has of late been abandoned by some surgeons, who have returned to the old method of suturing, an operation recently described by Abbe. His method, which has given excellent results, is as follows: After resection and closing the two ends as usual, he lays these ends alongside of each other and applies two rows of continuous Lembert sutures a quarter of an inch apart and an inch longer than the proposed cut (Fig. 288). Each thread (24 inches long) is left at the end of its row, being still threaded. The bowel is then opened for four inches a quarter of an inch from the sutures, both rows being to one side of the cut. The vessels are temporarily caught with hemostatic forceps. The opposite portion of the bowel is then opened in the same manner. The two adjacent cut edges are now united by an overhand suture, the needle piercing both the mucous and the serous cut, and so securing the bleeding vessels (Fig. 289). The forceps are removed as they are reached. The two free cut edges are similarly whipped, after which the serous surfaces on the opposite sides of the opening are approximated and secured by two rows of continuous Lembert sutures, the first two threads serving this purpose.

FIG. 288.



Suturing Intestines in Apposition before Incision (Abbe).

FIG. 289.



Showing the Four-inch Incision and the Sewing of the Edges (Abbe).

It is asserted that this method requires little, if any, longer time than that with plates or rings of any kind, and is free from many of their disadvantages.

Intestinal anastomosis is indicated—

1. In cicatricial stenosis of the intestines.

2. In inoperable carcinoma of the intestine if the disease is located sufficiently high up in the colon to permit the formation of an opening below it.

3. In irreducible volvulus and invagination when the parts affected present no external evidences of gangrene, and resection is impracticable on account of unfavorable general or local conditions.

4. As a substitute for circular enterorrhaphy when the lumina of the resected ends differ greatly in size.

5. In congenital atresia of the intestine.

The use of bone-plates in gastro-enterostomy has been referred to in the chapter on Injuries and Surgical Diseases of the Stomach.

Laparo-enterotomy.—Incision of the bowel for the removal of obstruction during laparotomy is indicated when the obstruction is due to the presence of a foreign body, a concretion, an enterolith, a gall-stone, or a pedunculated benign polypoid tumor. In the removal of a foreign body, a concretion, a gall-stone, or an enterolith not amenable to removal by submural crushing or fragmentation with a needle, the incision for extraction should not be made over the seat of impaction, as this part of the intestine has undergone changes unfavorable to the satisfactory healing of the visceral wound. It is much better in such cases to make the incision opposite to the attachment of the mesentery, in a healthy part of the intestine, an inch or two below the impaction, and then crush the foreign body by instruments introduced through the incision. The removal of a non-malignant pedunculated polypoid tumor is to be accomplished by making an incision on the convex side of the bowel large enough to admit of the dragging of the tumor through it, after which the base of the pedicle is transfixed with a needle armed with a stout ligature which is tied on each side, the tumor cut off, and the wound closed in the usual manner.

Enterectomy.—The indications for excision in injuries of the intestine have been already discussed. In the treatment of intestinal obstruction this operation becomes necessary when the obstruction is due to a malignant tumor if it is possible to remove the disease completely, also for the removal of benign tumors which cannot be excised by enterotomy, and in all cases in which gangrene has been caused by constriction, compression, or over-distention.

In incomplete enterectomy only a portion of the circumference of the bowel is excised. This can be done with safety only on the convex surface of the bowel, as partial enterectomy on the opposite side, by cutting off the blood-supply, might cause gangrene or result subsequently in intestinal obstruction from flexion. In making a complete enterectomy not more than three or four feet of the small intestine should be removed, as resection of a larger portion is likely to give rise to progressive marasmus should the patient recover from the operation. The intestine on each side of the proposed section should be tied with a rubber band passed through a slit in the mesentery. The mesentery is tied in small sections with fine silk ligatures before the bowel is excised. After excision enterorrhaphy or lateral anastomosis is done.

The mortality of this operation thus far has been very great. In a series of 35 resections of the large intestine for obstruction which Weir collected, it amounted to 100 per cent. Reichel has also shown that resection of the small intestine for conditions giving rise to obstruction gave a mortality of 75 per cent., whereas in secondary resection for artificial anus the mortality is reduced to 37 per cent., a statement which is supported by Makins in his report of 13 deaths in 39 resections for artificial anus.

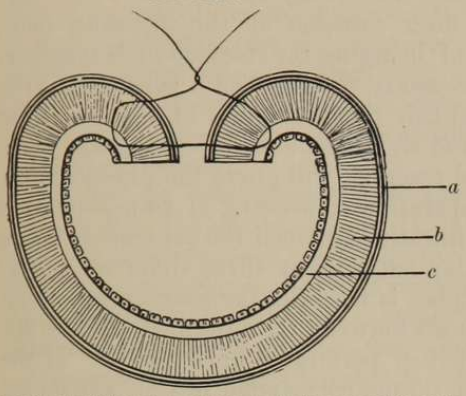
Enterorrhaphy.—The closure of a wound of the intestines with sutures, and also the joining of the ends of the intestine by sutures after resection, is called enterorrhaphy. End-to-end restoration of the continuity of the intestinal canal after resection is termed circular enterorrhaphy.

The appalling mortality after intestinal resection is due principally to the fact that, as a rule, the operation is delayed too long; besides, the immediate effects of so grave an operation are serious and often result in death from shock, while many cases have proved fatal from leakage at the place of sutur-

ing. Suturing of an intestinal wound is a very delicate operation, and every student of surgery should prepare himself carefully by working on the intestines of dead and living animals and the cadaver.

The subject of the suturing of intestinal wounds is one of the most bewildering topics of surgery, as hardly a year passes without the description of some new suture. It will be well, therefore, to limit our study to the two kinds of suture now almost universally employed, the superficial and the deep, or, as usually termed, Lembert's and Czerny's sutures. Lembert was the first to point out that in order to obtain union of an intestinal wound it is absolutely necessary to bring the *serous surfaces* in contact; according to his teachings, it is only necessary to include in the suture the peritoneal coat, but later it was suggested to include enough of the muscular coat to give the suture a safe hold. Halsted has clearly pointed out that it is unsafe to rely on the serous and muscular coats in giving the necessary hold to the sutures, and insists that the needle should penetrate more deeply and catch some of the fibers of the firm submucous coat, which he has so well described. In applying the Lembert suture the edges of the wound are turned in a little, and the folds sewed together with a fine round sewing-needle carrying a fine aseptic silk thread. The stitches are placed at intervals of about one-eighth of an inch (Fig. 290).

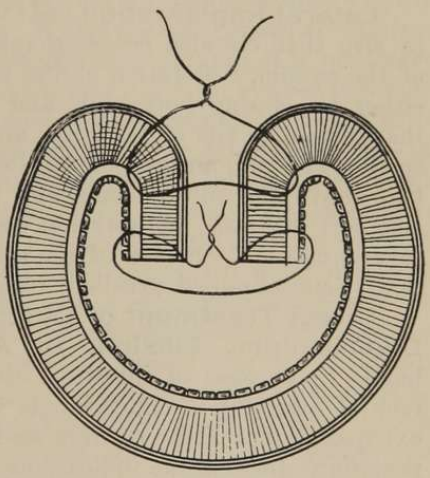
FIG. 290.



Lembert's Suture: *a*, serous coat; *b*, muscular coat; *c*, submucous fibrous layer.

In order not only to approximate these serous surfaces more perfectly, but also to bring together accurately the margins of the mucous membrane, Czerny reinforces the Lembert suture by a row of deep sutures (Fig. 291). These sutures to serve their purpose best should not, as Czerny advised, include all the coats, as it is much better to make this stitch extraperitoneal and cut the threads short to the knot. The deep row of sutures is then buried by the Lembert sutures. In circular enterorrhaphy the double or Czerny-Lembert suture should always be employed.

FIG. 291.



Czerny-Lembert, or Double Intestinal Suture.

If time is an object, the Lembert suture can be applied in the form of the continued suture, but when this element does not enter into consideration the interrupted suture should be invariably employed. In circular enterorrhaphy the greatest difficulty encountered is at the mesenteric attachment, where the bowel for a small space is not covered by peritoneum. It is necessary either to cover this space with peritoneum by stitching the two peritoneal layers of

the mesentery over it with a fine catgut suture, or carefully to adjust the mesentery on each side with the Lembert stitch. The safety of a circular enterorrhaphy is increased by covering the line of suturing with a strip of omentum, which is fastened on the mesenteric side of the bowel with two fine catgut sutures passed through the mesentery. Although completely detached, such omental grafts retain their vitality and become firmly attached to the serous surface of the bowel within from twenty-four to forty-eight hours, thus forming an additional safeguard against subsequent leakage at the seat of suturing.

Conditions may present themselves after excision of the intestine, more especially the colon, which do not admit of bringing the resected ends together. In such circumstances it may become necessary to establish a permanent artificial anus; but if it is possible to establish the continuity of the intestinal canal by lateral anastomosis, this method of treatment should be adopted. It is possible that, in the future, experimental research will prove the practicability of restoring such defects by a plastic operation, consisting of transplantation of a corresponding portion of the small intestine between the separated ends, a procedure which would necessitate circular suturing at three different points. Until it has been shown that some such plan is feasible, the surgeon must content himself with establishing an anastomosis between the proximal and the distal end by lateral apposition with decalcified perforated bone plates. If the two lumina of the intestine after resection do not correspond in size, and do not differ so much as to render circular enterorrhaphy impossible, the section of the smaller end should be made obliquely at the expense of the convex side of the bowel, which will increase the surface to be united. Madelung in resecting the bowel always makes his incisions somewhat obliquely in the same direction, for the purpose of guarding more effectually against gangrene on the convex side of the bowel.

Lateral Implantation.—If the lumina of the resected ends differ so much in size that circular enterorrhaphy is out of the question, as after resection of the cæcum, restoration of the continuity of the intestinal canal is secured either by closing both ends and establishing between the bowel above and that below the site of resection an anastomotic opening, or by implanting the smaller end into an incision on the convex surface of the larger end an inch or two above the sutured end, and fixing the implanted portion in its place by Lembert sutures. Billroth has resorted to this expedient with good success in several cases of excision of the cæcum for malignant disease. In two similar cases Senn obtained excellent results by intestinal anastomosis.

Direct Treatment of Obstruction or Strangulation by a Band or Diverticulum, Flexion, or Adhesion of Intestines.—Ligamentous bands as a cause of intestinal obstruction usually indicate an antecedent attack of peritonitis. Such bands when found are either divided or, preferably, extirpated, and if the strangulated loop has not suffered gangrene, this simple procedure answers the indications for which the abdominal section was undertaken. If the constricting band is a diverticulum, this appendage should not be divided, but extirpated, and the opening in the intestine carefully sutured. If an adherent long appendix is the cause of the obstruction, it is dealt with in the same way. If flexion of the bowel has produced the obstruction, the flexed part, which is almost without exception adherent, should be separated, and the flexion corrected by straightening the bowel or by excising the apex of the flexion by a V-shaped excision and closing the resulting wound with sutures in the usual manner. When intra-abdominal hemorrhage is followed by a complexus of symptoms indicative of the presence of intestinal obstruction, the abdomen should be opened and the coagulated blood removed by

sponging and flushing the peritoneal cavity with sterilized water, and the recurrence of the same condition prevented by arresting further hemorrhage. If a mass of intestinal coils has become firmly adherent and has caused the obstruction, it is often impossible to unravel them, and in such cases the whole mass is excised, as was done successfully by Baum and Koeberlé, followed by circular enterorrhaphy, or if this cannot be done an anastomosis is established between the portions of the intestines above and below the seat of obstruction.

Von Hacker has recently advised, in cases of intestinal obstruction caused by conditions which do not admit of resection, to exclude the affected part of the bowel from the fecal circulation by dividing the bowel above and below the obstruction, closing both ends by suturing, and restoring the continuity of the bowel by circular enterorrhaphy or lateral anastomosis. The secretions of the excluded part of the bowel do not appear to have caused an element of danger.

Toilet of the Peritoneal Cavity.—If everything that has come in contact with the abdominal cavity during a laparotomy for intestinal obstruction has been rendered aseptic by the most absolute antiseptic precautions, and the local conditions found have caused no infection, and no soiling of the peritoneal cavity with intestinal contents has taken place during the operation, the abdominal cavity is aseptic, and can be safely closed after the removal by gentle sponging of any blood that may have collected. If, however, infection from any source has occurred, the peritoneal cavity should be flushed with sterilized warm water, and the cavity dried with sponges wrung out of a 1:5000 solution of corrosive sublimate. In such cases drainage is a necessity. A large glass drain inserted into the bottom of the pelvis and loosely filled with strips of iodoform gauze best answers the purpose. An aseptic napkin or a small compress of gauze should protect the intestines during the time required for the introduction of the sutures. The omentum should be drawn downward sufficiently to cover the whole incision. When the sutures are all in place they are tied from above downward. If tension is considerable, it is necessary to add two or more button sutures, which are passed down to, but not through, the peritoneum, and are to be removed as soon as the tympanites disappears.

After-treatment.—Food by the stomach is not to be allowed for at least two days. Thirst is quenched by small fragments of ice, and stimulants and liquid food are administered during this time by the rectum. Hypodermatic injections of camphorated oil and strychnine are exceedingly useful in counteracting the immediate effects of the operation. The abdominal walls should be well supported with strips of adhesive plaster and a bandage applied over the dressing. Greig Smith states distinctly that "no case of operation for intestinal obstruction is properly concluded until the distended bowels are relieved of their contents." One of the most favorable symptoms after a successful operation for intestinal obstruction is a spontaneous action of the bowels, as it not only proves that the cause of the obstruction has been removed, but is also an evidence that peristaltic action has been restored. The retention of fecal material in the distended paretic intestines after operations of this kind not only retards recovery, but is in itself a grave source of danger. Mr. Tait has taught us the value of saline cathartics in the prevention of peritonitis after abdominal operations. It appears reasonable that the same treatment would be useful in the management of cases after operations for intestinal obstruction. Examination of the intestine above the seat of obstruction will satisfy the surgeon that it will respond slowly but surely to mechanical irritation, and it is only logical to conclude that the same effect would be produced by the administration of a brisk saline cathartic. Its use, however, should be delayed until after

the intestinal wound is well united—till the third day if possible. Dangerous as the use of cathartics must be before the obstruction is removed, their judicious employment may be beneficial after the continuity of the intestinal canal has been restored by operative treatment. Stimulating rectal enemata should be given to assist the action of the cathartics if the seat of operation has been above the ileo-cæcal valve. Opiates should be given only to relieve pain, and as sparingly as possible, so as not to impair the peristaltic action of the intestines.

Anatomico-pathological Forms of Intestinal Obstruction.—Before considering the special forms of intestinal obstruction, it must be understood that clinically they all belong either to the acute or to the chronic variety of obstruction.

The forms which give rise to ACUTE symptoms, and terminate in a few days either in death or in recovery, are those in which the mechanical difficulties that interfere with the passage of the intestinal contents arise suddenly, or at least in a short time. As illustrations of acute intestinal obstruction may be enumerated the sudden blocking of the lumen of the intestine by a gall-stone or other foreign body, invagination, the incarceration of an intestinal loop under or over a constricting band, and volvulus. In all such cases the lumen of the intestine at the seat of obstruction becomes impermeable, completely arresting the passage of feces.

The most conspicuous clinical **symptoms** of acute intestinal obstruction are absolute constipation, the fecal discharges, if any take place after the obstruction has occurred, consisting of intestinal contents from below the seat of obstruction; vomiting, which, as a rule, appears early and is most distressing if the obstruction is high up in the small intestine; and tympanites, which is most marked if the obstruction is low down in the intestinal canal. Peritonitis frequently gives rise to the adynamic form of intestinal obstruction by arresting the peristaltic action of the bowels, and it is often difficult to differentiate between the inflammatory or adynamic and the mechanical form of obstruction.

As important **diagnostic points** it may be mentioned that peritonitis is attended by more severe and continuous pain, tenderness, and rigidity of the abdominal muscles and a more decided rise in temperature, as a rule, from the very beginning, than is obstruction due to mechanical causes, in which the pain is paroxysmal, tenderness is either absent or less marked, the abdominal muscles are not rigid, and the temperature in the beginning is either normal or only slightly increased.

Acute intestinal obstruction, unless treated by surgical interference, with few exceptions results in death in from two days to two weeks. Spontaneous recovery in such cases is the exception, death the rule. If recovery takes place unaided by surgical interference, the mechanical obstruction is removed or corrected, as when an impacted gall-stone becomes dislodged and is forced into a larger portion of the intestinal canal, or when an intussusceptum sloughs and is eliminated, or when spontaneous reduction of a strangulated intestinal loop is effected.

In the **treatment** the administration of cathartics is absolutely contraindicated in such cases, as they invariably aggravate the symptoms and local conditions which have caused the obstruction. Absolute diet, and the use of the rubber stomach-tube, combined with irrigation of the stomach and *small* doses of opium to diminish the violent peristalsis, are the measures which should be relied upon in assisting the tendencies to recovery, and to bridge over the time until it is deemed necessary to interfere surgically.

In CHRONIC cases of intestinal obstruction the **clinical history** usually points to a gradually increasing stenosis of the intestine; an increasing difficulty in procuring a normal passage by the usual laxatives; frequently diar-

rhea, owing to a catarrhal inflammation of the mucous membrane above the seat of obstruction; colicky pains, caused by increased peristaltic action; and, finally, a gradually increasing tympanites and vomiting.

Chronic obstruction is **caused** most frequently by malignant disease of the bowel at or below the ileo-cæcal valve, cicatricial stenosis affecting the same portion of the intestinal canal, and chronic, slowly-progressing invagination. Spontaneous recovery in such cases is possible only if the obstruction is due to non-malignant causes and an intestinal anastomosis is established between an intestinal loop below the obstruction and the intestine above it by ulceration. It is not uncommon in cases of chronic obstruction for acute symptoms to develop suddenly, and the primary condition is usually found only after opening the abdominal cavity in search for the cause of the acute obstruction.

Treatment.—With the exception of chronic invagination, which sometimes can be reduced, the causes which give rise to chronic obstruction make it necessary to perform either enterectomy or intestinal anastomosis or to establish an artificial anus.

Entero-lithiasis.—Entero-lithiasis is due in the majority of cases to the impaction of a gall-stone or the formation of an enterolith, the nucleus of which is a gall-stone, in the lumen of the bowel.

Biliary Calculus.—Rokitansky asserted that a calculus the size of a hen's egg may pass through the bile-ducts. It is now generally believed that, as a rule at least, such large concretions can escape from the gall-bladder only by ulceration through its walls, and that a gall-stone of smaller size, after it has passed through the bile-ducts, subsequently becomes larger by the formation of concentric concretions during its retention in the intestinal canal. Leichtenstern has found that out of 1541 cases of intestinal obstruction from different causes, tabulated by himself, 41 were produced by gall-stones. Of 51 cases of intestinal obstruction caused by the impaction of a gall-stone, collected by Wising, 38 died. In some of these cases the calculi were of great size. In the cases reported by Smith and Fagge they measured four and a half by two and a half inches in circumference. The calculus may become impacted in any portion of the small intestine from the duodenum to the ileo-cæcal valve, but most frequently it becomes lodged in the duodenum or the lower portion of the ileum and just above the ileo-cæcal valve.

The **clinical history** of such cases points to a previous attack or passage of gall-stone, or, if the calculus has gained entrance into the intestine by ulceration, to an antecedent attack of circumscribed peritonitis in the region of the gall-bladder. If the calculus has become impacted in the duodenum or the upper portion of the jejunum, scanty urine, obstinate vomiting, and the absence of tympanites indicate that the obstruction is located high up in the intestinal canal. If the impaction has taken place in the lower portion of the ileum or above the ileo-cæcal valve, the symptoms will be the same as in obstruction from other causes in these localities. The administration of purgatives even in this form of intestinal obstruction is exceedingly hazardous, as the foreign body in a short time produces textural changes at the seat of impaction which render dislodgment impossible by this method of treatment.

Treatment by laparotomy should not be postponed until irreparable pathological changes have been produced by the foreign body. After the abdomen has been opened and the seat of impaction located, an effort should be made to crush the stone by pressure, provided the wall of the intestine is in such a condition as to warrant such an attempt. If this does not succeed, enterotomy is indicated. The stone should never be attacked at the seat of impaction, but should be pushed in an upward or downward direction, and then removed, if

possible, by breaking it up by manual pressure, or, if this fail, the method suggested by Tait, of passing a stout steel needle obliquely through the intestinal wall and attacking the calculus, may be tried. After the stone has been crushed and the débris within the gut has been pushed into a healthy segment of bowel below, the puncture in the serous coat should be closed by drawing the peritoneum over it with a fine superficial suture for the purpose of guarding against leakage. If the stone cannot be displaced and has to be removed by enterotomy, the site of operation should be covered by an omental graft. If the intestine at the seat of impaction presents evidences of gangrene, it must be resected and the continuity of the intestinal canal restored by circular enterorrhaphy.

Intestinal Concretions.—We have already seen that a small gall-stone when retained for a sufficient length of time in the intestinal canal may become the nucleus of an intestinal concretion, which by the addition of concentric layers gradually increases in size until it fills the lumen of the bowel, and after its impaction gives rise to intestinal obstruction. Enteroliths causing obstruction have been described in which a variety of foreign bodies have been found as nuclei. According to the analysis made by Virchow of two enteroliths, the concretions are composed principally of phosphate of ammonia and organic substances, especially of the derivatives of the biliary acids known as *dyslisin*. In one case Langenbuch removed an enterolith by enterotomy from the jejunum, but the patient died a few hours later, and at the post-mortem a second mass, still larger, was found in the pyloric region of the stomach. The surgical treatment of intestinal concretions is the same as that of impacted gall-stones.

Ascarides.—Halina, Saurel, Pockels, Stepp, and others have reported cases in which intestinal obstruction was produced by masses of ascarides becoming impacted in the small intestine. The patients were invariably children. When the surgeon is called upon to treat a case of intestinal obstruction in a child, such a cause should be borne in mind, as in a case of this kind a timely anthelmintic remedy, followed by a brisk cathartic, may prove efficient in removing the cause of obstruction. If such treatment should prove unavailing, no time should be lost in resorting to operative treatment by abdominal section, which should be conducted in the same manner as in operations for intestinal concretions.

Fecal Obstruction.—This is almost without exception met with only in the large intestine, and, in preference, in the cæcal region or in the sigmoid flexure. Cases have been reported where a congenital dilatation of some part of the colon predisposed to this affection. The acquired form of dilatation which attends all cases is the result of prolonged over-distention, resulting in paresis of the distended segment of the bowel. Impaction of feces sometimes gives rise to dangerous complications. Ulceration, and even perforation, may take place from this cause. Distention of the bowel often takes place to an enormous extent. Cruveilhier found on making a necropsy on an old man the transverse colon so dilated that it measured 35 cm. in circumference, and the cæcum had attained the size of a child's head. One of the most important diagnostic points is to give an anesthetic and make pressure over the swelling, when the fecal masses can be indented, the pressure leaving a permanent depression. Patients who have once suffered from fecal impaction are very prone to suffer from a recurrence of the same condition at intervals.

If the impaction is within reach, its removal should be accomplished by the use of a scoop, assisted by copious injections. If the bowel at the seat of impaction has lost its contractility, cathartics are useless, and, if it is in

a state of inflammation, positively hurtful. In such cases massage and high injections are indicated. After the mechanical removal of the fecal accumulation a recurrence should be prevented by the administration of extract of belladonna, gr. $\frac{1}{3}$, with an equal dose of extract of nux vomica, combined with half a grain of aloes and a grain of sulphate of iron in pill after each meal. Massage and electricity will render material assistance in restoring normal peristalsis. Perforation and suppurative inflammation in the connective tissue or the peritoneal cavity must be met by prompt surgical treatment. In cases where all ordinary measures fail to remove the fecal accumulation and the symptoms of obstruction continue unabated, it would be not only justifiable, but good surgery, to cut down upon the distended bowel and break up the mass within the gut, and push it along to a portion of the intestine below, where peristaltic action has not been suspended. In cases where the pathological conditions contraindicate such a course of treatment it may become necessary to resort to colotomy and remove the fecal mass through the wound, and, according to circumstances, either close the visceral wound by suturing or establish a temporary artificial anus in the corresponding inguinal region.

Invagination or Intussusception is that form of intestinal obstruction caused by the telescoping of one section of the bowel into another. A transverse section through an invaginated portion of the bowel reveals three intestinal walls, of which the outer, or sheath, is called the **intussuscipiens,** and the two inner the **intussusceptum.** The usual form of invagination is when the intussusceptum is directed downward, when it is called a descending invagination, to distinguish it from a rare form in which the intussusceptum is directed upward, which is called ascending invagination. It is estimated that 30 per cent. of all forms of intestinal obstruction, exclusive of hernia and congenital malformations, are cases of invagination.

The direct **causes** of invagination are not well understood. Some maintain that descent of the bowel takes place into a paretic section below it, while others assert that the intussusceptum is drawn into the intussuscipiens by active peristaltic action of the latter. The cause of a chronic invagination is often a tumor attached to the inner surface of the bowel. In more than 50 per cent. the patients are under ten years of age. Invagination, according to Heusner, is the cause of obstruction in three-fourths of all cases of intestinal obstruction in children. The disease, as a rule, is more acute in children than in adults, and the mortality is correspondingly greater. The average mortality without surgical interference is more than 80 per cent. Death is caused by exhaustion or gangrene and perforation at or near the neck of the intussuscipiens. Spontaneous recovery is possible only if reduction takes place or if the intussusceptum sloughs away after the bowel above has become firmly adherent to the neck of the intussuscipiens. In this way patients have eventually recovered after the elimination of several feet of gangrenous intestines. In the ileo-colic and colic varieties it is not uncommon for the apex of the intussusceptum to descend as far as the rectum, where it can be discovered by digital examination, and sometimes the bowel is protruded some distance beyond the anus.

In the **diagnosis** of this affection the greatest weight should be placed on the existence of an elongated cylindrical swelling, tenesmus, colicky pains, and the presence of mucus and blood in the discharges from the rectum.

The first indications in the **treatment** of invagination are to withhold food by the stomach and to administer opiates to diminish the peristaltic action of the bowel above the seat of obstruction, after which no time should be lost in effecting disinvagination by mechanical measures. The simplest, safest, and most

efficient of these is distention of the bowel below the obstruction with hydrogen gas or filtered air, which is done in the same manner as rectal insufflation for diagnostic purposes. Before insufflation is made, the colon should be thoroughly washed out with a high enema by Hegar's method, in which an ordinary enema nozzle connected with a funnel by a rubber tube about two feet long is inserted in the rectum. Warm water is then poured into the funnel and fills the rectum and colon. From two to four quarts may be injected. This should be done without an anesthetic, so that pain may warn us when to desist. Insufflation must always be practised while the patient is thoroughly under the influence of an anesthetic and with the patient nearly or completely in the inverted position. In recent cases of invagination below the ileo-cæcal valve this method of treatment will frequently succeed in effecting reduction. If reduction cannot be accomplished in this way, operative treatment must be resorted to at once. In patients too much prostrated to bear a laparotomy, an enterostomy or colostomy should be performed, according to the location of the invagination. Laparotomy is indicated after rectal insufflation has been faithfully and thoroughly tried with negative result, in all instances in which the general condition of the patient is such as to justify this procedure. Treves gives the mortality in 133 recorded radical operations for invagination as 72 per cent.; when reduction was easy it was 30 per cent., and when difficult 91 per cent. The difference between the mortality of early and that of late operations is the most convincing argument in favor of early operative interference.

As a rule to which there should be few exceptions, the incision should be made in the median line, as it furnishes the most ready access to the invagination and enables the operator to apply the various surgical resources with the greatest facility. For special indications a second lateral incision may be made later. In recent cases the difficulty encountered in reduction consists in an œdematous condition of the intussusceptum, and on this account the invaginated bowel should be firmly compressed between both hands of the operator before direct attempts at reduction are made. Reduction is then tried by making gentle traction on the bowel with one hand above the obstruction, while with the other the bowel is compressed below at a point corresponding with the apex of the intussusceptum, in such a manner as to force this in an upward direction, while the intussuscipiens is at the same time drawn in a downward direction. Reduction is sometimes facilitated by assisting the traction from above by elastic pressure from below, made by rectal insufflation of hydrogen gas or filtered air. If adhesions exist, they can be separated by inserting and passing around the bowel Kocher's director or a small probe. If reduction has been accomplished, the necessary precautions should be taken to prevent reinvagination, consisting in shortening the mesentery at the point of invagination by folding it upon itself in a direction parallel to the bowel and securing it in this position by a few catgut sutures. Should repeated attempts at reduction fail, one of three methods of treatment may be pursued: 1. The formation of an anastomosis between the bowel above and below the intussusception; 2. Resection of the invaginated portion, to be followed by circular enterorrhaphy; 3. Formation of an artificial anus.

Volvulus.—Volvulus, or the twisting of a loop of intestine around its axis, constitutes a well-defined form of intestinal obstruction. This pathological condition can occur only where the mesentery of the bowel is of considerable length, and is therefore most frequently met with in the lower portion of the ileum and at the sigmoid flexure of the colon. The condition, as compared with some other forms of intestinal obstruction, is quite rare. The immediate cause of the volvulus has been ascribed by Grawitz to accumulation of intesti-

nal contents above a constricted portion of bowel, while Nieberding has traced it in a few cases to adhesions of an omental stump to an intestinal loop.

The **symptoms** of volvulus will vary to some extent according to the location of the twist. If it affects the small intestine, early and persistent vomiting is the most important symptom. This symptom appears later, and is less persistent if the sigmoid flexure has become twisted around its axis. Wahl has called attention to a condition which he considers almost pathognomonic of volvulus—a circumscribed area of tympanites corresponding to the location of the twist and caused by gaseous distention of the twisted loop.

Treatment.—Of all forms of intestinal obstruction, volvulus leads most rapidly to a fatal termination. This fact alone is a sufficient warning to lose no time in temporizing measures. We have no reason to believe that a volvulus after it has caused symptoms of obstruction is ever reduced without direct surgical interference. On the other hand, it may be stated as a fact that if an early laparotomy is done the prognosis will be more favorable than in almost any other form of intestinal obstruction. It is necessary to make a long median incision, for the purpose of both detecting and correcting the volvulus. The untwisting in recent cases can be done without difficulty; where adhesions have become firm and numerous it may be impossible. If the bowel can be untwisted, a recurrence of the same lesion and at the same place can be prevented by shortening of the mesentery, which is to be done in the same manner as has been described in the operative treatment of invagination. If the untwisted bowel shows evidences of gangrene, resection becomes a necessity. If no such changes have taken place, but reduction is found impossible, the distended twisted loop is incised, emptied, and washed out with a mild antiseptic solution, the wound sutured, and an intestinal anastomosis established between the intestine above and that below the volvulus.

Flexions and Adhesions.—Flexions and adhesions as a cause of intestinal obstruction are almost without exception the remote consequences of a previous peritonitis. An adherent intestinal loop may gradually become flexed by the cicatricial contraction of the inflammatory material deposited between the bowel and the adjacent serous surface. Immobilization of a section of the intestinal tube in a mass of inflammatory exudation may cause intestinal obstruction by arresting peristaltic action of that part of the intestine. The obstruction may remain incomplete for an indefinite period of time, until the compensatory hypertrophy of the intestinal wall on the proximal side of the obstruction can keep pace no longer with the increasing mechanical difficulties, when symptoms of acute obstruction set in, which may be the first intimation of the existence of an old-standing obstruction.

Treatment.—If abdominal section is undertaken for the correction of such pathological conditions, an effort should be made to preserve the continuity of the intestinal canal by isolating the adherent loop or loops and straightening out the tube, and, if possible, displacing it in such a manner as to prevent it from subsequently resuming the same relations. Wherever it is possible to cover a raw surface by stitching over it the surrounding healthy peritoneum, this should be done to prevent a recurrence of the adhesions and malposition. If a section of the intestine is so firmly imbedded that it cannot be liberated without great violence or perhaps rupturing its wall, it should be allowed to remain and the fecal circulation be restored by establishing an anastomotic opening between the bowel above and that below the adherent portion. The same can be done in case a flexion has caused the obstruction and is similarly imbedded in a plastic exudation. If the flexed portion can be easily separated, the flexion is removed by the excision of a V-shaped piece, which,

after suture of the wound, leaves the intestine in a straight and permeable condition.

Strangulation by Ligamentous Bands or Diverticula.—Ligamentous bands resulting from old adhesions are usually found in those parts of the abdominal cavity which are most frequently the seat of peritonitis, viz. in the pelvis and the ileo-cæcal region. Their formation can generally be traced to a broad parietal adhesion which by the movements of the free portion of the intestine has become elongated and often narrowed to a delicate cord. It becomes a cause of obstruction when the migrating or free end forms an attachment to some fixed point, which then renders the band tense and unyielding. In case a loop of intestine becomes ensnared underneath it, strangulation takes place in the same manner as in strangulated hernia, the constricting cord by its pressure causing venous engorgement below the constriction and retention of intestinal contents in the afferent limb of the loop. As in hernia, an intestine may have become adherent and fixed underneath such a band for an indefinite period of time without strangulation taking place, so long as the immediate causes of strangulation are absent. Any cause which disturbs the mechanical relations still further in such a case, as a fall, lifting, coughing, the administration of an active cathartic, etc., may bring on an acute attack of intestinal obstruction. A displaced neck of a hernial sac may cause obstruction in the same manner as a ligamentous band. A band of constriction can also be formed by the margins of an opening in the mesentery or omentum, through which a loop of intestine may pass and become strangulated. An adherent portion of omentum in the course of time may become drawn out into a narrow twisted cord which may become a cause of internal strangulation. Another frequent location for bands is in the umbilical region, where the remains of the umbilical artery may cause constriction.

A considerable number of cases of intestinal obstruction are on record in which the obstruction was caused by a Meckel's diverticulum, and in several of these the strangulation was successfully treated by laparotomy. To the same category belong bands the remains of obliterated omphalo-mesenteric vessels. Diverticula are found most frequently in the lower portion of the ileum, and are supplied with a mesentery when they spring from the lateral aspect of the intestine or near the mesenteric attachment. Diverticula on the convex surface of the bowel are free, and are supplied with vessels from the intestinal wall. From a surgical standpoint the appendix vermiformis must be regarded as a diverticulum. This appendage may become a cause of obstruction when it is of abnormal length and supplied with a long mesentery, and when at the same time it is transformed into an unyielding band by fixation of its free extremity to some firm point by adhesive inflammation.

Treatment.—The operative treatment of the obstruction in this form of intestinal strangulation is usually not attended by any difficulties, provided the operation is not postponed until the strangulation has produced gangrene. The band of constriction, whatever its location or mode of origin may be, is traced to both the fixed points of attachment and excised between two ligatures. This not only relieves the strangulation, but also prevents a possible recurrence of a similar attack from the same cause. If gangrene has occurred, it will become necessary to make a partial or complete enterectomy according to the location and extent of the gangrene. In operating for obstruction caused by an elongated adherent appendix vermiformis or a diverticulum it is necessary to remove these appendages near their attachment to the intestine and to prevent extravasation by carefully inverting the margins of the wound and closing it by suturing. If this cannot be done, a ligature is applied near the attachment,

and after amputating the appendage the stump is buried by suturing the peritoneum over it. Bands composed of remains of the omphalo-mesenteric vessels are divided or excised between two ligatures; if this precaution of ligating them is omitted, troublesome hemorrhage may be encountered.

NON-MALIGNANT STENOSIS.

Congenital Stenosis.—Congenital narrowing of the bowel varies in degree from a slight contraction to complete atresia. If the stenosis is complete or sufficiently well marked to prevent the passage of intestinal contents, symptoms of intestinal obstruction will develop soon after the birth of the child. Even if the narrowing is considerable, the bowel remains permeable and no serious symptoms are produced until some foreign body becomes lodged above the seat of constriction and causes obstruction from fecal arrest. The surgical treatment is the same as in the next form.

Acquired or Cicatricial Stenosis.—Cicatricial stenosis is one of the remote consequences of deep ulcerative lesions, such as are caused by dysentery, typhlitis stercoralis, tuberculosis, and typhoid fever. The cicatrix which forms during the reparative stage of the ulceration contracts slowly and causes stenosis and chronic intestinal obstruction. As in cases of congenital stenosis, the obstruction often becomes complete and gives rise to acute symptoms when a foreign body or solid feces become impacted above the seat of constriction. Not infrequently the causes which have led to cicatricial stenosis are located at the same time or appear successively in different parts of the intestine, producing consequently multiple strictures. Cicatricial stenosis of the small intestine is caused most frequently by tubercular or typhoid ulcers, and the same condition in the colon results commonly from dysentery, while stricture of the rectum often appears as a syphilitic lesion.

The **clinical history** of cases of cicatricial stenosis must be traced to the primary lesions which produced the stricture, and terminates with the well-known symptoms characteristic of chronic obstruction. It is not uncommon in these cases to see the obstruction assume suddenly an acute form.

Treatment.—Enterectomy should be performed only if the bowel at the seat of obstruction presents pathological conditions which necessitate this operation, otherwise the continuity of the intestinal canal is restored by an enteroplasty or by intestinal anastomosis. Enteroplasty is performed in the same manner as pyloroplasty, and is applicable in narrow circular strictures. If the stricture is wider, and especially if several strictures are close together, an intestinal anastomosis is safer and much more easily executed than enterectomy and circular suturing.

Intestinal Tumors.—A tumor can give rise to intestinal obstruction in different ways, according to its location and anatomico-pathological character. A tumor or swelling outside of the intestinal tube may cause obstruction by compression. A polypoid growth springing from the mucous or submucous tissue interrupts the fecal circulation either by blocking the lumen of the bowel by its size or by causing an invagination or flexion. A circular carcinoma produces a stenosis which leads to chronic obstruction, but is also frequently the indirect cause of acute intestinal obstruction.

Benign Tumors.—Benign polypoid tumors seldom attain sufficient size to give rise to intestinal obstruction unless they cause additional mechanical disturbances, such as invagination or flexion, conditions which have already been described. If the tumor alone is the cause of obstruction, it is to be removed by laparo-enterotomy. If the tumor has caused invagination or flexion of the

intestine, its operative removal must be preceded or followed by removal of the mechanical difficulties to which it has given rise. Buchwald and Kulenkampff have reported cases of intestinal obstruction caused by cysts of a benign character which had evidently originated in the intestinal wall and had caused obstruction by flexing the bowel at an acute angle. If in such cases the cyst cannot be enucleated without opening the lumen of the bowel, and with a prospect that the flexion will be corrected by its removal, resection and circular enterorrhaphy will become necessary.

Malignant Tumors.—Malignant stenosis of the intestine may be caused either by a sarcoma or by a carcinoma, of which the former is more frequent above, and the latter below, the ileo-cæcal valve. A sarcoma of the intestine always has its starting-point in the wall beneath the mucous membrane, while carcinoma commences either in the mucous membrane or in its glandular appendages.

A **sarcoma**, as a rule, does not give rise to glandular infection, but to extensive regional infection in the course of the blood-vessels and connective-tissue spaces, and obstruction is caused more frequently by flexion than by circular constriction of the bowel. As a sarcoma of the intestine usually gives rise to symptoms of obstruction, and consequently comes under surgical treatment, usually after extensive infiltration of the mesentery and retro-peritoneal tissues has taken place, it is questionable if it is prudent to attempt a radical operation, as in case the patient recovers from the operation an early recurrence is almost inevitable. If a sufficiently early diagnosis were possible, resection could be made with a fair prospect of a permanent result; but if infection has extended to the tissues around the bowel, it is more judicious to leave the sarcoma and to exclude the obstruction by an intestinal anastomosis.

Carcinoma is found most frequently in the region of the sigmoid flexure, the cæcum, and the rectum. The disease either appears as a circumscribed circular affection, in which case the lumen of the bowel is narrowed gradually, giving rise to symptoms indicative of chronic obstruction; or diffused infiltration of the intestinal wall takes place at an early stage, in which case obstruction sets in later and the symptoms are less marked. A malignant stenosis may have existed for months without symptoms, when suddenly symptoms of acute obstruction set in. In cases of acute intestinal obstruction in elderly people, where no cause for it can be found in the abdomen, a thorough rectal examination should never be neglected. While sarcoma may occur in children, carcinoma is seldom met with in persons under thirty-five years of age. Carcinoma at an early stage is attended by regional infection in which the mesenteric and retro-peritoneal glands are principally involved. If the tumor has attained considerable size, it can be felt through the abdominal wall, and its location and relations to surrounding organs can be accurately determined by rectal insufflation of hydrogen gas or atmospheric air. If ulceration has taken place, hemorrhage into the bowel may occur, and this symptom when present should be taken into careful consideration in the differential diagnosis. Catarrhal inflammation of the mucous membrane above the seat of obstruction is an almost constant occurrence, and constipation alternates with diarrhea.

In malignant stenosis of the small intestine resection with circular enterorrhaphy can be done with comparative ease. While excision of a corresponding portion of the mesentery is not only unnecessary, but even harmful in enterectomy for non-malignant lesions, this should never be neglected in malignant cases, as by it the mesenteric glands, which are most liable to become infected first, are removed. In resection of the cæcum the retro-peritoneal glands should be removed as far as possible, and the continuity of the bowel restored

either by making an intestinal anastomosis a few inches above the closed ends of the ileum and colon, or by implanting the resected end of the ileum into a slit in the ascending colon a few inches above its closed end. If after resection of the lower portion of the colon it is found impossible to approximate the two ends of the bowel, and the distal end is not sufficiently accessible to make an intestinal anastomosis, it should be closed and dropped into the abdominal cavity, while the proximal end is brought out through a wound in the left groin, where it is secured by deep and superficial sutures, making thus a permanent artificial anus. If on account of the extent or location of the carcinoma it is found impossible to make a radical operation, one of two things may be done. If the bowel below the obstruction is accessible, an intestinal anastomosis is made, or the ileum is divided just above the ileo-cæcal valve, the distal end invaginated and closed with sutures, and the proximal end implanted into the bowel below the seat of obstruction. If on account of the location of the obstruction either of these operations cannot be done, an artificial anus should be established in one of the inguinal regions according to the location of the carcinoma, and if the first incision was made through the middle line, this is closed and dressed separately.

Retroperitoneal Tumors.—Tumors and swellings in the retroperitoneal space present to the surgeon many points of diagnostic and operative interest. In the diagnosis of such pathological conditions it is important to connect the tumor with its anatomical starting-point. The retroperitoneal location of a palpable tumor can sometimes be definitely ascertained by rectal insufflation of air. If the tumor is in contact with the anterior abdominal wall, the area corresponding with its circumference will be dull on percussion. If the colon is distended with air, the dulness disappears if the tumor is retroperitoneal, as the distended colon separates it from the abdominal wall; if the tumor is intraperitoneal, it is often displaced by the distended colon, but the disappearance of the tumor and dulness is less marked. Tumors in the retroperitoneal space, with few exceptions, are of mesoblastic origin. Dermoids in this locality are exceedingly rare. Inflammatory swellings take their starting-point most frequently in the bodies of the vertebræ, lymphatic glands, and connective tissue.

The operative treatment of retroperitoneal tumors is attended by much more risk to life than the removal of intraperitoneal tumors. The surgeon's efforts frequently cease with an exploratory laparotomy.

Fatty tumors develop most frequently in connection with the pararenal cushion of fat along the ilio-psoas muscle and in the obturator foramen and crural canal. Usually they do not reach large size; in a few cases they have attained an enormous size. They often undergo sarcomatous degeneration. Their growth is slow, and the symptoms which they produce are due almost exclusively to pressure. Their removal is effected through a median abdominal incision by splitting the peritoneum over the center of the tumor in a vertical direction, followed by enucleation. After careful arrest of hemorrhage the peritoneal incision is sutured before closing the abdominal incision.

Sarcoma in the retroperitoneal spaces springs either from one of the bodies of the vertebræ, the pelvic bones, lymphatic glands, or the connective tissue. Lympho-sarcoma of the retroperitoneal glands frequently appears as the result of regional dissemination of sarcoma of the testicle. As a primary and secondary affection of the lymphatic glands it presents itself in the form of a multiple rapid-growing tumor. Fascial, periosteal, and bony sarcomas are characterized clinically by a rapid-growing tumor in the retroperitoneal space.

Serous cysts have been found in the retroperitoneal space that originated

from remains of either the Wolffian body or Müller's ducts. Cysts of such histogenetic origin have thin walls and contain a clear fluid in which albumin, chlorides, and traces of urea and uric acid can be found. In some of these cases the kidney on the corresponding side was either absent or in a rudimentary form. In a few cases retroperitoneal serous cysts in the renal region have successfully been removed through a lumbar incision.

Tuberculosis of the retroperitoneal lymphatic glands is frequently one of the remote results of a similar affection of the testicle. By an extraperitoneal incision a chain of tubercular glands extending from the internal inguinal ring to the bifurcation of the common iliac artery have been removed. Progressive extension is one of the typical clinical features of glandular tuberculosis in this as well as in other regions. Caseation and abscess-formation occur if life is sufficiently prolonged. The abscess usually points above the crest of the ilium.

Chronic abscesses which develop in the course of tubercular spondylitis often appear as retroperitoneal swellings, and have frequently been mistaken for pyonephrosis and paranephric abscess. A careful study of the clinical history, combined with a painstaking examination to locate the swelling properly, aided, if necessary, by an exploratory puncture in the lumbar region, will usually enable the physician to make a correct diagnosis. Retroperitoneal tubercular abscesses of glandular or osseous origin, accessible through the lumbar region, should be treated by tapping, followed by injection of a 10 per cent. iodoform-glycerin emulsion.

Adynamic Intestinal Obstruction caused by Arrest of Peristalsis.—A number of pathological conditions are known to produce symptoms which so closely resemble those of intestinal obstruction due to mechanical causes that the abdomen has been repeatedly opened in such cases with the expectation of removing the cause of obstruction, yet no occlusion of any kind could be found. These are the cases that have caused the greatest difficulty in diagnosis, and have often brought disappointment and reproach upon the surgeon. The obstruction in these cases is not caused primarily by a narrowing of the lumen of the intestine, but by suspension of the forces which propel the intestinal contents, and which results in the accumulation of feces and gases in the paralyzed portion of the bowel; this is followed by distention of the intestines, constipation, and obstinate vomiting, which in rare cases may become fecal. Circumscribed or diffuse paresis of the intestines is often caused by an inflammatory affection, such as peritonitis or enteritis, which produces suspension of muscular contractions in the same manner as when an inflammatory process in any other organ affects directly the muscular tissue; or the tunics of the intestines may be in an intact condition, and paralysis result from reflex causes. In either case the most striking symptom is an extensive tympanites. While in obstruction from mechanical causes the peristaltic action of the intestines can sometimes be seen on the surface of the abdomen, paralysis from over-distention not having taken place, in the paralytic form the abdominal surface is smooth and the outlines of the intestinal coils are not perceptible. In this form of obstruction expulsion of gas and the passage of intestinal contents are prevented by the formation of numerous flexures, owing to the great distention of the intestines, which is followed by compression of some parts of the intestines by the distended loops.

The diseases which cause adynamic intestinal obstruction are rapid accumulation of gas from fermentative or putrefactive processes in the intestines, peritonitis, and catarrhal and ulcerative enteritis. A paretic condition of the bowels

has also been observed following prolonged laparotomies, especially when evisceration has been necessary.

If a positive diagnosis of adynamic obstruction can be made, the **treatment** consists in relieving the distention by puncturing the bowel, external support by enveloping the abdomen with strips of adhesive plaster, tubage of the colon, a rigid diet, and the administration of such remedies as naphthaline to procure an aseptic condition of the intestinal canal. If under such circumstances a laparotomy is made upon the supposition that a mechanical cause exists, the intestine should be emptied through one or more incisions at least an inch or more in length, which are at once sutured, the intestines returned, and the external wound closed, after which a treatment is adopted which is directed toward the removal of the primary cause and the prevention of the production of gas in the intestines.

APPENDICITIS.

Appendicitis, or inflammation of the appendix vermiformis, is now a well-recognized surgical lesion, and is regarded as the primary lesion in the causation of the numerous forms of inflammation in the ileo-cæcal region known as typhlitis, perityphlitis, paratyphlitis, and appendicular peritonitis.

Etiology.—As regards etiology, we may first consider (*a*) the predisposing causes. The explanation of the great frequency with which the appendix becomes the seat of inflammatory and destructive lesions as compared with the other portions of the digestive tract is undoubtedly to be found in its embryology and in its anatomical relations. There can be no question that those structures which remain to us as functionless vestiges of parts once useful in our prehistoric ancestors are possessed of low vitality and but feeble resistant powers. This is as true in the life of the race as in that of the individual. It doubtless explains in part the special susceptibility of the appendix to inflammation, as it does that of the uterus and the female breast to cancer during the post-sexual period of life.

In addition, its dependent position, its communication by an orifice, often more or less narrowed, with that portion of the intestine in which inspissation of intestinal contents first occurs, while at the same time it is removed from the direct fecal current—all appear to be conditions so markedly predisposing to inflammatory attacks that we need look no further for a sufficient explanation of the extraordinary frequency of appendix trouble.

(*b*) Exciting Causes.—Putting aside the comparatively rare cases in which tubercular or other general disease localizes itself in the appendix, we have two chief classes of exciting agencies, clinical differentiation of which is to be earnestly aimed at: the mechanical and the bacterial or infective. The latter comes into play usually, perhaps almost constantly, as a sequel of the former, which may, however, exert its action alone from first to last in a given instance, and does so in some cases.

The following anatomical points must be remembered: The appendix is commonly found curved upon itself, because its mesentery, derived from the inferior layer of the mesentery of the ileum, is too short for it. In the fetal type of the cecum and appendix the latter has a mesentery which runs to its tip, but in the majority of adults it ends about the center of the appendix or at the junction of its middle and distal thirds. Along the free concave border of the mesentery runs a single vessel, a branch of the ileo-colic, and from this branch the appendix, as a rule, derives almost its entire blood-supply. Another peritoneal fold runs from that part of the ileum most

remote from its mesenteric attachment and is united with the mesentery of the appendix. It carries no blood-vessels. It is the remains of the true mesentery of the appendix (Treves). It is interesting to note the fact that in the different types of cecum found in our species those which involve its disproportionate growth show that it derives its peritoneal covering partly at the expense of the mesentery of the appendix, which becomes more and more scanty and more vertical in direction the larger the relative size of the cecum.

We here have the factors which enter into the production of a large number of cases of appendicitis. Distention of the ileum with gas or of the caput coli with gas or fecal matter will cause dragging on one or the other of these folds, already too scanty, increase the torsion of the appendix, interfere with the blood-supply through its single vessel, and, according to the degree of torsion, produce congestion and tumefaction, catarrhal inflammation, ulceration, or gangrene, with the clinical symptoms that belong to each. The anatomical conditions are so simple and easily understood, and explain so completely various well-known types of the disease, that we may assume them to be sufficient in many cases to account for all the symptoms.

It seems probable that the bacterial cause of appendicitis is, as a rule, the bacterium coli commune. It is almost invariably to be found in the intestinal tract, and seems in the presence of sound mucous membrane to have little or no power for evil; but it is equally well demonstrated that if the epithelium is once destroyed, it has both pathological and pyogenic properties.

Experiments have shown that even a moderate degree of constriction of the intestinal canal may be followed by the penetration of its walls by this bacterium, and also that its virulence is much increased by the presence of irritative conditions, such as exist in advanced constipation or marked diarrhea, even when produced experimentally by tartar emetic.

Other micro-organisms are exceptionally associated with acute appendicitis, but the most reliable observations seem to show that in 82 per cent. of infective cases this bacterium is the active agent (Tavel and Lanz).

Barbacci found that in perforative peritonitis cultures from the exudate yield only one microbe in the vast majority of cases, the bacillus coli communis. Fowler, who has studied the bacteriology of appendicitis on an extensive scale, almost invariably found this bacillus, but in many cases associated with other microbes such as the streptococcus pyogenes, diplococci, micrococcus flavus liquefaciens, etc.

A third class of causes which may be regarded as both predisposing and exciting must be made to include fecal concretions and foreign bodies. The latter, once thought to be the chief factors in producing the disease, are now known to be of great rarity, occurring in only about 4 per cent. of operative cases (Matterstock, Fowler). Fecal concretions are found in 15 to 20 per cent. of such cases, and there is evidence to show that they may occasionally by their presence give rise to the lesion of the mucous coat which precedes infective processes; but they are so often absent in cases of all grades of severity, and so often present in autopsies on persons who have died from other diseases, that they should not be considered of primary importance.

Catarrhal appendicitis may be caused by an extension of catarrh of the cecum by continuity of the mucous membrane into this structure; in a few cases traumatism has been thought to have caused the disease.

The effect of age must be taken into account in summing up the etiological factors. It is certain that the two extremes of life are notably exempt, but the explanation of this fact is thus far purely theoretical. It is asserted that in very early life the funnel-shaped appendix, apex down-

ward, offers fewer opportunities for the formation and retention of masses of inspissated feces, while in old age atrophy of the mucous membrane about the cecal orifice of the tube again widens it; but we lack positive knowledge upon these points. The very existence of the fold of mucous membrane known as the valve of Gerlach is disputed, and in any event it is so imperfect mechanically as to be presumably of slight importance.

The disproportion between the sexes requires explanation. If we accept the usual description of the anatomy of the parts concerned, there seems to be no good reason why appendicitis should be found in men four or five times more frequently than in females; but if future observations confirm the assertion of Clado, that a fold of peritoneum passes from the right ovary to the meso-appendix—the appendiculo-ovarian ligament—and if this fold carries a blood-vessel, an obvious and sufficient explanation has been found. It has been shown (Bryant) that the male appendix is four-tenths of an inch longer than that of the female; that its caliber is slightly larger; and, possibly as a result of the latter fact, that it contains fecal concretions in a larger percentage of cases. But these circumstances do not seem to throw much light on the subject.

The manner in which constipation or diarrhea and digestive disturbances generally favor the development of appendicitis is now evident. We have a vestigial structure of relatively poor vitality and low resistant power, so situated mechanically that its one source of blood-supply is greatly interfered with by twisting or dragging, and connected by short or scanty folds of serous membrane with portions of the digestive tract especially liable to changes of form and size, which thus easily produce such torsion or tension. Furthermore, a micro-organism, capable of great virulence if epithelial exfoliation occurs or if any area of lessened resistance exists, is almost constantly present.

Pathology.—In an appendix the seat of inflammation, the mucous membrane is usually very vascular and considerably thickened, and as the opening into the cecum is narrowed by the same cause, accumulation of a viscid or muco-purulent product takes place, and the lumen of the appendix is generally found more or less increased. The ulcers, which are often multiple, present sharp, well-defined, infiltrated margins, and in depth vary from a slight superficial abrasion to complete perforation of the appendix. The examination of cadavers made with special reference to determine the relative frequency of disease of the appendix, by Kraussold, Tofft, Tüngel, Fergusson, Ransohoff, and others shows that almost always a primary appendicitis precedes an attack of perityphlitis or paratyphlitis. From the anatomical structure of the appendix and its relations to the peritoneal cavity we have reason to believe that the peritoneal cavity is implicated more or less in almost every case in which appendicitis leads to perforation. A diffuse cellulitis or phlegmonous inflammation of the connective tissue behind the cæcum, without participation of the general peritoneal cavity, will occur if before perforation takes place that part of the appendix has become firmly adherent to the parietal peritoneum, the perforation in such cases not opening into the peritoneal cavity, but into the loose retro-peritoneal connective tissue, and leading to a localized extra-peritoneal abscess. Such an abscess may present itself near the anterior superior spine of the ileum, above Poupart's ligament, or even in the lumbar region, in the latter instance simulating a perinephritic abscess, or it may discharge its contents into the cæcum, an adjoining adherent loop of the small intestine, the bladder, the vagina, or even the rectum. In cases of this kind a localized peritonitis always precedes the phlegmonous inflammation and suppuration. In other cases perforation takes place into the peri-

toneal cavity, but the extension of the infection is limited by the formation of an abscess-wall composed of loops of the small intestine which have become firmly adherent by plastic exudation, and the resulting abscess is the product of a limited suppurative peritonitis. The gravest form of appendicitis is determined if the whole appendix becomes gangrenous or if the perforation communicates with the free peritoneal cavity. If no attempt at localization occurs, the septic material, becoming diffused over the whole peritoneal cavity, gives rise to a diffuse septic peritonitis which results in death within two or three days. Identical conditions with the same result follow the rupture of a limited paratyphlitic or perityphlitic abscess into the peritoneal cavity. In a considerable percentage of cases a perityphlitis or paratyphlitis does not terminate in suppuration, but the inflammatory swelling disappears within a few weeks. This, the most favorable termination of appendicitis, is most likely to follow if perforation does not occur or if the perforation is small and the appendix surrounded by a mass of plastic exudation. In recurring appendicitis a limited swelling forms in the region of the appendix, and disappears after the acute symptoms subside, to reappear later.

Symptoms.—Let us suppose that we have a case in which constipation, which is usually present, or diarrhea, or at least some digestive derangement, has caused intestinal distention with fecal matter or with gas, or irregular and excessive peristalsis in the ileo-cecal region. The meso-appendix is dragged upon, the torsion of the appendix increased, the return of blood interfered with; the arterial supply, more difficult to disturb than the venous current, is but little affected. If we could see such an appendix, we would undoubtedly find swelling and congestion, hypersecretion, nerve-irritation. It seems theoretically unreasonable to suppose that in every such case there is necrosis even of epithelium or infection even of low grade. It is probable, however, that there is, even in the mildest cases, an exudate under pressure into the submucous and muscular coats of the wall of the appendix, and a slight adhesive peritonitis of very moderate extent. The post-mortem findings, which show that in one person out of every three there has been some pathological condition present in the appendix, are so out of proportion to the clinical percentage of frequency, large as that is, that it seems evident that some such minor attacks must take place, and often with phenomena so slight that they scarcely attract attention.

The usual symptoms of such a case as we are considering are: pain, at first general and diffused over the abdomen, because the superior mesenteric plexus of the sympathetic, which supplies the appendix, also largely supplies the intestines, and because irritative nerve-pain is apt to be referred to the peripheral extremities of nerves; next and within a very short time it is felt in the umbilical region, because as such pain increases in intensity it is often referred to the nearest nerve-centre, and the great sympathetic ganglia of the abdomen are situated in that region.

The pain at this time is often colicky in nature, and a discussion has arisen as to whether or not the circular muscular fibers in the appendix have actually been observed in alternate spasm and relaxation when exposed in a wound (Morris); but it seems unimportant, as appendix irritation may result in colicky spasm of neighboring portions of either small or large intestines.

After a few hours the pain is felt in the right iliac fossa, because then a neuritis has developed of sufficient grade to cause tenderness on pressure. It is a localized tenderness in all the varieties of appendicitis, because while the appendix itself is movable, it always arises from the same part of the cecum, and the mobility of the latter is much more restricted. The point

of pain on pressure known as McBurney's point, situated nearly midway from the anterior superior spine to the umbilicus, indicates, therefore, with moderate accuracy the base, not the tip, of the appendix, and is rarely absent even in gangrenous cases, because that portion of the appendix is usually the last to be affected by interference with the blood-supply.

Vomiting commonly follows, with little relation to gastric conditions, and is ordinarily reflex and due to reversed peristalsis, as the ejecta show a degree of digestive change corresponding to the time which has elapsed since the last meal.

Moderate fever (99.5° to 101° F.) and slightly increased pulse-rate (90 to 110) are usually present, and are doubtless due to the same sort of absorption of intestinal products as gives rise to the same symptoms in constipation or in true bilious colic, for which cases of this kind are sometimes mistaken.

There is slight rigidity of the right rectus muscle, and later of the abdominal muscles over the right iliac fossa, often, but perhaps not necessarily, due to peritonitis, and in any event arising from the fact that those muscles receive their nerve-supply from the seven lower intercostals, while the superior mesenteric plexus gets its splanchnics from the same seven intercostals.

As long as the disease is limited to the appendix the swelling is not distinct, and if the appendix is located behind the cecum it often eludes detection.

The swelling sometimes increases quite rapidly within a few days, and varies in size according to the extent of the disease and the character of the tissues involved. It appears early, and attains considerable dimensions as soon as the connective tissue behind the cecum is extensively involved in the inflammatory process. Even if a large abscess has formed, fluctuation is generally absent or indistinct, on account of the rigidity of the abdominal wall covering the inflamed area.

Diagnosis.—As to the diagnosis of the mild class of cases tending to recovery, it is to be made chiefly from stercoral typhlitis, a condition which has been so overshadowed during the advance of our knowledge in regard to appendix disease that we are in danger of acting as if it were non-existent. In some elaborate reviews of the diagnosis of appendicitis it is hardly mentioned, and yet a very moderate clinical experience ought to convince any careful observer that it is occasionally present. It has many features in common with appendicitis, and it is quite possible that to some degree this is present in most cases of stercoral typhlitis, but the independent existence of the latter condition has apparently been shown both at autopsies and at operations, where it is asserted that severe forms of typhlitis and perityphlitis have been found to be dependent on stercoral ulcers of the cecum, and the appendices were normal. Some surgeons of large experience have never seen this condition, and there is still much difference of opinion about it. It is true that in the vast majority of cases of severe inflammation and suppuration in the right iliac fossa the appendix is at fault, but it should not be forgotten that in many of them the original trouble is a constipation, associated with distention of the cecum by fecal masses often containing undigested food, and exciting both mechanical and chemical irritation. The relation of the mild attacks of appendicitis to digestive derangement is unmistakable, and it is not very uncommon to find in relapsing appendicitis that one particular article of food is the especial exciting cause of an attack.

If in many cases fecal distention of the cecum is the starting-point of

appendicitis, it is reasonable to believe that in some of them the trouble does not pass beyond the cecum, and it is important to recognize these cases, because the prognosis is so much more favorable, and operative measures need not, as a rule, be thought of.

They occur chiefly at the times of life when appendicitis is less common, and more especially in children. They can be recognized with certainty only by the initial presence of a doughy, sausage-shaped tumor in the cecal region, associated with the usual symptoms of appendicitis in a modified form. The localized tenderness is not so great; the fever is very moderate; vomiting is rarely a prominent symptom; constipation is almost invariable, though occasionally a spurious diarrhea (analogous to the "incontinence of retention" in bladder cases) may make its appearance.

The discovery of a tumor at the very beginning of an attack of apparent appendicitis of obviously mild type would, perhaps, justify the diagnosis of stercoral typhlitis, but in the absence of that symptom it would be safer to consider doubtful conditions as almost certainly indicating appendicitis.

A differential diagnosis between an inflammatory lesion in the ileo-cecal region and intestinal obstruction in the same locality is sometimes difficult. Appendicitis is almost always attended by a rise of temperature from the very beginning, while an intestinal obstruction uncomplicated by inflammatory lesions is not attended by fever. The history of the case is often valuable in making an early and correct diagnosis, as it is well known that a person who has once suffered from appendicitis is prone to subsequent attacks unless the primary cause is removed by operative measures; hence if a patient has passed through an attack of appendicitis at some previous time, however remote this may be, if he again presents evidences of inflammation in the ileo-cæcal region it is very probable that he is suffering from a recurring attack of appendicitis. If during the course of an attack of appendicitis the patient experiences a sudden diffuse pain and presents evidences of shock, frequent, small, and wiry pulse, and a subnormal or high temperature, it is almost certain that an ulcer of the appendix or a perityphlitic or paratyphlitic abscess has ruptured into the peritoneal cavity.

Prognosis.—The mortality of appendicitis and the attending perityphlitis or paratyphlitis is about one out of seven or eight cases. Without prompt surgical interference death is almost sure to ensue if the general peritoneal cavity is invaded. Life is in great peril if the resulting abscess opens into the pleural cavity or the bladder. The prognosis is favorable if the peritonitis is of the plastic type, as in such cases the disease remains circumscribed and the general peritoneal cavity is protected against infection. In recurring appendicitis the danger to life increases with each successive attack, as every subsequent attack by aggravating the local lesion may give rise to perforative peritonitis.

Treatment.—The *medical* treatment of appendicitis should aim at the prevention of perforation and at giving the peritonitis a plastic character. During the incipient stage it would be advisable to administer saline cathartics in such doses and at such intervals as to secure an early and free evacuation from the bowels, and in this manner remove the fecal accumulation in the cæcum which is so frequently present in these cases. A warm-water enema containing an ounce of sulphate of magnesium should be given for the same purpose. Externally, hot fomentations and the use of mustard or turpentine relieve pain, and at the same time rather favor a plastic peritonitis. As soon as the bowels have moved freely, deodorized tincture of opium should be given, with a view of relieving pain and of securing rest for the inflamed parts. If this drug is rejected by vomiting, morphia is to be given by subcu-

taneous injection. Except during the incipient stage, cathartics are positively contraindicated until the acute symptoms have subsided and the danger of perforation has passed. Only liquid food is to be given during the acute stage. The use of blisters and other potent counter-irritants is more harmful than beneficial.

In a large majority of cases judicious *surgical* treatment will become necessary if the inflammation does not yield to the treatment detailed above. Ulcerative appendicitis and perforating appendicitis are surgical affections, and should be treated as such. The propriety of surgical intervention in acute suppurative appendicitis was first established by Willard Parker of New York in 1867. The treatment of recurring catarrhal and ulcerative appendicitis by laparotomy and removal of the appendix, either during an attack or after the acute symptoms have subsided, has been placed on a sound surgical basis by McBurney, Treves, Senn, Kümmell, and others. As it is often necessary in these cases to open the abdominal cavity, the strictest antiseptic precautions must be observed. The abdominal incision may be made directly along the outer border of the rectus muscle from the level of the umbilicus nearly to the middle of Poupart's ligament, or it may be a curved incision nearer the spine of the ilium with its center on the omphalo-spinous line, or in the presence of a tumor it may be directly over the most prominent part of the swelling. McBurney's plan of incising the abdominal wall has found much favor with the profession. It consists in dividing the muscles in the direction of their fibers; that is, the external oblique and internal oblique are divided in opposite directions, more by tearing than by cutting. Retractors become necessary to keep the wound open during the operation. After the operation the opening is closed by the muscular fibers resuming their former position, the resisting power of the abdominal wall is but little impaired, and the occurrence of a ventral hernia is more effectually prevented than by cutting in one direction through the muscular plane of the abdominal wall. The margins of the wound are retracted by an assistant, and prolapse of the small intestine is prevented by packing the abdominal cavity around the cecum with a compress of antiseptic gauze. If the appendix cannot readily be found, the anterior longitudinal band of the cecum is taken as a landmark; if, as is frequently the case, the appendix is located behind the cecum, this must be lifted forward and the band followed to the appendix. The appendix is then freed from all adhesions, ligated with aseptic silk or catgut close to the cecum, and cut off below the ligature. The mucous membrane of the cut surface should be disinfected with the cautery or pure carbolic acid. Subserous amputation of the appendix is now generally practised when this method is applicable. A few lines from the cecal end of the appendix a circular incision is made through the peritoneum, which is reflected in the form of a cuff. The denuded part of the appendix is then tied with a fine silk ligature and cut off a line or two below, after which the mucous membrane is cauterized with pure carbolic acid, the stump iodoformized, and the peritoneal cuff sewed over it with fine catgut sutures. As in all lateral incisions, the external wound is to be closed by deep and superficial sutures.

If an ulcer of the appendix or an abscess in its vicinity has perforated into the free peritoneal cavity, a lateral incision, such as has been described, should be made, as it affords better access to the parts which require direct surgical treatment than a median incision. In such cases the abdominal cavity should be freely irrigated with warm sterilized water or Thiersch's solution of salicylic acid before the appendix is removed, and the flushing repeated after the removal has been effected. Adequate provision for drainage is an absolute necessity in

all cases where pus or fecal matter has obtained access to the abdominal cavity.

If the appendicitis has resulted in the formation of a *circumscribed abscess* in the right iliac fossa, a slightly curved incision from four to six inches in length, commencing just above the middle of Poupart's ligament and extending toward the anterior superior spine of the ilium, will answer in the majority of cases. The deeper tissues are divided and retracted in the same manner as though the operator were about to ligate the external iliac artery. This incision leads down to and behind the cæcum, the most frequent location of an incipient abscess resulting from appendicitis. The use of the exploring needle as a means of locating the pus before the operation is to be condemned. Exploratory puncture made at the time of operation is attended by less danger, and may give valuable information in regard to the location of the abscess. If the peritonitis has become limited, it must be the great object of the surgeon to reach the abscess and to remove its primary cause without invading the general peritoneal cavity, and on this account the utmost care must be exercised not to penetrate the abscess-wall on the peritoneal side during the search for the appendix and its removal. As soon as the abscess is reached its contents should be washed out with a weak antiseptic solution, and gentle search made for fecal concretions and foreign bodies if the appendix is found to be perforated. In some cases the appendix will be found completely detached from the cæcum and adherent to the surrounding tissues or lying in the abscess as a gangrenous slough. It will generally be impossible to cover the stump with peritoneum in these cases. In many cases of circumscribed abscess, and especially in those in which the appendix is bound down by adhesions in the depth of the wound, the surgeon should be content with evacuation, irrigation, drainage, and packing with iodoform gauze. Persistent search for the appendix and attempts at its removal in these cases are attended with such danger of opening the general peritoneal cavity that they are not to be recommended. When it is impossible to enucleate and remove the appendix, it may sometimes be laid open by an incision in its long axis and drained, as advised by Tait. If the abscess presents anteriorly underneath the abdominal wall, it is opened by an incision which will afford the best drainage, and after flushing it with an antiseptic solution it is well drained and the drainage maintained until the surgeon is satisfied that healing is taking place from the most remote portions of the abscess. The too early removal of drains is often followed by recurrence of the abscess. If the abscess does not heal, it is a sign either that sinuses have formed, which must then be scraped out with a sharp spoon and thoroughly disinfected, or that a perforated appendix has to be removed, which can be done either by enlarging the sinus which leads down to it or through the peritoneal cavity.

Obliterating Appendicitis; Appendicitis Obliterans is a name recently given by Senn to a form of appendicitis in which the lumen of the appendix at different points is gradually obliterated by cicatricial contraction. The obliteration begins as a stricture which may appear at any point in the lumen of the appendix, and leads to its complete closure. Occasionally the entire appendix is transformed into a solid cord, in which event the symptoms disappear completely and a permanent spontaneous cure is the result.

Recurrent Appendicitis.—A patient who has had even a mild attack of appendicitis is more prone to others, and these may vary in type from the mildest to the most severe. It is probable that after a second attack operation during the interval would be recommmended by most surgeons as offering less risk than further delay. But it cannot be denied that many persons

who have had several such attacks have recovered under judicious medical treatment. If the condition in the first instance was at all serious as regards danger to life, or if the second attack was distinctly of a graver type, there would be practically no difference of opinion among surgeons, operation being certainly indicated.

Chronic Relapsing Appendicitis.—In chronic relapsing appendicitis the case is somewhat different. The interval then is not one of entire health; there are digestive disorders, flatulence, constipation or diarrhea, and pain in the right iliac fossa, aggravated by motion or exercise or fatigue. The attacks themselves are of a higher grade of severity, are accompanied by the appearance of a tumor, which often never entirely disappears, and by distinct evidence of localized peritonitis. The general health suffers severely, and the patient is apt to be anemic and emaciated.

In the majority of these cases which finally require operation, especially in those in which the persistence of the local symptoms during the interval is marked, pus is present in small quantity and is surrounded by thick, firm adhesions.

The **diagnosis** may usually be made by the history, the localized pain, the variable tumor, etc. Not infrequently, especially where the early stage of a malignant neoplasm is suspected, the only possible diagnosis is by exploratory incision.

Even these cases do not *invariably* require operation. Treves, who originally proposed the operation in 1877, has thought it necessary to call attention to the fact that it has been performed recently without proper discrimination, and adds: "The circumstances which would justify an operation in these cases must be precisely defined, and it cannot be too emphatically stated that, in a fair proportion of instances in which the trouble has relapsed, no surgical interference is called for. I am aware of many cases in which a patient has had three or more attacks of typhlitis, and has then ceased to be troubled with any further outbreaks. In some examples of the relapsing form much can be done by medical means, by diet, by attention to the bowels, and by placing the patient under conditions more favorable to a state of peace within the abdomen."

There is good reason for believing that the mortality of the operation in skilful hands will be a low one. If the indications for operation are clear, the question as to whether it shall be done between or during attacks must be unhesitatingly decided in favor of the period of quiescence, the operative difficulties being then much less, especially as regards the important question of possible general infection. In the recurrent type, if operation is to be considered at all, it might be well to take the risk of waiting for another attack, which may never come.

In the chronic relapsing cases, however, if the surgeon, in deciding upon operation, limits himself to the following indications formulated by Treves, he had far better take advantage of the interval. Operation is indicated when—1. The attacks have been very numerous. 2. The attacks are increasing in frequency and severity. 3. The last attack has been so severe as to place the patient's life in considerable danger. 4. The constant relapses have reduced the patient to the condition of a chronic invalid and have rendered him unfit to follow any occupation. 5. Owing to the persistence of certain local symptoms during the quiescent period there is a probability that a collection of pus exists in or about the appendix.

White has recently summarized his conclusions upon the general subject of appendicitis, which must be regarded as one still open to discussion:

1. The explanation of the great frequency of inflammation of the appendix is to be found in the following facts:

(*a*) It is a functionless structure of low vitality, removed from the direct fecal current; it has a scanty mesentery, so attached to both cecum and ileum that it is easily stretched or twisted when they become distended; it derives its blood-supply through a single vessel, the caliber of which is seriously interfered with or altogether occluded by anything which produces dragging upon the mesentery.

(*b*) In addition, there is almost always present a micro-organism—the *bacterium coli commune*—capable of great virulence when there is constriction of the appendix or lesions of its mucous coat or of its parietes.

2. The symptoms in a case of mild catarrhal appendicitis—general abdominal pain, umbilical pain, localized pain, and tenderness on pressure in the right iliac fossa, vomiting, moderate fever, and slightly-increased pulse-rate—cannot at present with any certainty be distinguished from the symptoms, apparently precisely identical, which mark the onset of a case destined to be of the very gravest type.

3. It must be determined by future experience whether or not operation in every case of appendicitis, as soon as the diagnosis is made, would be attended by a lower mortality than would waiting for more definite symptoms indicating unmistakably the need of operative interference. At present such indication exists in every case if the onset is sudden and the symptoms markedly severe, and whenever in a mild case the symptoms are unrelieved at the end of forty-eight hours, or, *a fortiori*, if at that time they are growing worse.

4. It must be determined by future experience whether cases seen from the third to the sixth day, which present indications of the beginning circumscription of the disease by adhesions, and which tend to the formation of localized abscesses, will do better with immediate operation with the risk of infecting the general peritoneal cavity, or with later operation when the circumscribing wall is stronger and less likely to be broken through. At present operation is certainly indicated whenever a firm, slowly-forming, well-defined mass in the right iliac fossa is to be felt, or, on the other hand, when a sudden increase in the sharpness and the diffusion of the pain and tenderness points to gross perforation of the appendix or breaking down of the limiting adhesions.

5. In the beginning of general suppurative peritonitis operation offers some hope of success. In the presence of general peritonitis with septic paresis of the intestines operation has thus far been useless.

6. Recurrent appendicitis of mild type, like acute appendicitis, frequently results from digestive derangements. Several attacks may occur followed by entire and permanent recovery, but it is as yet impossible to differentiate these cases accurately from those which do not tend to spontaneous cure. Operation is certainly indicated whenever the attacks are very frequent.

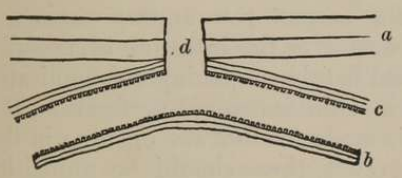
7. Chronic relapsing appendicitis is characterized by the persistence of local symptoms during the intervals and by more or less failure of the general health. Operation is usually to be advised in these cases.

Fecal Fistula.—A fecal fistula is a communication between any portion of the intestinal tract and the external surface of the body or some hollow internal organ through which gas and the solid or liquid contents of the intestine escape. In the majority of cases the external opening will be found in one of the inguinal or lumbar regions. The pelvic organs through which an outlet is most frequently established are the bladder, uterus, and vagina. An artificial anus made for the purpose of relieving an intestinal obstruction becomes

a fecal fistula if the cause of the obstruction is not removed subsequently, either spontaneously or by operative interference. Fecal fistulæ are established spontaneously most frequently after strangulated hernia where the strangulation has resulted in gangrene of the bowel, or in case of perforation of an intestine or of the appendix vermiformis by an ulcer after the inflamed part has become adherent to the abdominal wall or some of the internal organs, or they may result from the rupture of an abscess into an intestine, the external opening being established later. An intestinal fistula may also be caused by a malignant tumor located in the intestinal wall or reaching it from an adjacent organ. Traumatic fecal fistula caused by a perforating gunshot or stab wound of the abdomen generally heals without surgical interference. In the history of a number of these cases it has been noticed that the openings have closed once or twice and opened again before the final closure has taken place.

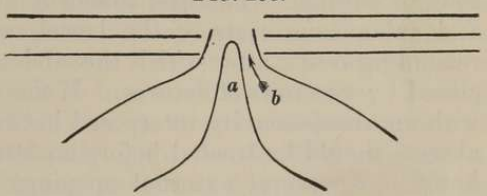
Anatomically and from a practical standpoint it is important to divide fecal fistulæ into two varieties. In the *first* variety the perforated intestine has become or will become adherent to the abdominal parietes or to an adjacent organ over a considerable surface, while the affected segment of the gut remains straight; consequently the lumen of the intestine is not diminished and the fecal circulation is not impaired. For these reasons only a small quantity of intestinal contents escapes through the fistula, while the rest passes *per viam naturalem* (Fig. 292). A fistula of this kind often heals without operative treatment.

FIG. 292.



Intestinal Fistula without Lining of Mucous Membrane: *a*, abdominal wall; *b*, intestinal wall; *c*, mucous membrane; *d*, fistula (Fowler).

FIG. 293.



Artificial Anus: *a*, spur; *b*, direction of fecal current (Fowler).

In the *second* and more troublesome variety the opening in the gut is larger, and, in case a whole loop of the intestine has sloughed, represents the entire circumference of the lumen of the bowel, the afferent and efferent tubes lying side by side like the parallel tubes of a double-barrelled gun (Fig. 293). The feces are, in consequence, diverted toward the external opening incessantly and with force, rendering the case incurable so long as this condition remains. If the bowel has not been destroyed in its entirety, but has suffered a lateral defect of considerable dimensions, the affected loop becomes flexed, the apex of the flexion corresponding with the opening in the gut: the wall opposite the opening is then thrown into a projection technically called a septum or spur, which directs the contents of the intestine toward the opening, and according to the length and direction of this spur a large part or the whole of the contents escape through the fistula.

The length of the fistulous tract from the external opening to the intestine varies from half an inch to eight or more inches, its direction often being circuitous and difficult to follow. This is especially the case if the intestine has become adherent to the floor of the pelvis and the perforation has given rise to extensive phlegmonous inflammation, the formation of an abscess, and finally a fecal fistula. The location of the fistulous opening in the intestinal canal is often not easily determined. If the perforation exists below the ileo-cæcal opening, the discharge consists of feces; if it is above this point, the discharge

is more fluid, is devoid of offensive odor, and on closer examination is found to be not feces, but chyle from the small intestine. Rectal insufflation of hydrogen gas may be an important aid in locating the intestinal opening. If it is below the ileo-cæcal valve, the gas will escape from the fistulous opening under slight pressure, without much distention of the abdomen, and prior to the sound indicating that the gas is passing through this valve.

No specific rules can be laid down for the surgical **treatment** of intestinal or fecal fistula. The treatment must necessarily vary according to the location and size of the opening in the gut, the length of the fistulous tract, and the condition of the intestine at the seat of perforation. If the opening in the bowel is small and no obstacle exists to the passage of the intestinal contents, healing frequently takes place without surgical interference. A spontaneous cure is hastened in such cases by clearing out the intestinal canal thoroughly by cathartics and injections and placing the patient subsequently for several weeks on a liquid diet, with rest in bed. The fistulous tract should at the same time be rendered as nearly aseptic as possible by the use of the curette and peroxide of hydrogen, and the external opening protected against infection from without by an antiseptic hygroscopic compress. If the intestine has become adherent to the abdominal wall, and if the opening in the gut can be easily reached by an incision through the abdominal wall without opening the peritoneal cavity, an attempt should be made to close it by suturing. The fistulous tract is excised carefully and the whole wound closed by at least four rows of sutures. The first row of fine silk sutures should embrace the mucous and submucous coats of the bowel, while the second row approximates the remaining coats, after which the abdominal wall over the intestine is carefully closed by two rows of sutures. If the external fistulous opening communicates with an abscess-cavity interposed between it and the intestinal perforation, the abscess should be treated before an attempt is made to close the opening in the bowel. If several external openings are present, these should be united by incisions which will expose the suppurating or granulating cavity between the bowel and the external surface for effective treatment, and at least transform the abscess into a simple fistulous tract, if the fistula is not closed, as will be the case occasionally. Treves has successfully dissected out the entire fistulous tract with its walls, sewed up the opening into the gut, and closed the abdominal wound.

In the second variety a cure is impossible without removal of the mechanical obstruction to the fecal circulation at a point opposite the opening in the bowel. The introduction of a rubber tube, as suggested by Banks, for the purpose of gradually forcing the spur out of the way, has not yielded satisfactory results. Dupuytren sought to destroy the septum by an instrument which he devised and which he called an "enterotome." This consists of a couple of steel forceps-like blades, which, being introduced into the canals, are made to compress the septum by the action of a screw. For the sake of safety it is necessary that the instrument should be made to cut its way through the tissues very slowly, so that union may take place between the apposed serous surfaces before the section is completed. In the hands of careful surgeons the use of this instrument has been followed by good results, but its employment is not devoid of danger, neither does the fistula always close after the septum has been divided. Senn has described a method of dealing with fecal fistulæ and artificial anus in cases in which the mucous membrane of the intestinal opening is continuous with the skin, which greatly diminishes the danger of peritonitis and increases the certainty of the result. It consists in closing the intestinal opening by a row of sutures placed transversely to the long

axis of the bowel. After this preliminary closure of the wound the field of operation is thoroughly disinfected. As no intestinal contents escape, the abdomen can be opened and the intestine separated without fear of producing peritonitis. The preliminary sutures are then buried by Lembert sutures, the intestine reduced, and the external incision closed throughout. In four cases complete closure of the intestinal opening and satisfactory primary healing of the external wound were secured. If the intestine is completely detached, the spur will soon disappear spontaneously after this method of operating. The treatment of intestinal fistula by laparotomy, resection, and enterorrhaphy under strict antiseptic precautions has been most encouraging. Unless special indications are present, the abdomen is to be opened in the middle line for fistulæ communicating with the small intestine, and laterally for fecal fistulæ. The adherent perforated portion of the bowel is then separated, special care being taken to prevent fecal extravasation during this step of the operation. If no spur is present and the opening is small, it can be closed by suturing. If the opening is large and a spur has formed, and especially if the adherent loop is much flexed, enterectomy and circular enterorrhaphy or a lateral anastomosis will be necessary for the cure of the fistula and the restoration of the continuity of the intestinal canal.

PART IV.—INJURIES AND DISEASES OF THE PERITONEUM, OMENTUM, AND MESENTERY.

The peritoneal cavity is anatomically and physiologically a large lymph-sac which is noted for its capacity of absorption. Large amounts of absorbable aseptic fluid and solid substances are removed from it in this manner in a remarkably short time when the peritoneum is in a healthy condition. During the pre-antiseptic period this cavity was a *noli me tangere* to the surgeon, as it was well known that open wounds usually gave rise to fatal peritonitis. Recent researches have shown that the peritoneum is not so susceptible to the action of pathogenic microbes as many of the other tissues, provided the abdominal cavity can be kept free from fluids which serve as a nutrient medium for pathogenic micro-organisms and the peritoneum itself is in a healthy condition.

Wounds.—Wounds of the peritoneum heal with remarkable rapidity if the peritoneal surfaces are kept in uninterrupted contact by mechanical means. Within a few hours firm adhesions will take place by the interposition of plastic material, and the definitive healing is often nearly completed within a week or two. The process of repair may be hastened by scarification. Wounds of the peritoneum should always be closed by suturing wherever this is possible, as otherwise it is very probable that organs brought in contact with them will become permanently adherent, and unsutured wounds of the parietal peritoneum might become the starting-point of a ventral hernia. In the treatment of all visceral wounds of the abdominal organs it is important that they should be made as nearly extra-peritoneal as possible by suturing the peritoneum over them after uniting separately their deeper portions. If it is deemed necessary that the operation should be completed as speedily as possible, this can be done by the continued suture. Wounds in the mesentery should be closed, for if this is not done a loop of intestine may become ensnared in the rent, causing acute intestinal obstruction.

Foreign Bodies.—The tolerance of the peritoneum to the presence of aseptic foreign bodies is remarkable. It has been shown by experiments on animals that large fragments of aseptic tissue are removed by absorption within a short time. Aseptic fluids, such as blood, serum, and saline solutions, are

promptly removed by the same process. Aseptic metallic and other substances incapable of removal by absorption become encapsulated and remain harmless in the peritoneal cavity. Bullets should be removed only in case they can be found without extra loss of time and can be extracted without involving additional risk. If the patient recovers from the injury, the bullet becomes encysted and seldom causes further mischief.

In the **treatment** of penetrating wounds of the abdomen by laparotomy it is essential to search for and remove *septic* foreign bodies, as fragments of clothing, splinters of wood, etc., which, if allowed to remain, will become the cause of septic peritonitis; but no time should be lost in search for bullets and other small projectiles.

PERITONITIS.

For good reasons the existence of primary or so-called idiopathic peritonitis is considered more than doubtful by most modern surgeons, and it has become the routine practice to search for a local cause in every instance, with a view of adopting a rational course of treatment. The pathology, prognosis, and treatment of peritonitis vary according to the causes which produce it. The most favorable cases are those in which the inflammation is produced by an aseptic cause, such as a trauma or the action of a chemical irritant, and an inflammation of this type is termed plastic peritonitis.

Plastic Peritonitis is a purely regenerative process, and should not be classed with the inflammatory affections. It is produced by aseptic causes, remains limited to the seat of trauma or chemical irritation, and does not extend much beyond the surface-area to which the stimulus was applied. The general febrile disturbance which accompanies it is caused by the introduction into the circulation of the products of coagulation-necrosis or metabolic tissue-changes. A plastic peritonitis attends every healing of an aseptic wound of the peritoneum or subcutaneous injury of this structure unattended by infection. The existence of this form of peritonitis is indicated by circumscribed pain and tenderness and rigidity of the abdominal wall corresponding to the inflamed area. It leads to the formation of firm adhesions, which, however, in the course of time may disappear in part or completely. The prognosis is favorable. In the treatment rest and opiates to relieve pain, and a limited diet, are of the greatest importance. Hot fomentations are more agreeable to the patient than the use of cold, and have a favorable influence in limiting the disease.

Septic Peritonitis.—All forms of progressive peritonitis can be said to owe their origin to a septic cause, but the adjective septic is here used to designate a form of peritonitis which destroys life before the peritoneum has undergone any serious pathological changes. Death results in a short time, sometimes within twelve hours, from the absorption of septic material from the peritoneal cavity. The peritoneum in such cases, aside from increased vascularity, presents no well-marked macroscopical changes. This disease is well known to obstetricians as the most virulent form of puerperal fever, resulting from infection through the lymphatic vessels of the uterus. It is also frequently caused by perforation of an intestinal ulcer or an abscess into the free peritoneal cavity, and by gangrene of an intestinal loop caused by internal strangulation and after abdominal section. It is ushered in by a chill or symptoms resembling those of shock; the pulse runs up to from 140 to 160 beats per minute within a few hours, and remains constantly high. The temperature is often subnormal, and remains so during the whole course of the disease. Retching and vomiting are prominent and distressing symptoms. Abdominal distention is often well marked; in other cases it is completely absent. In perforative sep-

tic peritonitis (from appendicitis) the pain is usually very intense and diffuse, but in the septic form of peritonitis after abdominal section, and when the disease occurs during the puerperal state, it is not unfrequently entirely absent. Delirium and dry tongue are almost always present. The duration of the disease seldom extends beyond a week. Death is caused by toxemia. Patients are often pulseless for twenty-four hours, with cold, livid extremities and bathed in a clammy perspiration before death.

As this form of peritonitis almost uniformly proves fatal, the **treatment** should be prophylactic rather than curative. As it is caused by infection with pus-microbes, it can be prevented only by guarding against their entrance into the peritoneal cavity through a wound, and by the early removal of suppurating foci which threaten to rupture into the peritoneal cavity. After the disease has once become fully developed, even flushing of the abdominal cavity is powerless to check its progress. The treatment must be purely symptomatic. If septic material has accumulated in the abdominal cavity, it should be removed by flushing with Thiersch's solution of salicylic acid, and reaccumulation prevented by securing drainage. The heart's action is to be kept up by alcoholic stimulants, champagne or brandy, up to a point just short of intoxication, and by subcutaneous injections of camphorated oil or strychnine; in short, life should be supported until elimination of the septic micro-organisms can be accomplished through the excretory organs, while the surgeon assists the system in the process of elimination by drainage and flushing of the abdominal cavity.

Fibrino-plastic Peritonitis.—This is a combination of plastic peritonitis and septic peritonitis, and was first accurately described by Mikulicz. An attempt at localization takes place by the formation of numerous adhesions between the intestinal coils and between them and the parietal peritoneum and adjacent organs. It results from the same causes as septic peritonitis, only that probably the quantity of septic micro-organisms introduced is less or that the resisting powers of the peritoneum or the system are greater. If life is sufficiently prolonged, the disease often terminates in a circumscribed suppurative peritonitis.

Suppurative Peritonitis.—Etiologically, septic peritonitis and suppurative peritonitis are identical; clinically, they differ in so far that septic peritonitis is generally diffuse and leads to a rapidly fatal termination, while what is known as suppurative peritonitis is more frequently circumscribed and more amenable to surgical treatment. Both forms are caused by infection with pus-microbes. In the purely septic variety death results from sepsis before suppuration has occurred, while in suppurative peritonitis the pyogenic microbes are either fewer in number or meet with conditions less favorable to the production of a fatal dose of ptomaïnes, or, finally, the peritoneum is in a condition which is unfavorable for the entrance of pyogenic microbes or their ptomaïnes into the circulation.

Experimental research has demonstrated that in the causation of suppurative peritonitis two conditions must be present at the same time: 1, the presence of pyogenic bacteria; 2, a wound of the peritoneal surface or an antecedent pathological condition which diminishes the absorptive capacity of the peritoneum. The microbic cause is the essential etiological factor, as without it the other conditions would not result in this form of peritonitis. Serum or blood in the peritoneal cavity prevents the speedy removal of pyogenic microbes by absorption, and if they remain they multiply and produce their specific pathogenic effect on the peritoneum.

In addition to the ordinary pus-microbes it has been found that the bacillus coli communis and the pneumococcus are occasionally the etiological

factors in the production of peritonitis. In the case of the former microbe it is probable that infection takes place through a damaged intestinal wall and independently of the existence of a suppurating depôt in any of the abdominal organs.

In suppurative peritonitis pain, as a rule, is more pronounced and constant than in the septic variety, and the disease is usually attended by a rise in the temperature to 102° or 104° F. Rigidity of the abdominal muscles is a constant symptom in all forms of acute peritonitis. Vomiting and obstinate constipation are often such prominent symptoms that it becomes difficult to make a differential diagnosis between peritonitis and intestinal obstruction. Arrest of the fecal circulation may be caused by tympanites alone, while perforative peritonitis is attended by a local and general shock, causing intestinal paresis by the inhibitory action on the sympathetic nerves. In differentiating between these two conditions it must be remembered that in the absence of a swelling absolute constipation and fecal vomiting are the most characteristic symptoms of obstruction, and that in most cases of peritonitis the pain is severe and continuous, with diffuse tenderness, tympanites, and absence of visible intestinal coils. In mechanical obstruction of the bowels the temperature is usually not above normal unless complications have set in, while in peritonitis a rise in temperature is the rule, although in some of the gravest cases the temperature is subnormal. Many cases of alleged recovery from intestinal obstruction without operation undoubtedly were cases of adynamic obstruction, and the recovery was either entirely spontaneous or facilitated by means which assisted in the restoration of peristaltic action.

In perforative peritonitis and peritonitis with putrefaction the presence of gas in the free peritoneal cavity gives rise to an important physical sign. In tympanites from peritonitis without perforation and intestinal obstruction the distended intestines push the liver in an upward direction; hence on percussion the liver dulness remains, but is transferred higher up. But under the circumstances mentioned above the gas in the free abdominal cavity occupies the space between the liver and the chest-wall; consequently the liver dulness has disappeared and the whole right side of the chest is tympanitic on percussion. Tympanites is often a most distressing symptom in circumscribed peritonitis, but may be entirely absent in the most fatal form of this disease. In suppurative peritonitis the presence of pus in considerable quantity is indicated by the physical signs arising from the accumulation of fluids either in the free peritoneal cavity or in a circumscribed portion of it. If the pus is not confined by adherent intestines and plastic exudation, it will gravitate toward the most dependent portion of the peritoneal cavity, and on this account the area of dulness will vary according to the position of the patient. In circumscribed suppurative peritonitis (peritoneal abscess) the pus is confined in a limited space by adherent abdominal organs and fibrinous exudation, and will then present all the signs and symptoms of a deep-seated abscess. To determine the character of the peritoneal effusion or of the contents of a circumscribed intraperitoneal inflammatory swelling it is necessary to resort to an exploratory puncture. The needle is inserted at a point where the fluid is in contact with the abdominal wall, and, in the circumscribed forms of peritonitis, at a place where the puncture can be made without traversing the free abdominal cavity.

Treatment.—For years it was the universal practice to resort to the use of opium in the prevention and treatment of peritonitis, until Tait showed the fallacy of this treatment and recommended saline cathartics in threatened cases of peritonitis. The explanation of the beneficial effect of this treatment consists in the fact that a brisk saline cathartic promotes the absorption of fluids

from the peritoneal cavity, and by so doing removes the indirect cause of peritonitis and at the same time favors the elimination of pyogenic microbes. Intra-abdominal wounds and dead tissue of all kinds favor the development of peritonitis in the same way as blood or serum.

The proper prophylactic treatment of peritonitis, therefore, consists in guarding against the ingress into the peritoneal cavity of pyogenic microbes by following the strictest antiseptic precautions in all operations which necessitate abdominal section, and by preventing the accumulation of putrescible material in the abdominal cavity by a careful toilet of the peritoneal cavity after the completion of the operation; and, when the conditions are such that reaccumulation is likely to ensue, by establishing free drainage.

In perforative peritonitis cathartics are absolutely contraindicated, as increased peristalsis would aggravate the existing conditions by increasing the extravasation and by preventing limitation of the infection. Of the beneficial effect of the use of such drugs in the prevention and treatment during the early stage of septic and suppurative peritonitis from other causes mention has been made above. In perforative peritonitis opium should be administered to diminish the peristalsis, to relieve pain, and to diminish shock. Unless the location of the perforation can be ascertained beforehand, the incision should be made in the median line. If on opening the peritoneal cavity the perforation cannot be readily found, it is better to resort to rectal insufflation of hydrogen gas at once, which will probably show not only that a perforation exists, but also its exact location. The perforations are treated in the same manner as an incised wound. Care must be taken to suture the opening in a direction that will interfere the least with the lumen of the intestine. After suturing the perforation the abdominal cavity is washed out freely with warm sterilized water or Thiersch's solution. Drainage in these cases must never be omitted, as the operator has no assurance that the peritoneal cavity has been rendered perfectly aseptic. A threatened septic peritonitis after laparotomy can often be aborted by giving half an ounce of sulphate of magnesium, dissolved in a glassful of water, upon the appearance of the first symptom. The action of the saline cathartic can be hastened and its beneficial effects increased by the administration of a turpentine enema. After the bowels have been thoroughly moved, opium should be given in sufficient doses to relieve pain. If the symptoms do not subside under this treatment, the abdominal wound should be opened sufficiently to permit free irrigation with salicylated or sterilized water, a Keith drain, loosely packed with iodoform gauze, inserted, and a copious antiseptic hygroscopic dressing applied.

In opening the abdomen for the evacuation of pus the surgeon must look for a primary lesion, but he will not always find it, as it is not invariably present. If the primary cause is found, it should be removed, if possible, and if this cannot be done, free drainage from the primary focus must be established. Localized suppurative peritonitis brought about by curable causes is amenable to successful surgical treatment. An operation is always indicated as soon as the presence of pus is ascertained. Delay is dangerous in these cases, as the delicate walls, composed of plastic exudation, may yield to the pressure, and the extravasation of pus infect a new portion of the peritoneal cavity or perhaps its entire extent. In circumscribed suppurative peritonitis the incision is to be made at a point where the pus is in contact with the abdominal wall. If, on cutting through the peritoneum, no pus is found and the free peritoneal cavity has been opened, it is not safe to evacuate the pus until the peritoneal cavity has been shut out by suturing the abscess-wall to

the parietal peritoneum or packing the wound for a few days with iodoform gauze, postponing the opening of the abscess until firm adhesions have formed between the margins of the wound and the surface of the abscess-wall. This method of operating in two stages must be frequently resorted to in the treatment of pelvic and visceral abscesses. All operations for suppurative peritonitis are to be conducted upon rigid antiseptic principles, and antiseptic measures are to be followed without relaxation during the entire after-treatment. As patients suffering from peritonitis are always greatly debilitated from the effects of the disease, as well as from lack of solid food, which for obvious reasons must be withheld, every effort should be made to sustain strength by the systematic administration of liquid nourishment, by nutritive enemata, and by alcoholic stimulants. Absolute rest must be enforced, for the purpose of limiting the extension of the disease and with a view of aiding the process of repair.

Tubercular Peritonitis.—Tubercular peritonitis occurs as one of the lesions of acute general tuberculosis, with chronic pulmonary phthisis, with tubercular inflammation of the genito-urinary tract, and as a local inflammation. The form of tubercular peritonitis which interests the surgeon is the local form, in which the disease occurs in the peritoneal cavity as a primary lesion. Kümmell regards this form as a purely local affection, amenable to surgical treatment in the same sense and to the same extent as a tuberculosis of joints. A considerable number of such cases have been permanently cured by abdominal section: in one of the first cases operated upon by Sir Spencer Wells the patient remained in perfect health for twenty-six years after the operation. The effect of the bacillus of tuberculosis on the peritoneum is not uniform, and the conditions found in peritoneal tuberculosis are variable: as a result a number of forms of localized tuberculosis of the peritoneal cavity have been described. Of these the following may be mentioned; but only the first variety of tubercular peritonitis here described is amenable to successful surgical treatment.

Tubercular Ascites.—In this form the peritoneum is thickened, hyperemic, and studded with masses of tubercle-tissue in the form of miliary nodules. If the effusion is general, occupying the whole peritoneal cavity, the adhesions are few and slight. If the fluid is encapsulated, the walls of the cavity are formed by intestinal loops which are adherent among themselves and to the surrounding structures. The circumscribed form usually takes its origin from the floor of the pelvis, and often gives rise to a swelling which simulates an ovarian cyst to perfection. The fluid which causes the dropsy is either a clear, transparent serum or serum in which small flocculi are suspended, or which has become slightly turbid from the admixture of the products of retrograde tissue-metamorphosis. Coagulation-necrosis and caseation of the nodules appear to be retarded for a much longer time than in cases of glandular tuberculosis. The amount of fluid may vary from a teacupful in the circumscribed form to from four to six gallons in diffused tubercular ascites. Secondary infection is found most frequently in the spleen, pleura, and lymphatic glands.

Fibrino-plastic Tubercular Peritonitis.—In this variety of tubercular peritonitis no serum is found in the peritoneal cavity. The peritoneal surfaces, which are studded with miliary tubercles, are covered by a thick layer of gelatinous fibrin which cements together all the adjacent serous surfaces, so that the whole abdominal cavity appears to be filled with a large, boggy mass composed of all the viscera adherent to one another, and with the interspaces filled with fibrin.

Adhesive Tubercular Peritonitis.—In this form the primary inflammatory

exudation is slight, but the endothelial cells proliferate and form new tissue, which undergoes cicatrization, giving rise to firm and extensive adhesions. The plastic peritonitis may be so extensive as to cause intestinal obstruction from perfect immobilization of a large portion of the intestinal tract. In this as well as in the foregoing form of tubercular peritonitis ulceration of the intestine may take place, resulting in the formation of a bimucous, internal fistula if the openings in two adjacent loops correspond, or in the formation of a fecal abscess, terminating later in an external fecal fistula.

Diagnosis.—The diffuse variety of tubercular dropsy of the peritoneal cavity might be mistaken for ordinary ascites or for a large single cyst of the ovary or some other abdominal organ. Ordinary ascites is usually caused by cirrhosis of the liver, malignant disease of the omentum or peritoneum, and valvular disease of the heart; and if these conditions are absent there is good reason for suspicion that the effusion has resulted from a tubercular inflammation of the peritoneum. The circumscribed form of tubercular ascites might be simulated by a small ovarian cyst, pregnancy, pyosalpinx or hydrosalpinx, pyonephrosis or hydronephrosis, cyst of the pancreas, a distended bladder, an enlarged gall-bladder, and pelvic abscess. All of these conditions must be kept in view in making a differential diagnosis. An exploratory puncture may become necessary before rendering a positive opinion.

Treatment.—Abdominal section with drainage has proved most useful in arresting the disease if the dropsy is circumscribed. After evacuation of the fluid the parts should be well dried and dusted lightly with iodoform. The abdominal cavity must be drained with a Keith's large glass tube loosely packed with iodoform gauze: the capillary action of the gauze transfers the fluid, which is secreted constantly, into the hygroscopic antiseptic dressing. The drain is allowed to remain as long as fluid escapes, which is often the case for several weeks and sometimes for months. Good results have been obtained by tapping, followed by injection of half an ounce of a ten-per-cent. emulsion of iodoform in glycerin or in twenty-five per cent. boro-glyceride. If reaccumulation of fluid takes place, the same procedure can be repeated after an interval of two weeks. In operating for circumscribed tubercular ascites it is very important to exercise great care in opening the abdominal cavity, as a loop of adherent intestine may be found at the point where the incision is made. The peritoneum must be recognized and carefully divided, in order to avoid wounding of the bowel should such a condition be met with. If any caseous foci are found, they should be removed with a sharp spoon, or they can be destroyed or rendered harmless by ignipuncture and thorough iodoformization. A tubercular salpingitis calls for removal of the affected appendage.

DISEASES OF THE OMENTUM.

The omentum being only a duplicature of peritoneum, between the layers of which more or less fat is found, and being in contact with the parietal and visceral peritoneum, it is not surprising that this structure almost without exception participates in all the acute and chronic inflammatory affections of the peritoneum. It is a well-known pathological fact that in injuries and circumscribed inflammatory lesions of nearly all the abdominal organs the omentum becomes adherent to the affected region, and in this manner furnishes a valuable protection for the peritoneal cavity against extravasation through small intestinal wounds and perforations.

Cysts.—Cysts of the omentum of non-parasitic origin and non-malignant

in character are exceedingly rare. They can be readily removed by enucleation or extirpation. In the latter case it is necessary to guard against hemorrhage by tying in small sections the part of the omentum which has to be cut through with fine silk ligatures before the division is made. Solitary echinococcus cysts are extremely rare. Disseminated echinococcus cysts from rupture of a mother-cyst in the liver or its vicinity are occasionally met with, but their removal by operative procedure is usually impracticable. An isolated echinococcus cyst of the omentum is to be treated in the same manner as when the cyst is located in the liver; that is, by an operation in two stages.

Malignant Tumors.—Primary carcinoma of the omentum does not occur, as the essential matrix for carcinoma, epithelial cells, is not found in the omentum. A primary malignant tumor which springs from the omentum is always a sarcoma. When the tumor has attained considerable size it is easily recognized, as it is located immediately underneath the abdominal wall, and adhesions to surrounding surfaces do not take place at an early stage of the disease, and consequently the tumor remains movable for a long time. If the tumor has attained a large size and involves the omentum over its whole extent, it is flattened out and feels under the abdominal wall very much like the back of a large turtle. Not long ago one operator removed such a tumor that weighed forty pounds. Sanguineous tumors of the omentum have been described by Reamy, Doran, Thornton, and Gardner, but these are only a vascular variety of sarcoma. If primary malignant disease of the omentum could be recognized before the disease had extended to adjacent organs, a radical operation for its removal could be done with a fair prospect of a permanent cure. In such cases it would be necessary to divide the omentum some distance from the tumor between ligatures, or between ligatures and clamp forceps on the tumor side.

CYSTS AND TUMORS OF THE MESENTERY.

Cysts.—Cysts between the peritoneal layers of the mesentery containing serum or a sanguineous fluid have been successfully removed by operative treatment. Chylous cysts, resulting from the obstruction of a chyle-duct and the retention of secretion behind the seat of obstruction, sometimes attain the size of an adult's head. Carson of St. Louis cured such a case by abdominal section and drainage. Extirpation of a cyst of the mesentery should not be attempted, as it is attended by troublesome hemorrhage, and the obliteration of a number of mesenteric vessels might be followed by gangrene of the intestine. These cysts can be dealt with successfully by incision and drainage. It is preferable to make the operation in two stages. The incision in the abdominal wall is made over the most prominent portion of the swelling, and the cyst-wall is stitched to the incised parietal peritoneum and the wound packed with iodoform gauze. In about five days the dressing is removed, and the cyst incised and drained. It is important that strict antiseptic precautions should be observed, not only before and during the operation, but until the cyst is obliterated, in order to prevent suppuration in the interior of the cyst, an event which would indefinitely postpone recovery or even endanger life.

Tumors.—The only tumor of the mesentery which deserves mention is lipoma. Lipoma of the mesentery has been subjected to operative treatment by Ellis, Homans, Terillon, and others. The removal of such tumors when they are of large size, as in the two cases reported by Homans, is an exceedingly difficult and dangerous operation, and unless they give rise to serious symptoms it is best to be content with the exploratory laparotomy should the relations of the parts indicate great difficulties in effecting enucleation.

PART V.—DISEASES AND INJURIES OF THE LIVER, GALL-BLADDER, SPLEEN, AND PANCREAS.

SECTION I.—THE LIVER.

HYDATID CYSTS OF THE LIVER.—Hydatids are found in connection with the liver more frequently than with any other organ. The cysts vary greatly in size, and are usually single, but may be multiple. They are found in every part of the liver—in the center, at the upper border, where they may project into the thorax, and on the lower surface, where they escape from under the free border of the liver and may even fill the greater part of the abdomen, and be mistaken for cysts of the ovary.

Symptoms.—A tumor is present in the right hypochondriac or epigastric region; it is painless and does not interfere with the general health. A hydatid fremitus has been noted by some, but this sign is uncertain. If the tumor is behind the liver, it may push it forward and increase the area of liver dulness. When enlargement is great, symptoms such as œdema of the lower extremities may arise from pressure on the inferior cava. The tumor in some cases is liable to enlarge very rapidly, and to become inflamed and suppurate, or rupture may take place into the abdominal cavity. It is often a most difficult affection to diagnosticate from cancer or other tumor of the liver, and when suppurating it is not readily distinguished from abscess of the liver. The pus of a hydatid tumor has a peculiar odor. The diagnosis may often be cleared up by the aspirator. Should the fluid evacuated contain hooklets and scolices, all doubt as to the character of the tumor is at an end. König condemns preliminary aspiration, considering it dangerous. He prefers to open the abdomen at once in doubtful cases and examine the tumor. Should the case not prove to be one of hydatids, the operator will be in a position immediately to remove the tumor if practicable.

Treatment.—Although the existence of hydatids in the liver is compatible with a fairly comfortable existence, and most medical authorities advise non-interference when there are no distressing symptoms, still the success of operative treatment has been so great that it is advisable when hydatids have been diagnosticated to proceed at once to operation. Simple aspiration has been successful in many cases, but more recent authorities state that by this method of treatment the mother cyst has not been removed, and that relapses frequently occur after apparent cure. When suppuration has set in, some surgeons yet advocate the employment of a large trocar and canula and the frequent washing out of the cyst with iodine, Condy's fluid, carbolic acid, or other antiseptic; but operative measures have proved so safe that most modern surgeons do not hesitate to recommend them. The operation may be performed in either one or two stages:

Operation in One Stage.—Lindemann was the first to recommend this mode of operating, and Landau and König both practise it in preference to Volkmann's operation in two stages. Tait also advocates performing the operation in one stage. All antiseptic precautions having been taken, as in other operations on the abdomen, an incision is made over the most prominent part of the tumor down to the peritoneum. This is then carefully opened and the edges packed round with sponges. The tumor is incised, the contents are evacuated, and the edges of the cyst sewed to the abdominal wound, the sponges being withdrawn as the stitches are introduced. Silk or catgut may be used. A large drainage-tube should be introduced into the cavity and the wound dressed antiseptically. In cases where the cyst is covered by a considerable thickness of liver, an aspirating needle should first be introduced to make sure of the character of the contents, the liver incised, and the finger thrust through the

opening to prevent hemorrhage, which can usually be controlled by sponge pressure. The edges of the opening in the liver should next be stitched to the abdominal wound, and a large drain introduced into the cyst and a dressing applied. The stitches in the liver usually hold well. Tait, in a case where he accidentally opened a large sinus, arrested the hemorrhage easily by passing a thread down on one side of the sinus and up on the other and tying it. Landau before incising the liver recommends the passing of deep sutures parallel to the axis of the wound at each angle. These sutures should be of strong silk, and should include the abdominal wall as well as the cyst-wall.

Operation in Two Stages.—This operation, which was first recommended by Volkmann, is easily performed. An incision is made along the lower margin of the ribs over the cyst down to the peritoneum: all bleeding having been arrested, the peritoneum is incised the whole length of the wound, and then the wound is dressed with iodoform gauze or other antiseptic dressing. Adhesions between the parietal peritoneum and that covering the tumor are usually pretty firm in five or six days, when the tumor may be incised, the contents evacuated, the cavity washed out with antiseptic solution, and a drainage-tube introduced. This operation has been most successful, and is, perhaps, safer than the operation performed in a single stage. Some cases of hydatids of the upper surface of the liver have been successfully attacked through the thorax by resecting the ribs. All other methods of treating hydatids of the liver, such as acupuncture, electrolysis, caustics, parasiticide injections, have been superseded by the more scientific operative procedures above described. After operation for hydatid tumor of the liver a biliary fistula sometimes results.

Simple Cysts, and also dermoid cysts, are occasionally found in the liver. These should be treated in exactly the same way as hydatid cysts.

Tumors.—Carcinoma, sarcoma, gumma, lymphoma, adenoma, and erectile tumors are seen in the liver, but usually they are not amenable to surgical treatment. Cases of excision of cancerous and gummatous nodules have been reported, and also of tumors formed by hydatid cysts. Excision of cancerous nodules would usually be of little avail, as, when the liver is affected with carcinoma, it is, as a rule, secondary and the organ is studded with nodules. Carcinomatous tumors of the liver have, however, been successfully removed by Von Eiselsberg and others, and Hochenberg, in a case of carcinoma of the gall-bladder, removed the diseased and the neighboring portion of the liver. Simple tumors of the liver have not infrequently been successfully removed of late, cases being reported by Lücke, Von Bergmann, and Keen. The latter, in a paper, gives a table of 20 cases of liver resection, 16 of which occurred in females; of the 20 cases, 17 recovered. The tumor may be removed by repeated small touches of the cautery—all large vessels being tied. In this way hemorrhage is prevented. In 6 of the cases above mentioned the stump was sutured to the abdominal wound; in the others it was returned into the abdominal cavity.

Abscess of the Liver.—This affection may follow contusions, wounds, etc. It is much more common in tropical than in temperate climates, and is associated frequently with dysentery. Acute hepatitis may terminate in abscess. It may follow operation on the rectum, being due to septic phlebitis. It has followed confinement, with phlebitis of the uterine veins. It is an occasional result of pyemia. Hydatid cysts, by taking on suppurative inflammation, may result in abscess, and abscesses have been excited by the invasion of lumbrici. The predisposing causes are exposure, drinking, irregular habits, and residence in tropical climates.

Symptoms.—The patient usually has had frequent attacks of illness, has an unhealthy look, a rapid pulse, elevation of temperature, vomiting, a furred tongue, and an anxious countenance. He may occasionally have a rigor, or

merely shivering fits. There is a dull, aching pain felt in the liver and sometimes in the right shoulder, and tenderness over the liver; sometimes fluctuation may be made out. When the abscess has attained any size there are fulness and bulging in the right hypochondrium. Jaundice is rare. Should the abscess be on the upper surface of the liver, it may push up the diaphragm and cause shortness of breath; occasionally it may inflame the diaphragm and adjacent pleura and give rise to severe pain.

Diagnosis.—It is sometimes difficult to diagnosticate from inflamed and distended gall-bladder, hydatids, cancer, malaria, pneumonia, etc. The introduction of an aspirating needle will frequently clear up the case. These abscesses may burst into the pleura, lung, or pericardium, may point externally or may open into the intestine or the general cavity of the peritoneum.

The connection of liver-abscess with the *amœba coli* has been carefully worked out by Kartulis, Councilman, and Lafleur, and they have proved beyond a doubt that *amœbæ* are the cause of the large single liver-abscess. In a person suspected of liver-abscess, whether or not there be enlargement of the liver, exploratory aspiration is indicated if *amœbæ coli* be found in the stools. Aspiration is best performed by introducing the needle in the mid-axillary line between the seventh and eighth ribs: too small a needle should not be used.

When a liver-abscess bursts into the pleura it may be mistaken for empyema. The character of the pus is, however, distinctive, for it is of a brown-red color and contains *amœbæ*. Again, the pus may perforate the lung and be coughed up: here the same reddish color and the presence of the *amœba coli* would enable the surgeon to distinguish the affection from simple empyema.

The **prognosis** of liver abscess is usually grave. Septic cases are almost universally fatal, surgical treatment being of no avail.

Treatment.—In tropical abscess surgical treatment is not infrequently followed by success. In some cases the abscess has been cured by aspiration, but if the abscess has been definitely located it should be treated like an abscess anywhere else, viz. by incision and drainage. The incision should be made along the edge of the ribs, near the subcostal angle, and when the liver is reached it should be stitched to the abdominal wound, incised, the abscess evacuated, washed out if fetid, and drained; in fact, treated much in the same way as a hydatid cyst. Some have advised operation in two stages, but in one stage with aseptic precautions the operation has been eminently successful. Abscesses which form on the upper surface of the liver frequently discharge through the lung. They have been successfully attacked through the lower part of the thorax by excising one or two ribs, incising the diaphragm, and draining. It is advisable to sew the parietal and phrenic pleura together before incising the liver through the diaphragm.

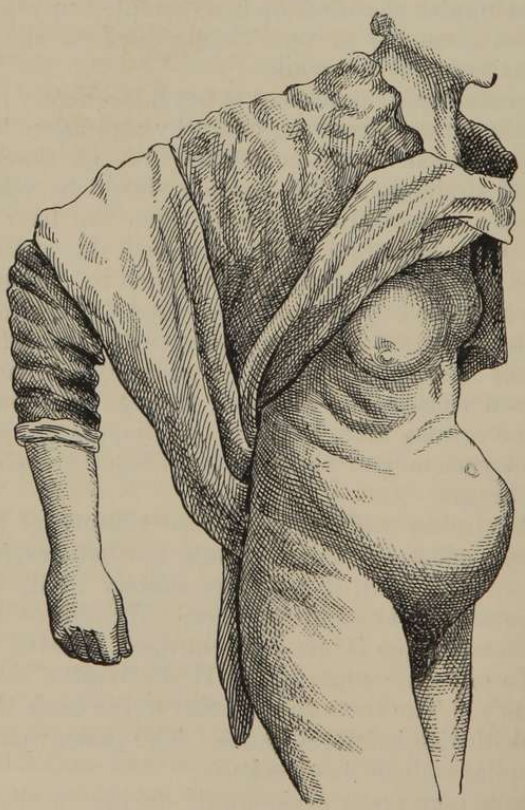
Rupture of the Liver.—An injury sufficient to cause rupture of the liver usually causes equally serious effects in other organs, so that surgical interference ordinarily is of no avail. Still, if not immediately fatal, the abdomen should be opened and the wound brought together. Wounds of the liver substance heal rapidly, and hemorrhage is generally at once arrested by approximating the torn edges. In one case reported by H. E. Walton there was rupture of both liver and kidney. The liver rupture was so far back that it could not be sutured, so was packed with iodoform gauze. The patient made a rapid recovery, going out of hospital well in five weeks.

Wounds of the Liver.—These may occur accidentally during an operation or be produced by stabs, bullets, etc. Many cases of recovery after punctured and incised wounds of the liver are reported by Otis in the *Medical and Surgical History of the War of the Rebellion*. Cases of recovery are reported

after a bullet had passed completely through the liver. Should the case be complicated by wound of the stomach, spleen, kidney, or great vessels, it is very unfavorable. In cases of incised or gunshot wounds of the liver the proper course is to open the abdomen and suture the wounds. In suturing the liver it is important to place the sutures at some distance from the edge of the wound. No doubt in the future a quicker resort to laparotomy in wounds of the viscera will save many lives, and surgeons will no longer be willing to stand by and see the patient die without attempting some form of surgical relief.

Resection of Portions of the Liver.—Portions of the liver have been of late successfully excised both by the knife, by the thermo-cautery, and by the elastic ligature applied externally after suturing the liver to the margins of the abdominal incision. Langenbuch records a case in which he successfully removed the greater part of the left lobe in a woman aged thirty. The lobe had been extensively deformed by tight lacing, and caused serious inconvenience. There was considerable hemorrhage, but the vessels were secured and the woman made a good recovery. Portions of the liver, the seat of hydatid cysts, have also been successfully removed by the thermo-cautery and elastic ligature. Nodules of cancer and gummata have been excised, but with no great permanent benefit to the patient, the operations having usually been based on mistaken diagnoses. Portions of the liver have extruded from the abdominal wound, and have been removed successfully. Free hemorrhage sometimes occurs in operating on the liver, which is usually rapidly arrested by tamponing with iodoform gauze and securing the bleeding vessels.

Fig. 294.



Floating Liver.

Floating Liver.—In this rare malady the liver forms an abdominal prominence which can be moved about, which is apt to transmit aortic pulsations, and which changes its situation as the patient shifts her attitude. This condition usually arises from a lax abdominal wall following repeated pregnancies. Fig. 294 exhibits a typical case verified by a post-mortem.

The only **treatment** is the use of an abdominal belt. Possibly operative measures for its fixation might be of use.

Gall-stones and Distention of the Gall-bladder.—Gall-stones, or biliary calculi, occur more frequently in women than in men. They are rare in

infancy and childhood. Tight lacing, by obstructing the flow of bile, and hence leading to its inspissation, is one of the causes of gall-stones. High living and want of exercise also favor their formation. They occur of all sizes, from that of a grain of sand to that of a hen's egg. Gall-stones are most frequently multiple, and are then faceted by reciprocal pressure—a valuable point in diagnosis when a stone has been passed and found in the stools—but when of large size they are usually single or double. When small they occur in large numbers, several thousands having been found in one person (Otto). When small and numerous the patient frequently passes them, and they may be found in the stools. The passage of gall-stones from the gall-bladder to the duodenum is attended by vomiting and intense pain, which is relieved only by full doses of morphine, administered preferably hypodermatically. After an attack of biliary colic, jaundice, to a greater or less extent, is observed. If the urine be examined, bile-pigment will often be discovered in it, even if there be no jaundice.

The conditions which call for surgical interference may be caused by the arrest of the gall-stone in its passage to the intestine, either in the cystic or in the common duct. When arrested in the common duct there is obstruction to the outflow of bile, and the gall-bladder becomes enlarged, and may be felt as a rounded, pear-shaped tumor under the edge of the right lobe of the liver. The contents are not usually bile, but may be mucous, muco-purulent, or purulent fluid. A greatly distended gall-bladder has been mistaken for ascites, and has been tapped for ovarian tumor, hydatids, etc. The bile-duct may become obstructed also by the pressure of tumors involving neighboring organs, as the stomach, pancreas, or liver, or it may become occluded by the spread of cancerous diseases commencing in the contiguous organs. Gall-stones are not infrequently the accompaniment of cancer of the liver, as obstruction to the flow of bile favors their formation. Obstruction of the *common* duct is always accompanied by jaundice, but the *cystic* duct may be occluded and give rise to grave symptoms without there being any trace of jaundice or any history of biliary colic. Not a few cases of enlarged gall-bladder thickened and altered by inflammation are difficult of diagnosis, owing to the downward displacement of the liver from tight lacing or other causes. Such tumors have been mistaken for diseased or floating kidney, malignant disease of the bowel, etc. On the other hand, cancerous nodules in the liver have been mistaken for diseased gall-bladder and the abdomen opened. In many cases there is no distention of the gall-bladder, but, on the contrary, it is small and surrounded by thick adhesions produced by the presence of the calculi.

Rupture of the Gall-bladder.—Several cases of this accident have been reported as successfully treated by incision and drainage (Lane) or by aspiration (I. Bell). In these cases large quantities of bile escaped into the abdominal cavity. Peritonitis does not necessarily follow, as the bile is usually aseptic.

Suppuration of the gall-bladder not infrequently occurs, and this adds much to the seriousness of the case. The obstruction in these cases is nearly always situated in the cystic duct. In some cases the gall-stones may ulcerate through the gall-bladder into the stomach, duodenum, or colon, and in this way large stones have escaped from the gall-bladder and afterward have produced obstruction of the bowels. For the relief of the conditions of the gall-bladder above described two operations have been devised, viz. *cholecystotomy* and *cholecystectomy.*

Cholecystotomy is performed for the relief of distention of the gall-bladder from obstruction of the cystic or common duct and for the removal of

calculi. This operation has been very successful. It is essentially of American origin, having been first done by Bobbs of Indianapolis in 1867, and its establishment and practical perfection being due to Marion Sims in 1878. Tait in 54 cases had 52 perfect recoveries. The operation is performed by making an incision over the tumor into the abdominal cavity; then the distended gall-bladder is stitched to the abdominal wound, incised, the fluid evacuated, and the stones removed; a drainage-tube is then introduced, and the wound closed. Bile flows freely from the tube for some time, but after its removal the fistula usually closes in from two to four weeks. Occasionally it remains open and there is a permanent biliary fistula. In such cases the common duct is probably occluded by gall-stones. There is often great difficulty in removing stones impacted in the ducts. Some surgeons have succeeded in piercing the stone with a needle, thus breaking it up and pushing the fragments into the duodenum; others (Tait) break up the stone by using padded forceps from outside the duct; others, again (K. Thornton), have opened the duct, removed the stone, and afterward sutured the duct successfully. Walker has succeeded in dissolving a stone impacted in the common duct by means of ether injected through a sinus left after cholecystotomy. In cases where the stone is lodged near the duodenal opening of the duct, McBurney has successfully removed it by incising the duodenum, slitting up the duct, and thus reaching the stone. Abbe has performed a somewhat similar operation for obstruction of the common duct, but in his case the obstruction was due to a cancerous nodule. In performing the operation of cholecystotomy, Sir Spencer Wells, after evacuating the distended gall-bladder and removing the stones, stitches it up again by continuous suture and returns it. In these cases the gall-bladder is first carefully packed around with carbolized sponges, aspirated, and then drawn out of the wound before being incised. By this means the necessary manipulations are carried on without any danger of the contents of the gall-bladder getting into the peritoneal cavity. In many cases the operation of cholecystotomy, or incision of the gall-bladder, is an easy one, but the operation may present unusual difficulties when the gall-bladder is small and shrunken and cannot be brought to the abdominal wound. In such a condition it may be sutured and returned into the abdomen, as recommended by Küster, or a glass drain surrounded by iodoform gauze may be inserted. Others advise excision, while some fill in the space between the gall-bladder and the abdominal wound by omentum.

Cholecystotomy is the proper operation in cases where the common duct is blocked, and also in cases where gall-stones exist in the gall-bladder, giving rise to repeated attacks of biliary colic. In other cases cholecystectomy may be performed.

Cholecystectomy, or excision of the gall-bladder, was first practised by Langenbuch of Berlin in 1880. His method is as follows: An incision is made in the right hypochondrium, parallel to the lower border of the liver, and is joined by a second incision running along the outer border of the right rectus muscle. The abdomen having been opened, the transverse colon and small intestine are pushed aside by a large sponge; the liver is then elevated, so as to bring the lesser omentum into prominence. The gall-bladder is easily separated from the liver by a few strokes of the knife, and the cystic duct freed and ligated in two places with silk. After removal of the gall-bladder the wound in the abdomen is closed and the operation is completed.

The great point in favor of this operation is the fact that once the gall-bladder is extirpated no more gall-stones are formed. Cholecystectomy is also

advocated in cases where there is degeneration of the gall-bladder and there is no chance of restoring its function, or where the gall-bladder is small, contracted, or perhaps suppurating, so that it cannot be fixed to the abdominal incision.

Cholecyst-enterostomy, or the formation of a communication between the intestines and the gall-bladder, has been successfully performed. This operation endeavors to avoid the formation of a biliary fistula; but of course the danger to the patient is much greater, and the opening is liable to contract.

This operation has of late been frequently performed by means of the smallest-sized Murphy's button. It is a rapid, easy, and comparatively safe method of forming a communication between the gall-bladder and small intestine. In cases in which, after the operation of cholecystotomy, the fistula persists and discharges large quantities of bile, it is a sign that the common duct is occluded and cholecyst-enterostomy should be undertaken, the opening in the gall-bladder closed by Lembert's sutures, and then the gall-bladder should be returned into the abdominal cavity and the abdominal wound closed. It would be well to keep in a drain for a few days, in case any leak should occur in the gall-bladder.

SECTION II.—THE PANCREAS.

Notwithstanding the fact that the pancreas is the most inaccessible of all the abdominal organs, it has been a number of times successfully subjected to operative measures.

CYSTS.—This affection has been fully described by Senn, who comes to the conclusion that all cysts are retention cysts, and are due to cylindrical contraction or obliteration of the common duct or its branches, or to impacted calculi. Cysts are more frequently met with in men than in women, and often follow injury. The cyst usually grows rapidly and is situated above the umbilicus. Gastro-intestinal disturbances, such as vomiting and diarrhea, are common symptoms. The skin has an unhealthy, muddy look, and the pain is sometimes considerable.

The tumor itself is generally well defined and has an elastic feel, as if very tense. If aspirated, the fluid has a brownish color, is alkaline in reaction, digests fat, and turns starch into sugar. The skin about the sinus which is left after operation is often raw and sore. A considerable number of cases are now scattered through medical literature, and not a few have been diagnosticated before operation. Treves has collected 24 cases, and of these 16 were operated on by incision and drainage, with 1 death. Excision has proved very fatal, only 1 case recovering out of 6, and simple tapping has proved fatal in 2 cases. The cyst has been mistaken for hydatids, ovarian cyst, tumor of the kidney, etc.

Treatment.—An incision is made over the tumor down to the cyst, which is then aspirated, pulled gently out of the wound, and incised. After evacuating the contents the cyst should be stitched to the parietal wound and the cavity drained. A fistula may persist for some time.

ABSCESS of the pancreas is sometimes seen, and usually ends fatally, nearly all the reported cases having been found only post-mortem. Should a diagnosis be arrived at, the proper procedure would be to incise and drain.

WOUNDS of the pancreas have been recorded from time to time. Rupture of the pancreas has been seen from severe contusions. Many cases of gunshot wound of the organ are reported, also stab wounds from a knife or other instrument. In such cases portions of the pancreas have protruded from the wound

and have been cut off, with subsequent recovery of the patient. Dargan reports a case where the pancreas was successfully replaced in the abdominal cavity. In cases of severe abdominal wounds where the pancreas is injured the lesion would be discovered in performing abdominal section for the treatment of wounds of other organs. It would be quite justifiable to excise portions of bruised or injured pancreas.

Cancer of the pancreas is so insidious that when diagnosticated it is usually too far advanced for operation.

Portions of the pancreas have been removed during operation on neighboring organs for carcinomatous tumors or other diseases, without bad results.

SECTION III.—THE SPLEEN.

Cysts of the Spleen.—These may be simple, dermoid, or hydatid, and are very difficult to diagnosticate positively without opening the abdomen. Hydatids may be recognized by the fremitus or by an examination of the aspirated fluid. Usually these cysts should be treated like those of the liver, viz. by abdominal incision over the tumor, fixing the cyst-wall to the abdominal wound, incising, evacuating, and then draining.

Carcinomatous and Sarcomatous Tumors of the spleen do not offer any hope of being treated surgically with success.

Abscesses may follow injury or be the result of septic infection, and should be incised and drained with strict aseptic precautions. They are not usually recognized until they approach the surface and fluctuate freely.

Rupture produced by kicks, blows, or other injuries is usually fatal. When accompanied by an external wound the spleen may protrude, and the surgeon may find it necessary to remove it wholly or partially.

Stab or Gunshot Wounds.—If the patient be seen in time, it will be proper to perform abdominal section and endeavor to arrest the hemorrhage by tamponing with iodoform gauze, by ligature of vessels, or even by excision of the spleen if the injury be great.

Splenectomy, or excision of the spleen, has been performed a number of times. Vulpius has collected 117 cases of splenectomy with a death-rate of 50 per cent.; if, however, from these cases those suffering from leucocythemia, lardaceous spleen, spleno-megaly, in which the operation should not be done, be deducted (32), the mortality in the remaining cases (85) is reduced to 33 per cent. The indications for the operation are tumors and cysts, wounds, and movable or dislocated spleen. In leukemia the operation has been invariably fatal from hemorrhage, which is the great danger of splenectomy. Hypertrophied spleens have been successfully removed, but for the most part these cases are not suitable for operation.

Operation.—An incision is made in the left semilunar line, the peritoneum freely opened, and the hand introduced to explore the tumor. All adhesions are separated, and ligated if necessary, and the spleen delivered through the wound, the lower extremity first. Great care should be taken not to twist or drag on the pedicle. The vessels entering the hilum should be clamped, the spleen removed, and then each vessel ligated separately some distance from its extremity. Some advise cutting the pedicle away piecemeal between pressure artery forceps and then securing the vessels. The after-treatment is the same as after ovariotomy.

PART VI.—DISEASES AND INJURIES OF THE RECTUM.

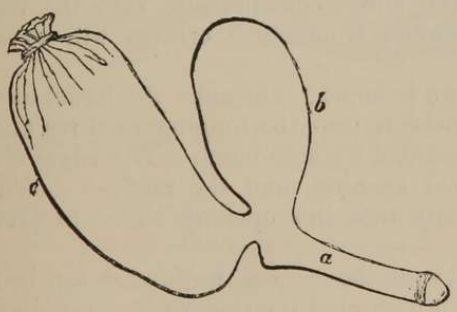
Surgical Anatomy.—The *rectum* in the male is in relation in front with the trigone of the bladder and the seminal vesicles, and in the female with the vagina and uterus. The lower three or four inches are uncovered by peritoneum. It is freely supplied by blood-vessels, chiefly from the superior hemorrhoidal branch of the inferior mesenteric artery. This artery passes down in the mesorectum, and divides into two branches, each of which forms a loop on the side of the bowel, about five inches above the anus. From these loops a number of vessels are given off which pierce the muscular coat and run down immediately beneath the mucous membrane to the anus. There is a branch in each column of the rectum. These arteries anastomose freely with one another, and are connected by lateral branches, but they do not anastomose with the middle and inferior hemorrhoidal arteries, which supply the skin about the anus. From a knowledge of the development of the rectum it will be easily understood that the lower end descends a considerable distance to meet the involution of the skin at the anus, and in descending carries with it its own vessels, the superior hemorrhoidal. The veins have much the same anatomical arrangement as the arteries.

Ischio-rectal Fossa.—On each side of the rectum is a fossa called the ischio-rectal. It is two or three inches in depth, pyramidal in shape, and filled with fat. There are very few blood-vessels in this fossa, and it is the common seat of fistulæ and ischio-rectal abscess.

Congenital Malformations.—These are not infrequent, and are very various. In early fœtal life the bowel and urogenital sinus end in a common cloacal opening; later, separation between the bladder and urethra and the rectum takes place, and there are two distinct orifices. But occasionally this separation does not occur, and the lower end of the rectum opens into the bladder (Fig. 295), or, more commonly, if the child be a male, into the membranous portion of the urethra; or into the vagina if the child be a female.

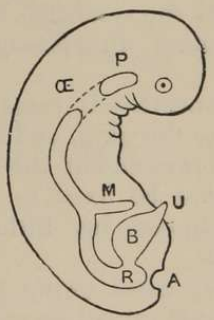
Imperforate Anus and Imperforate Rectum.—The lower one and a

Fig. 295.



Rectum opening into Bladder: *a*, penis; *b*, bladder; *c*, rectum opening into bladder (Owen).

Fig. 296.

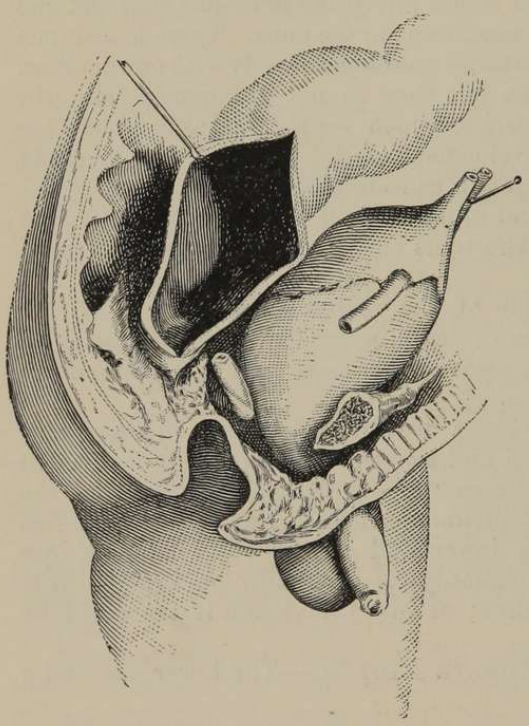


A, Depression for anal piece of rectum; R B, bladder; M, Meckel's diverticulum; Œ, future œsophagus; P, pharynx; U, urachus (Owen).

half to two inches of the rectum are not formed from the hypoblast, as is the rest of the alimentary canal (with the exception of the mouth), but by an

involution of the epiblast or skin which meets the end of the alimentary canal formed by the hypoblast (Fig. 296). Occasionally this involution does not occur, and there is no union with the lower end of the alimentary canal. This is called *imperforate anus*. Again, a simple cul-de-sac may exist at the anus, and the bowel may terminate at some distance above, and either end by a blind extremity or open into the membranous urethra or the vagina. In such a case the involution of the skin occurred normally, but the rectum above was not sufficiently developed to meet it, and the result is a deformity called *imperforate rectum* (Fig. 297). Imperforate anus and imperforate rectum may exist together. The term imperforate anus is often applied to either condition. In some cases the involuted portion of skin meets the end of the large intestine, but a septum remains between them still unabsorbed, and occludes the bowel. This may be easily divided, and the child will then have a free exit for feces. Sometimes the anal opening, though present, is so small as to admit only a fine probe, and the surgeon is compelled to nick the edges with a narrow-bladed knife and then dilate with his finger.

Fig. 297.



Imperforate Rectum (Holmes).

Diagnosis.—The fact that the child has had no motion of the bowels is usually noticed at an early period by the nurse: even if there should be a well-formed anus, an intelligent nurse will inform the doctor that there has been no passage through the bowels, and an examination will soon reveal the condition. Should the bowel communicate with the vagina or the urethra, the passage of meconium from these orifices will soon be detected.

Treatment.—In cases where there is imperforate anus the bowel usually lies close to the skin, and a simple incision into the bulging anal region will reach the lower end of the rectum distended by meconium. The edges of the bowel should be fixed to the external opening, and the mother should be instructed to pass her little finger daily into this opening, so as to prevent contraction.

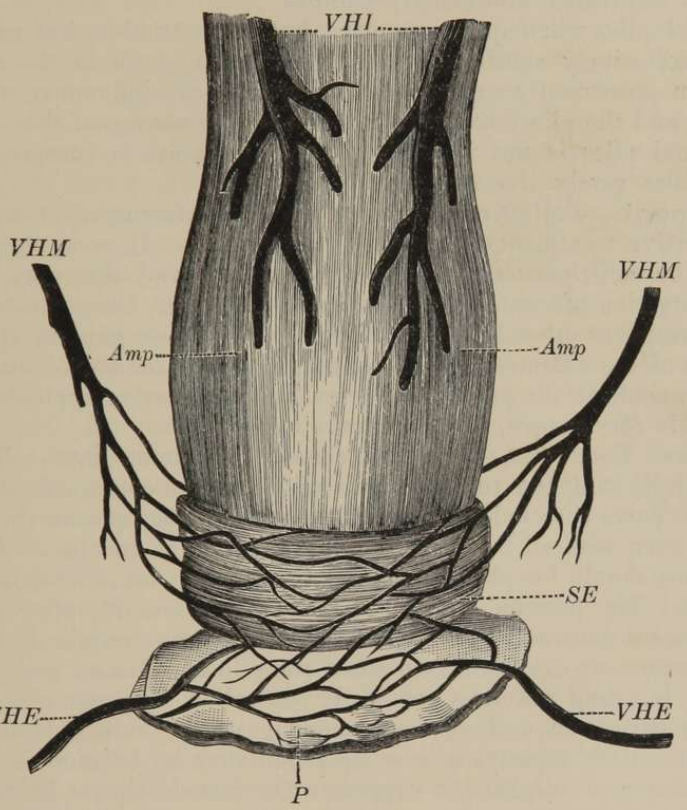
In some cases, owing to deficiency of the rectum, no fulness can be felt, and the bowel cannot be reached through an anal incision, even though a deep exploration be made. In such patients the abdomen should be opened in the left groin, as in inguinal colostomy, and the end of the bowel searched for. Sometimes the sigmoid flexure is absent, and other portions of the large bowel must be secured and brought to the abdominal wound. Some surgeons, when the bowel cannot be reached through the anal region, advocate leaving the case alone, saying that a child is better dead than with a false anus in the groin,

but the fact remains that individuals have grown to full maturity in comfort with such openings, and have even married and lived to an advanced age.

Operation is especially necessary when the bowel ends in the urethra or vagina, for here the bowel usually terminates in a narrow canal and cannot be reached from the perineum. These cases, if left alone, do not die in three or four days, as do the others described above, but live on very uncomfortably, passing feces through the urethra and vagina. In such cases inguinal colostomy is a very necessary operation, and one which gives great relief to the little patient.

HEMORRHOIDS, OR PILES.—These may be defined as tumors which are composed chiefly of varicose or dilated veins of the lower end of the rectum, surrounded by infiltrated connective tissue. Fig. 298 shows the rectal veins.

FIG. 298.



Rectal veins seen from without: *Amp*, rectal pouch or ampulla; *P*, skin at margin of anus reflected: *SE*, external sphincter; *VHE*, external or inferior hemorrhoidal vein; *VHI*, internal or superior hemorrhoidal vein; *VHM*, middle hemorrhoidal vein (Duret).

Causes.—The chief predisposing causes of piles are man's erect position and the absence of valves in the hemorrhoidal veins. Heredity also influences their formation, as it does that of varicose veins elsewhere. Pregnancy and anything which obstructs the portal circulation predispose to piles, as do also sedentary habits, over-eating, over-drinking of alcoholic liquors, the excessive use of purgatives, and, lastly, constipation, which is nearly always the exciting cause of an attack. Piles are almost as common in women as in men, and are oftenest seen in middle life. They rarely occur before puberty, though cases occurring in infants and young children are reported. Piles are usually divided into *external* or blind piles, and *internal* or bleeding piles.

External Piles.—The external are subdivided into *venous* and *cutaneous*.

Venous Piles.—These are due to a varicose condition of the external hemorrhoidal veins. They appear about the margin of the anus as bluish, soft, round tumors which, by pressure, can be easily emptied of the contained blood. When thrombosed and inflamed they are filled with blood-clot and become hard, tense, and extremely painful, causing often much constitutional disturbance. There is a great deal of tenesmus and a feeling as if a foreign body were in the rectum. Defecation causes severe suffering.

Cutaneous Piles.—These are often a sequence of the venous pile, frequent inflammations producing hyperplasia of the connective tissue around the dilated veins, and thus small tags or tumors are formed, which, in some cases, are pedunculated. In other cases, however, the cutaneous pile consists of a hypertrophied fold of skin about the anus, which when inflamed becomes œdematous, infiltrated, and acutely painful.

External piles when quiescent give but little trouble, but when inflamed they are excessively sensitive and cause much malaise in the most robust. Suppuration occasionally supervenes, but usually the inflammation subsides in a few days, and the pile remains as a somewhat larger tag of skin. Associated with external piles is not infrequently seen a fissure or eczema of the anus. External piles rarely if ever bleed.

Treatment.—Palliative treatment is unsatisfactory, yet when patients refuse operative treatment it must be undertaken. It is most important to overcome the constipation which usually coexists, and this may be done by the administration of confection of senna and sulphur, the compound liquorice powder, cascara, or other laxative. Usually, to relieve pain an application of equal parts of the extracts of belladonna and opium, or belladonna and glycerin, may be made to the part, and then a hot fomentation applied. If the inflammation is very severe, leeches often do good.

Operative Treatment.—For the *venous* pile immediate relief may be obtained by incising the tumor and turning out the contained clot, and then dusting the parts with iodoform. Before making the incision the part should be painted over with an 8 or 10 per cent. solution of cocaïne. A very small bit of cotton should be placed between the lips of the wound if the pile be of any size. The patient should be kept in bed for a day after the incision, lest there be subsequent hemorrhage. For the *cutaneous* pile there is no remedy so efficacious as excision, even when the pile is inflamed and œdematous; there is no bleeding which is not easily controlled by pressure; some advise excision by dissection and afterward sewing up the skin. If the ulcer left does not granulate rapidly, it may be stimulated by balsam of Peru or the local application of sulphate of copper. The bowels should be confined for a day or two and the patient kept in bed. The wound should be dusted with iodoform. In cutting away cutaneous piles care should be taken not to cut into the anus, for stricture may follow too free excision.

Internal or Bleeding Piles are situated within the sphincter, and are much more serious and troublesome than the external. They are conveniently divided into *venous*, *columnar*, and *nævoid* (Ball). The *internal venous pile* resembles the external one, except that it is covered with mucous membrane instead of skin, and tends to bleed easily, especially during defecation. This form is often seen in people with cirrhotic livers, in spirit-drinkers, and in women who have borne many children.

The Columnar Pile is commoner than the venous, and "consists essentially of hypertrophy of folds of mucous membrane surrounding the anal opening, the so-called pillars of Glisson. They have a red, almost vermilion color,

elongated form, and contain within them one of the descending parallel branches of the superior hemorrhoidal artery" (Hamilton). In these piles the arteries can be frequently felt pulsating.

The Nævoid Piles, or capillary hemorrhoids, are small, bright-red tumors having a spongy, granular look, situated high up in the rectum. They are rarely larger than a ten-cent piece, and bleed very easily; in fact, the loss of blood is continuous and is a serious drain on the system. They are composed of hypertrophied connective tissue, plentifully supplied with both arteries and veins, which become thrombosed when the pile is inflamed. In fact, the blood-vessels are so numerous that they look like nævoid growths.

Symptoms.—Of course the symptom which most attracts the attention of the patient is the frequent and sometimes constant bleeding, which is much increased by defecation. Hence the name *bleeding piles*. At first the patient loses blood at stool only; then for some time before and after. Later the bleeding may occur at any time, exhausting the patient, and sometimes producing extreme anemia. During defecation there is usually considerable pain, or rather discomfort, and the piles have a tendency to protrude, dragging with them the bowel and causing prolapse. Occasionally the pile-tumors remain protruded so long that they become strangulated, being caught by the sphincter, or they may inflame and become so congested that their great size prevents their return. The pain in these cases is excessively great. If left to themselves, they sometimes become gangrenous and slough off, thus producing a natural cure of the disease, though often not a complete one. In such cases, if the consent of the patient can be obtained, it is better at once to proceed to the radical cure by operation. The irritation of inflamed internal piles not unfrequently produces urinary disturbance and even retention. In women these piles are often the accompaniment of womb disease. If there be excessive pain during and after defecation, an examination will probably reveal a fissure of the anus. Small polypi also are sometimes seen in cases of hemorrhoids.

Treatment of Internal Piles.—Palliative treatment in the milder forms of piles is sometimes successful, but in the severer forms, especially where there is much bleeding, nothing but a radical operation will afford permanent relief. The patient should above all things avoid constipation. His bowels should be kept regular by laxatives, such as the compound liquorice powder, confection of senna and sulphur, a pill of aloes (gr. $1\frac{1}{4}$), belladonna (gr. $\frac{1}{2}$), nux vomica (gr. $\frac{1}{2}$), aided by an enema or some mineral water in the morning. Next, the patient should wash and grease the protruded piles after defecation, and then carefully return them by gentle pressure. Regular exercise should be taken, and over-eating should be avoided; alcoholic liquors should be given up. The piles may occasionally be anointed with some astringent ointment, such as the unguentum gallæ comp.

Operative Treatment.—The two chief methods of radically curing piles are by the ligature and by the clamp and cautery.

Before any operation for the radical cure of piles the patient should be prepared by the administration of a brisk purgative the evening previous to the operation, and immediately before the operation the rectum should be well washed out with two or three large soap-and-water enemata. After an anesthetic has been administered the sphincter should be stretched by the introduction of both thumbs, and the tension should be kept up until the muscle is felt to give way. By this means the rectum can be easily explored and the whole diseased area brought into view; in addition, there is much less pain after operation. This procedure also enables the surgeon immediately to recognize the occurrence of hemorrhage after operation, for all the blood flows externally instead of being

confined by the spasmodically contracted sphincter, as it would be if the muscle were not stretched. The patient should be placed during operation in the lithotomy position, the knees being kept apart by Clover's crutch or other means; or on the side with the thigh drawn up.

Ligature.—Each pile should be seized with a small volsellum forceps, drawn down, and separated from the submucous and muscular tissue from below with scissors. As the vessels enter the pile from above, there is no danger in separating the lower end of the pile. The pedicle should now be tied tightly with a strong silk ligature: that there may be no danger of the knot slipping, three half hitches should be employed instead of the usual two. The ligature should be cut off short, and also the pile beyond the ligature, enough being left to prevent the knot from slipping. It is better to tie the piles from below up. In the columnar pile it may be necessary to transfix the base with a curved needle on a needle-holder armed with a double thread, and then the muco-cutaneous border around the base of the pile should be incised, the pile tied in two halves, and the superfluous portion cut off.

Clamp and Cautery.—The patient having been prepared as described above, each pile is seized in a volsellum, brought down, and clamped tightly with one of the numerous clamps, such as Smith's, Lee's, Volkmann's, etc. Smith's clamp without the ivory plates is as good as any. The pile should now be cut off about an eighth of an inch in front of the clamp, and the cut surface slowly cauterized several times with a Paquelin cautery heated to a dull-red heat. The clamp should then be relaxed slightly, and if there is any bleeding the pile should again be cauterized. The old-fashioned cautery, although more troublesome, is quite as good as, if not better than, Paquelin's. Some dispense with the cutting of the pile by scissors, preferring to trim it off with the cautery. After both the above-described operations the parts should be washed thoroughly with an antiseptic solution, then dusted with iodoform and a morphia suppository introduced. Absorbent cotton should be placed over the perineum and kept in place with a T bandage.

After-treatment.—After pile operations it is necessary to confine the bowels for a few days, and this may most easily be done by giving a grain of opium two or three times a day. By this means also the pain is controlled. On the third morning the patient should have a dose of castor oil, and after that a daily movement of the bowels. There is often difficulty in urination after operations for piles. This may be overcome by applying hot fomentations over the lower part of the abdomen and by encouraging the patient to make a great effort to urinate. If retention does occur, a catheter may have to be used for a few days. Operation for piles by ligature or cautery is very safe, the mortality being very slight indeed.

Other operations than those above mentioned have been devised for the cure of piles. Excision of the piles has been extensively practised by Mr. Whitehead of Leeds, England.

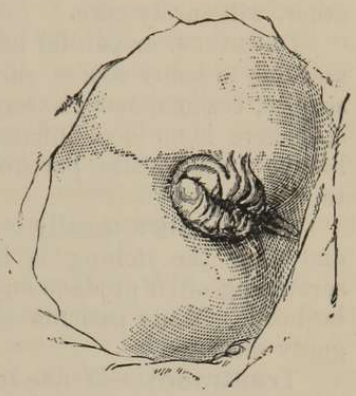
Whitehead's Operation.—The whole circumference of the mucous membrane of the bowel is divided at the muco-cutaneous junction; the mucous membrane bearing the hemorrhoidal tumors is dissected from the muscular coat and brought down below the margins of the anus. The mucous membrane above the piles is then divided transversely and attached by sutures to the free margin of the skin below. In this way the whole hemorrhoidal area is got rid of. The objections to the operation are that it is tedious, bloody, and apt to cause stricture if one does not get union by first intention; in fact, it has few advantages over the ligature or the clamp and cautery.

Treatment by ignipuncture, crushing, the injection of carbolic acid (1 : 10),

all have their advocates, but none of these methods has given as satisfactory results as the two first described, viz. ligature and the clamp and cautery.

Prolapsus.—This is a descent or a protrusion only of the mucous membrane of the bowel (*prolapsus ani*), or of the whole thickness of the bowel, through the anus (*prolapsus recti*) (Fig. 299). When the whole bowel protrudes the tumor may reach the length of five or six inches. It is a rare affection in adults, but is comparatively common in children, and it is usually seen in those of slight resisting power and of relaxed fiber. Anything which causes straining at stool will produce it, such as constipation, phimosis, stone in the bladder, polypi, irritation from worms, etc. In elderly people it frequently accompanies hemorrhoids, enlarged prostate, etc.

Fig. 299.



Prolapsus Recti (Bryant).

Treatment.—In children the cause should be removed if possible, and the general condition improved by iron tonics and cod-liver oil, which help to keep the bowels regular. The stools should be passed with the child lying on its side, and when the bowels protrude they should be gently pushed back and kept in place with a bandage. Broad strips of adhesive plaster, applied so as to keep the buttocks together, are useful in young children. In some cases touching the protruded bowel in several longitudinal strips with a solid stick of nitrate of silver or with nitric acid is beneficial. In adults palliative treatment is not so successful, and operation is frequently demanded. Many operations have been devised for the relief of prolapse of the rectum. Some still believe the cautery is the best method of treatment. Cripps says four lines of cautery a quarter of an inch wide should be quickly drawn in the long axis of the bowel at equal distances; then the bowel is returned and a tube introduced some five or six inches. This is packed around with cotton wool and iodoform. The bowels should be confined by opium for ten days, and for at least six weeks the patient should pass his motions lying on his side. In using the cautery the old-fashioned cautery-iron is better than Paquelin's, as it does not cool so quickly. In the most inveterate cases a V-shaped piece has, with good result, been excised from the sphincter and the edges of the wound brought together. Roberts advocates the excision of V-shaped portions of the sphincter and the entire posterior wall of the rectum, having a common base at the back of the anal opening. Treves excises the protruded mucous membrane and attaches the cut mucous membrane to the skin. The sphincter is not divided. The removal of several of the vertical folds by clamp and cautery is an operation which is often successful. When the patient refuses operation he should be directed to inject ʒvij–viij of warm water into the bowel before going to the closet, and after the motion has passed an ounce of cold water should be introduced and allowed to remain.

To reduce a prolapsus the patient should be placed on his side; the tumor should be well oiled, and then pressed back gently with a soft towel, or, if this fail, the finger may be covered with lint and introduced into the bowel, gently pressing up the tumor; the finger can then be withdrawn and the lint left behind. Occasionally the tumor, if allowed to remain out for any time, becomes strangulated and gangrenous, and finally sloughs off, the affection thus undergoing a spontaneous cure.

Sphincterismus, or spasm of the sphincter, is nearly always associated with ulcer or fissure of the rectum or an inflammation of some neighboring organ, as the prostate, bladder, etc. In some very rare cases there is no discoverable lesion. It is attended by considerable pain, and is liable to occur in women who are hysterical. If due to fissure or ulcer this must be first treated. Sometimes in hysterical cases a suppository of belladonna (gr. ij of extract) and the administration of enemata will remove the spasm, but should these means fail, forcible dilatation of the sphincter with the surgeon's fingers, under ether, will surely cure.

Pruritus, or painful itching of the anus, is a most troublesome affection, and due to many causes, such as thread-worms (oxyuris vermicularis), pediculi, scabies, eczema, small external piles, etc. In some cases it is a pure neurosis, and there is no local inflammation to be made out, the skin about the anus having a dead-white, parchment-like look. These cases are the most difficult to treat.

The irritation usually is worse at night after the patient gets warm in bed, and then the itching is intolerable. Nervous patients who give way to scratching often produce an eczema or excoriate the whole anus and its neighborhood. Many patients who suffer from this troublesome affection are of a gouty diathesis.

Treatment.—If due to thread-worms or eczema, these should be treated. The eczema may be moist or dry. If moist, soothing applications, such as liquor plumbi (1 : 40), linimentum calcis, etc., should be employed, but if dry, then some preparation of tar, such as liquor carbonis detergens, oil of cade, etc. It is a very important thing to keep the buttocks apart, and this may be done by a pledget of marine lint (fine oakum), the tar with which it is impregnated acting remarkably well as a local application. To get rid of the thread-worms, cold water may be injected into the rectum, or salt and water, or infusion of quassia, but it must be remembered that these parasites live chiefly in the cæcum, and that removing them from the rectum is a temporary measure, as they will soon reappear. Purgatives often prove useful.

The neurotic cases are usually elderly persons and the most difficult to treat. First, the patient should avoid scratching and should keep the bowels regular; should abstain from alcoholic liquors and smoking, especially cigar-smoking; should live plainly and on a non-gouty diet. Marine lint locally applied is useful, and in some cases a mercurial ointment, as the dilute citrine, oleate of mercury, etc. Bathing in very hot or cold water or in solutions of cocaïne sometimes relieves. Painting the part with iodine or nitrate of silver may be tried. In some cases, however, nothing seems to benefit. The actual cautery has been used and the sphincter has been stretched with good result, but it is very common to find that what will relieve one patient will have no influence on another.

Foreign Bodies.—These are not infrequently introduced into the rectum to arrest a diarrhea or from perverted sexual impulse or by the insane. A great variety of these foreign bodies have been removed from the rectum—jam-pots, stones, pieces of wood, soap, nails, bottles, etc. Sometimes foreign bodies, such as fish-bones, chicken-bones, etc., that have successfully passed through the rest of the alimentary canal become arrested in the rectum. These may form the nucleus of concretions. It may severely tax the ingenuity of the surgeon to extract such foreign bodies. If the body be small, it may be removed with forceps or thumb and finger; if larger, the patient should be placed under ether, and, after thoroughly dilating the sphincter, the body should be extracted.

WOUNDS.—These are sometimes produced by the rough use of an enema syringe or the careless introduction of a bougie, and cases are recorded where perforation of the bowel and entrance into the peritoneal cavity have occurred and death from peritonitis has followed. Wounds caused by falling on sharp instruments may perforate the rectum and bladder. Punctured wounds are much more likely to lead to septic complications than free incised wounds where there is good drainage. The rectum may be injured during parturition and the recto-vaginal septum completely torn through. Gunshot wounds of the rectum and bladder may occur and yet the patient recover, but if the peritoneum be perforated the chance of recovery is not so great. In gunshot wounds pieces of bone may be lodged in the rectum. Wounds of the rectum may occur during an operation for stone, and if discovered should be sutured immediately.

In the **treatment** of wounds of the rectum *free drainage* should be obtained, even if the wound has to be made larger. This, with frequent irrigation with antiseptic solutions and antiseptic dressings retained by a T-bandage, ought to be sufficient. (For the treatment of puerperal lacerations see the chapter on the Female Genito-urinary Organs.)

IMPACTION OF FECES.—This most frequently occurs in elderly people of sedentary habits who have been the victims of habitual constipation. In them the rectum above the sphincter is dilated into a pouch in which feces collect and become a hard, solid mass which the bowel is unable to expel. The patient, of course, complains of constipation, distention, pain, etc., and the presence of the mass of feces produces sufficient irritation to cause a spurious or catarrhal diarrhea. In some cases acute obstruction supervenes, with vomiting and symptoms of collapse. On attempting to administer an enema it is found that but a small quantity of fluid can be injected, and the introduction of the finger reveals the bowel packed with feces. The fecal mass should be removed with the handle of a large spoon or a lithotomy forceps, aided by copious injections of hot water and soapsuds. Many of these cases when not examined have been treated as cases of diarrhea, with the result of aggravating the condition of the patient.

FISSURE, OR ANAL ULCER.—This is a most painful and troublesome affection, which must not be confounded with the larger ulcerations occurring in the bowel. It commences first as a mere excoriation or crack of the mucous membrane, produced by the passage of a large, hard motion. This exposes some of the nerve-filaments of the anus, and every motion increases the pain and irritation until an ulcer is formed which will not heal. Fissure is always accompanied by severe spasm of the sphincter.

The **symptoms** are severe pain during and after defecation, with the discharge of a small amount of blood. The patient dreads a motion of the bowels and postpones the act as long as possible, with the result of very much increasing the pain, which is out of all proportion to the amount of disease. Fissure is more common in women than in men, and women frequently refer the pain to the vagina and womb, and have much unnecessary special treatment before the cause of the trouble is discovered. On examination the fissure is found on the posterior border of the anus, marked by a red œdematous fold of mucous membrane which looks like an external pile, and which is very tender on pressure. On separating these folds about the anus a fissure is seen leading to a rather broad elliptical ulcer, which is often not so large as the nail of the little finger.

Treatment.—If the case is a recent one, it may possibly be cured without operation. The bowels should be opened daily with a mild laxative, and afterward the parts should be well washed with soap and water, and some mer-

curial ointment applied, such as the ung. hydrarg. ammon. chlor. or dilute citrine ointment,[1] etc. The ointment should be spread on a piece of lint and carefully introduced into the anus. Touching the ulcer with a sharp-pointed stick of nitrate of silver or the actual cautery is excellent practice, but is so painful that the previous application of cocaïne is necessary. In the event of the milder measures not being successful, the surgeon can promise a speedy cure. Placing the patient under ether, the ulcer is exposed by means of a speculum and is incised in its whole length, the incision reaching well into the sphincter and partially dividing it. Many surgeons strongly recommend dilatation of the sphincter under ether as a curative measure, a procedure which is now undertaken before performing most operations on the rectum. The after-treatment should be rest in bed, with opium to confine the bowels, followed by a dose of castor oil on the third day, and daily evacuation thereafter.

Rectal Abscess.—There are various kinds of abscess found about the rectum. The commonest are the ischio-rectal and the marginal. We may also have an intramural abscess of the rectum or a perirectal abscess; these two latter give rise to but few symptoms except fulness and weight, and are usually first discovered by the exit of pus through the anus.

Ischio-rectal Abscess may be acute or chronic. The *acute* variety is attended by very severe pain and often considerable constitutional disturbance. It is more common in middle life in people who are run down in health; it may follow severe illness. It is felt on one side or other of the anus as a prominent, hard, brawny mass, having as it softens a red surface. If not opened it may burst externally or into the rectum.

Chronic Ischio-rectal Abscess.—This occurs in the broken-down and debilitated and in people of a phthisical diathesis. It commences insidiously, without pain, and the pus gradually collects and presents externally or breaks into the bowel. It sometimes follows kicks and blows, or it may be due to a tubercular focus in the rectum which ulcerates into the ischio-rectal fossa.

Treatment of Ischio-rectal Abscess.—Early and free incision in the acute form is the proper treatment. The surgeon should operate as soon as the hardness can be felt, and not wait for fluctuation, which rarely appears. The patient should be etherized and an incision made deeply into the fossa. The finger or a sharp spoon should be introduced and all the loculi should be broken down. If the pus has burrowed in any direction, it should be followed by free incision. After thoroughly washing out the cavity with sublimate or other solution, it should be stuffed with iodoform gauze. Some recommend dusting the cavity with iodoform and introducing a large drain. Early and free incision will prevent in most cases the formation of a fistula. The treatment of the chronic variety is similar to that of the acute, free incision and drainage.

The *Marginal Abscesses* usually originate from a suppurating pile or an inflammation of one of the anal mucous follicles, due possibly to some foreign body, as a fish-bone, etc. These abscesses are often attended with great pain and frequently end in fistula. Treatment by early and free incision under ether spray or chloride-of-ethyl spray or cocaïne is always satisfactory.

Fistula.—This is a sinus going up the side of the rectum, and having usually two openings, one in the bowel and one in the skin, and is the result of rectal or anal abscess. It may also follow injury or the ulceration of a

[1] Mr. Allingham recommends the following ointment:

Hydrarg. chlor. mit.,	gr. iv;
Pulv. opii,	
Ext. belladonnæ,	āā gr. ij;
Ung. simpl.,	℥j.

tubercular focus in the lower end of the bowel. When a fistula follows an anal abscess, it is not a very serious matter, the extent of the suppurating tract being small and subcutaneous, and the internal opening superficial to the sphincter and at the verge of the anus. The more severe forms of fistula are altogether outside the sphincter, the internal opening being half an inch to an inch and a half from the edge of the anus, that is, either between the external and internal sphincter or above the internal—and the external opening may be anywhere in the neighborhood of the anal region; usually it is in the ischio-rectal fossa, as this form of fistula is generally a sequence of ischio-rectal abscess. There may be several external openings, and, in fact, the fistulous tract may burrow in all directions; occasionally a fistulous opening is seen on each side of the gut. The more severe forms of fistula with sinuses proceeding from them in all directions are not infrequently connected with stricture of the gut. In some cases the fistula is very tortuous and will not readily admit a probe.

The usual division of rectal fistulæ is into *Complete* and *Incomplete*. The incomplete are again subdivided into *Blind External* and *Blind Internal*.

Complete Fistula.—This is the most common form. It has both an external and an internal opening. The external opening is usually situated within an inch of the anal verge, and is small; it is distinguished by a little projecting mass of granulation, and continually discharges a thin, purulent fluid. The internal opening is generally within an inch of the margin of the anus, most frequently immediately above the sphincter, and from this opening a sinus may extend for some distance up the bowel. The escape of fluid feces and flatus through a complete fistula is common, and the patient is subject to repeated inflammatory attacks due to the fistula being blocked up with portions of feces. This may lead to suppuration and the formation of new external openings. The internal opening may be on the opposite side from the external, and the sinus may almost encircle the bowel ("horseshoe fistula"). A single internal opening may communicate with several external ones.

Incomplete Fistulæ may be of two kinds, internal and external. When a sinus leads up to the bowel from an external opening in the skin, but there is no opening into the bowel, it is called a *blind external fistula*. When there is only an internal opening, but no opening in the skin, it is called a *blind internal fistula*. This is much more difficult to diagnosticate than the blind external. A blind internal fistula may be suspected when the patient gives all the usual symptoms of fissure and yet no fissure can be found (Kelsey). From time to time there will be swelling about the anus, which, after a discharge of pus from the bowel, will disappear. It is only by placing the patient under ether, stretching the sphincter, and carefully examining the lower three inches of the bowel with a speculum that the affection can be satisfactorily detected. If the sinus is of any size, it will betray itself by induration, and in this region the internal orifice should be searched for.

The **diagnosis** of an ordinary complete fistula is easy, for the patient is usually already under the care of the surgeon for ischio-rectal abscess, or consults him for some of the secondary attacks of suppuration which are so common in the severe forms of fistula.

Symptoms.—Where a fistula is well established, it may give rise to but little trouble, but usually there are some tenesmus, a little blood in the stools, the passage of flatus and pus through the external opening, and the inconvenience and discomfort of stained linen. With fistula is often associated a condition of hypochondriasis. To examine a patient with fistula he should be placed on the side on which the disease is supposed to be, the buttocks brought

well over the edge of the examining table or couch; a probe should now be gently introduced into the external opening, and without force pressed onward till it reaches the internal opening; now the finger should be introduced and the probe felt in the bowel. Should one attempt to pass a probe with the finger in the bowel, the contraction of the sphincter would much distort the sinus and make the passage of the probe difficult. Should the sinus be tortuous or the probe not pass easily, the finger may be introduced to feel for the internal opening and the indurated track leading to it.

Treatment.—The evening before operation the patient's bowels should be emptied by a laxative, and an enema of soapsuds should be administered shortly before giving the anesthetic. The operation for fistula is usually a simple one. After having passed a grooved director through the sinus and out at the anus, the whole track should be laid open with a curved bistoury. If the internal opening be not easily found and the probe be felt under the mucous membrane, it should be forced through at this point. The after-treatment is simple. The bowels should be confined for the first three days by opium (gr. j two or three times a day), and a dose of castor oil should be given on the morning of the third day. The opened fistula should be packed with iodoform gauze daily with the minutest care, and by the surgeon himself, lest it unexpectedly burrow in some direction. If the wound heals slowly, it should be painted over daily with balsam of Peru or compound tincture of benzoin. It should not be allowed to be bridged over by granulation-tissue, but should be made to heal from the bottom. Occasionally the operation is not so simple as that described above: the sinus may be tortuous and the internal opening not easily found, or there may be several external openings or sinuses leading from the main one. In such cases the fistula, instead of being cut through at once with a knife, should be dissected up carefully on a director from the external openings. The secondary sinuses can thus be easily followed up, and there need be no unnecessary sacrifice of healthy tissue. This method is one which is very suitable for the more complicated cases.

Sometimes the entire fistulous canal has been dissected out and excised, the raw surface thus left being sutured in the hope of obtaining primary union.

Where there are several external openings, and perhaps two internal ones, only a single straight cut should be made through the sphincter. It is always unwise to cut the sphincter twice, as it is very likely to lead to incontinence. The external openings should all first be connected by incisions, and the various tracks laid freely open and then connected with the bowel by a single straight incision. A free division of the bowel is not always wise if the fistula should run deeply alongside the bowel and open high up; here incision would lead to very free hemorrhage. Treatment by elastic ligature is preferable in such cases.

The treatment by elastic ligature, as a rule, should be advised only in these cases or where the patient will not submit to treatment "by the knife." The cutting operation is much superior; healing is more rapid and the scar tissue much less in amount. If the ligature be used, it should be of solid India rubber and about one-tenth of an inch in diameter, and after having passed it through the fistula it should be tightly clamped with a leaden ring.

Albuminuria, diabetes, and such like grave organic diseases are contraindications to operation.

Phthisis and fistula in ano are not unfrequently seen together, the fistula being formed by a tubercular ulcer in the lower end of the rectum, piercing the gut, and thus producing suppurative inflammation in the loose areolar tissue about the lower end of the rectum. Surgeons some years ago advised against

operation in these cases, but there is no reason why a tubercular focus should not be extirpated here as elsewhere. The operation should be followed by a thorough scraping out of the fistulous track. Unless the lung trouble is very active and far advanced, operation is not contraindicated.

Recto-vesical and Recto-urethral Fistulæ.—These fistulæ are of somewhat rare occurrence and may be due to various causes. Perhaps the most common cause is ulceration due to cancerous disease. Other forms of ulceration, simple or tubercular, may cause them, and also they may be the result of abscess. Wound of the gut during the operation of lateral lithotomy has produced this form of fistula. The affection can be easily recognized by the fact that urine is continually dribbling through the anus, causing excoriation and giving rise to an offensive urinous odor. When the opening between the rectum and bladder is of some size, as occurs in cancerous fistulæ, feces and flatus may be discharged through the urethra; in such cases the opening of communication is usually high up.

Treatment.—In cancerous fistulæ curative treatment is impossible: all that can be done is to keep the parts clean, and if the amount of feces escaping into the bladder be large, relief may be obtained by the performance of colotomy. In fistula from other causes, if small, the application of the thermo-cautery may prove successful, but in fistulæ of larger size the edges should be freely pared and brought together with silkworm gut or horsehair sutures, the urine being drained away by a soft-rubber catheter introduced into the bladder. In *recto-urethral fistulæ* an old method of treatment which is often successful is to introduce a grooved staff into the bladder and cut on this through the sphincter ani, commencing the incision at the fistula. In this way the rectal is converted into a perineal fistula. During the healing process the bladder should be drained by a soft-rubber catheter.

Recto-vaginal Fistula and its treatment are described elsewhere.

Syphilitic Ulceration.—This usually occurs near the anus during the first year after the contraction of the initial lesion. The severer forms of ulceration are met with in the later stages of the disease, and are due to the breaking down of gummata. This form is most intractable. There is also a form of ulceration about the anus in inherited syphilis which appears three or four months after birth.

Tubercular Ulceration may occur as a primary lesion or be secondary to disease in other parts. It is often very extensive, oval in shape, with ragged, undermined edges. The long axis of the ulcer is parallel to that of the bowel. It not infrequently leads to the formation of a fistula. Ulceration is occasionally seen in connection with hemorrhoidal tumors. Multiple follicular ulceration is sometimes seen, and in old people with chronic venous congestion about the lower end of the bowel a varicose ulcer may form. Cancerous ulceration of the bowel has already been fully described. Ulceration following true epidemic dysentery is seen in countries where this disease occurs.

Symptoms.—Ulceration of the rectum has been frequently mistaken for dysentery, and not without reason, for pain, diarrhea, and discharge of bloody mucus are the constant accompaniments of ulceration of the rectum. There is a constant desire to go to stool, and when the desire is satisfied only a little bloody mucus is the result. Ulceration about the anus is much more painful than ulceration higher up. There may be extensive ulceration high up without the patient's suffering any great degree of pain.

Treatment of Ulceration of the Rectum.—This is not very satisfactory. The earlier forms of *syphilitic* ulcer about the anus usually yield to anti-syphilitic treatment and the application of some form of mercurial oint-

ment. The severer forms, which are more common in women, are difficult to treat. They lead to a form of inveterate stricture, and the only relief to be obtained is either by excision or colostomy.

Patients the subjects of *tubercular* ulceration should be treated constitutionally with cod-liver oil and nourishing diet. The parts about the ulcer should be kept clean by washing out the bowel morning and evening with warm water. Occasional injections of starch (℥j) and tincture of opium (♏xx) give much relief. When the ulceration is situated low down and there is much spasm of the sphincter, the ulcer should be incised.

TUMORS OF THE RECTUM.

Polypus.—This affection is not very rare in children. It frequently gives rise to hemorrhage, for in children the polypi are more vascular than in adults. Polypi are more often seen in patients under ten years of age, and may cause intussusception, prolapsus, and hemorrhage. Frequent hemorrhages from the bowel in children are nearly always due to a vascular polypus. These polypi are from the size of a pea to that of a cherry, and are often attached by long stalks to the bowel. If high up, the polypus is difficult to find, but when low down the small red growth may protrude from the anus. If it cannot be seen, an enema will bring down the bowel and the polypus with it. It may be felt by the finger in the bowel. Removal is the only treatment.

Villous Growths.—These are comparatively rare, and, though innocent at first, may develop malignant characters later on. The tumor is sessile or has a short, broad pedicle growing into the bowel; it is lobulated, and the surface has a soft, velvety feel. When situated low down it may give rise to straining and prolapse, and also to hemorrhage. There is no induration about the base, as in cancer, and it is freely movable. On microscopical examination it has all the characteristics of an adenoid polypus. Complete removal is the only treatment. Recurrence is not uncommon.

Condylomata are met with about the anus, and are usually due to syphilis. (See Syphilis.)

Warty growths are sometimes seen, and call for excision. They may be of large size.

Sarcoma of the rectum is very seldom seen.

Cancer.—The form met with in the rectum is nearly always cylindrical epithelioma, and it commences in the epithelium of the follicles of Lieberkühn. Colloid cancer, as well as scirrhus, may affect the rectum, but both are very rare. Colloid cancer is often a later stage of epithelioma.

There are two forms of the **epithelial cancer.** The *first* commences in the mucous membrane, ulcerating and soon destroying it, and afterward invading the submucous tissue. It extends more commonly laterally, often completely surrounding the bowel by a ring of cancerous ulceration and having an indurated base. This ulcer bleeds easily and increases by extending upward. In the later stages a fungating mass may project into the bowel.

The *second* variety is first seen as a nodule beneath the mucous membrane, projecting into the bowel, and may attain considerable size without ulcerating through the mucous membrane. It increases equally in all directions, and exists in its earlier stages more as a cancerous tumor than as a cancerous ulceration of the bowel. Later, when the mucous membrane ulcerates, it grows rapidly, presenting a huge fungating mass in the cavity of the bowel.

There are also various degrees of hardness in these cancers. In some, the fibrous stroma being more abundant, the cancer grows and ulcerates slowly, and bleeds less readily when touched. The softer varieties grow more rapidly,

quickly infiltrate surrounding structures, and soon involve the lymphatic glands. They break down readily under the finger and bleed freely. In these forms the glandular elements are more abundant, alveoli being numerous. The softer varieties are not so favorable for operation as the slowly-growing, firmer cancers. When cancer affects the *anus* it is always of the squamous form of epithelioma.

Symptoms.—Rectal cancer is a disease of middle life, usually occurring in persons over forty. It often comes on very insidiously, and is not discovered until the surgeon makes an examination. The symptoms may be first constipation, pain, and bearing down, with, at times, discharge of mucus and blood. Blood always appears sooner or later, and diarrhea occurs from time to time. The pain occasioned by the feces passing over the ulcerated surface is very severe, and the patient dreads a movement of the bowels. On examining the rectum with the finger, at from three to five inches from the anus a hardened, ulcerated mass will be met with, which has so contracted the bowel that the finger can be passed through it with difficulty or not at all. The edges of the stricture feel ragged and irregular. When the cancer is high up it may be difficult to reach unless the patient bears down strongly or is examined in the standing position. In the late stages of the disease the patient suffers from marked cachexia, the cancer having by this time invaded the neighboring organs. Death occurs from extension of the disease, exhaustion, rupture into the peritoneal cavity, etc. The stricture caused by the malignant disease frequently leads to fistulæ, which may open into the vagina, into the bladder, or on the external surface, forming a sort of artificial anus.

The **diagnosis** of cancer rests between that of other tumors outside the bowel and that of non-malignant stricture. In non-malignant stricture the disease is apt to extend to the anus, whereas in cancerous stricture there is usually healthy mucous membrane between the disease and the anus. Non-malignant stricture has a smoother feel and is devoid of nodules, but often the diagnosis is very difficult, and can be determined only by microscopic examination. The diagnosis between malignant and non-malignant stricture is described in the section on Stricture of the Rectum (pp. 784, 785). Tubercular ulceration of the rectum, enlarged prostate and tumors of the prostate, and villous tumors have been mistaken for cancer.

Tubercular Ulceration of the Rectum much resembles epithelioma, and a microscopic examination is often necessary to clear up the case. But the history of the individual and the fact that tuberculosis may exist elsewhere are often conclusive.

In Enlarged Prostate and Tumors of the Prostate one always finds the tumor on the anterior wall of the bowel and covered with healthy rectal mucous membrane. The tumor itself is firm and smooth if the case be one of simple hypertrophy of the prostate.

Villous Tumor.—This is a rare form of growth, which is soft and is not accompanied by the deep infiltration of cancer. Villous tumor is always covered by a viscid mucus, and, although it bleeds, does not do so readily. The discharge may be blood-stained in villous tumor—in cancer the discharge is always bloody. Villous tumor may exist for years without affecting the general health; frequently, however, it ends by becoming malignant.

Abscess or Acute Inflammation has been mistaken for cancer, but the history of the case and time will easily clear up the diagnosis.

Treatment.—Proctectomy, or Excision.—In all cases where there is a possibility of entire removal of the growth its excision should be undertaken. Should the growth be freely movable and should there be no great involvement of the glands, while at the same time the general condition

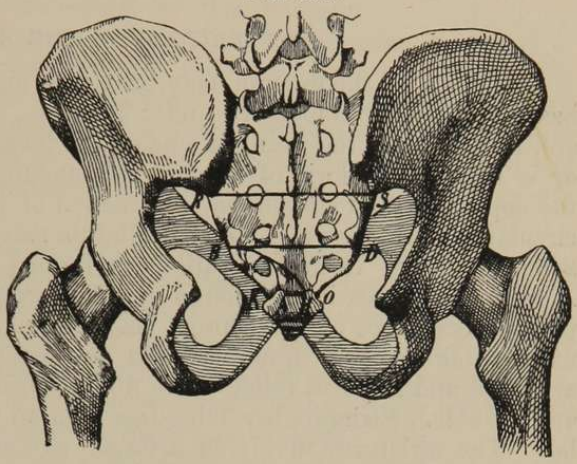
of the patient remains good, the case is one in which extirpation by the perineal or sacral method should be attempted. It was formerly advised that no excision should be attempted unless, under anesthesia, the finger could reach above the growth, but recently many successful cases of excision have been reported where the growth was high up, as much as twelve inches of the lower bowel being removed. In these cases Kraske's operation or some modification of it is usually adopted. When the sigmoid flexure is involved, the growth may be reached from above. The most favorable cases for operation are those in which the disease occurs in the posterior wall. When the anterior wall is involved, the bladder and prostate in the male and the vagina in the female are sure to be implicated early, rendering operation difficult and often ineffectual. If the patient's general condition is feeble and cachexia is present, excision is contraindicated. The immediate results are favorable, only from 10 to 15 per cent. succumbing from the operation. Of course in selected cases the mortality should not be so high as this.

Operation.—The patient is prepared for the operation by having the intestines thoroughly emptied, and immediately before operation the rectum should be washed out with warm water and boric acid by means of a tube carried well up the bowel. He should then be placed in the lithotomy position, with the buttocks raised. The bladder should be emptied before operation, and if the rectum has to be dissected out, a sound should be placed in the bladder for a guide. If the cancerous nodule be small, movable, and on the posterior wall, it may be excised by an elliptical transverse incision, and the cut edges of the mucous membrane should then be brought together with sutures or the wound packed with iodoform gauze. When the disease is more extensive an incision should be made from the anus to the coccyx in the median line; then the lower part of the rectum should be separated from the tissues in front of the sphincter by two crescentic cuts, which go into the ischio-rectal fossæ, and dissected up quickly beyond the growth posteriorly, and more carefully in front, where the attachment is closer and the structures more important. Bleeding should be stopped by forceps, or the cut parts should be tightly packed with sponges. When the rectum has been separated to a point well above the growth, it is cut off, and any enlarged lymphatic glands are removed. The upper end of the gut should then be brought down as closely as possible to the lower end and sutured. The external wound should be well irrigated with sublimate solution, and a drainage-tube packed around with strips of iodoform gauze introduced above the sutured gut. The wound and bowel should be thoroughly irrigated twice a day. Some surgeons suture the external wound, but this method presents few advantages, secretions being retained and the pain and discomfort to the patient being much greater. Packing the wound with iodoform gauze is a simple procedure and gives good results. Immediately after the operation the bowels should be kept confined by opium, but later laxatives should be given. After the second week bougies should be passed daily.

Kraske's Operation.—For cancer high up in the rectum Kraske of Freiburg has devised a very radical operation. The patient is placed on his left side, and an incision is made from the second piece of the sacrum, in the middle line, to the anus. The soft parts are then dissected off on the left side to the edge of the sacrum; then the coccyx is excised and the attachment of the sacro-sciatic ligaments divided close to the sacrum. In this way the rectum is exposed; but still better access is obtained by chiselling away a part of the left side of the sacrum, commencing opposite the third left sacral foramen and avoiding the nerves passing through the foramina (line *BA* in Fig. 300). By this operation the upper part of the rectum can be fully exposed and ex-

cised without injuring the lower end. Should the peritoneum be injured in freeing the rectum, it should be immediately sutured, and, as a rule, no ill results will follow. Some surgeons deliberately open the peritoneum and tampon it with iodoform gauze or after operation leave a drain in it. Others have removed even larger portions of the sacrum transversely, thus invading the spinal canal and without any ill results. These various operations are shown in Fig. 300. It is well before excising the diseased portion of bowel to slit the posterior wall of the rectum down to the sphincter, and then to make the transverse cut below and above the cancer. The advantage of completely suturing the cut edges of the rectum is doubtful. The sutures do not hold, and feces are apt to escape between them. Kraske now provides an artificial anus at the line of suture, whilst Schede, after making a complete suture of the bowel, performs inguinal colostomy. The sacral wound should be left open and stuffed with iodoform gauze. The after-treatment is the same as after other forms of excision.

FIG. 300.



Different levels of Resection of the Sacrum: *KO*, Kocher's line; *BA*, Kraske's; *BH*, Hochenegg's; *BD*, Bardenheuer's; *RS*, Rose's (Maas).

Rydygier's Operation.— The soft parts are incised on the left side, beginning at the posterior superior spine of the ilium and extending downward to the tip of the coccyx; from here the incision proceeds in the median line to the anus. After division of the sacro-sciatic ligaments the soft parts are separated from the anterior surface of the sacrum. A transverse incision is now made below the third sacral foramina and the bone divided along this line with a chisel. The flap of soft parts and bone is then reflected to the right side, the rectum exposed, and the diseased structures excised, the cut ends of the bowel sutured after excision; the flap of soft tissues and bone is replaced, the flap being retained in place by silk or other sutures through the soft parts. Levy has devised a new operation for exposing the rectum. He makes a transverse incision through the soft parts and bone, half an inch above the cornua of the coccyx, four and a half inches long, and from the ends of this incision vertical ones down through the gluteus maximus on each side. He then frees the connective tissue on the anterior wall of the sacrum, and the bone and skin flap is turned down and the rectum exposed; after resecting and suturing the bowel the flap is replaced and the bone and skin sutured in position. In many cases excision of the cancerous portion is much facilitated by a simple removal of the coccyx in connection with the posterior incision. In cases unsuitable for excision, and where the stricture has considerably reduced the lumen of the bowel and obstruction occurs, either inguinal or lumbar colostomy should be performed. This frequently gives great relief to the patient and prolongs his life. Ullmann in these cases recommends the formation of an anastomosis of the bowel above the disease and the lower end of the rectum by means of Kraske's incision.

When there is but little obstruction, or where operation is refused, the

patient's life may be made more bearable by a strict attention to diet. A purely milk diet, with some form of meat juice, is often very satisfactory. Cod-liver oil and milk laxatives give much relief, as does a daily enema of warm water. It should be injected high up and beyond the disease by means of a rubber catheter attached to the syringe, and afterward a small starch injection with 20 to 30 drops of laudanum should be administered. The parts should be kept very clean, and, if the patient has much pain and is restless at night, opium should be given.

STRICTURE OF THE RECTUM.

Stricture of the rectum may be either simple or malignant. The latter has already been considered under Tumors. The *simple* stricture is fibrous, and is frequently the result of one of the forms of ulceration described above, or is due to some form of chronic inflammation (as dysenteric), which leads to the deposition and subsequent contraction of fibrous tissue normally arranged circularly in the bowel. Pelvic cellulitis may lead to stricture of the bowel, as may also the various operations performed for prolapsus, piles, fistula, etc. A stricture is occasionally found in young women which appears to be due to partial persistence of the septum between the anus and the rectum: it gradually grows narrower from irritation and recurring ulceration until it attracts attention and requires relief. The fibrous stricture is divided into the *annular* and *tubular*. Stricture involving less than an inch of the bowel is called annular. The strictures involving a larger extent of bowel are named tubular. Fibrous stricture of the rectum is found from four to six inches from the anus or immediately above that opening. Syphilitic stricture is usually found immediately above the anus, and is most frequently seen in young women under thirty. All forms of simple stricture are more common in women than in men. When the stricture has lasted some time the bowel above becomes dilated and often ulcerated.

Symptoms.—If due to ulceration, it will be preceded by symptoms of that affection, but surgeons rarely see stricture of the rectum in an early stage, being first called in when symptoms of obstruction present themselves. The patient has frequent attacks of diarrhea, followed by constipation. He will often have difficulty in defecation, straining at stool and passing scybala or motions reduced in size. Flat, ribbon-shaped motions are usually but not always due to stricture, as they may be produced by an irritable sphincter. After having passed a motion the patient will feel as if the bowel has not been emptied, and when diarrhea exists it will compel him to go to stool very frequently, passing each time only a little flatus and mucoid discharge, with a few small scybalous masses. Later on, bloody mucus may be discharged and the diarrhea is almost continuous. The patient spends most of his time trying to relieve his bowels. Abscesses may now form in the neighborhood of the stricture and result in fistulæ. Recto-vaginal fistula is a not uncommon sequence of stricture. The parts about the anus become excoriated and raw, and the patient's condition is pitiable: his general health fails, he becomes hectic, has albumen in his urine, and death ensues, produced either by complete obstruction or by peritonitis. This is the course of a severe form of stricture. Many cases of annular stricture do not produce such severe symptoms and do not go on to a fatal termination. Should the stricture be within three or four inches of the anus, the diagnosis is easily made by the finger, but in strictures high up the diagnosis is often very difficult; the patient has diarrhea, alternating with obstinate constipation. The detection of such strictures by the passage of a

bougie is uncertain, and may be dangerous because of the risk of perforating the bowel. Bryant of London describes a condition of "ballooning of the rectum," which exists when the stricture is high up. The finger in passing the sphincter will enter a cavity the walls of which are "ballooned" or expanded. The surgeon will be able to move his finger freely, and the walls of the rectum can be felt only when searched for. The high strictures may, of course, be diagnosticated by the passage of the hand into the rectum, as recommended by Simon: it should be passed cautiously after dilating the sphincter, and a small hand is necessary for this procedure.

The **diagnosis** between malignant and simple stricture is not always easy. The fact that the stricture has existed some time and is in a patient under middle age will often determine the diagnosis. The peculiar sensation of malignant stricture conveyed to the finger is almost unmistakable: masses of new growth can be felt, and there is ulceration at some one point where the growth is more pronounced. The sacral lymphatic glands are involved in the later stages of rectal cancer.

Treatment.—If the stricture be of moderate extent and within reach, the patient may be made comparatively comfortable by proper diet and the use of laxatives and enemata. Rectal bougies should also be passed daily and be gradually increased in size. The bougie should be retained five minutes to an hour—as long, indeed, as the pain is not severe. It is well at the commencement to confine the patient to bed. After the stricture has been fully dilated the patient should pass a bougie himself at least once a week.

If this treatment fails, the stricture must be divided. An annular stricture, if low down, should be divided posteriorly and bougies passed as before. In the severer cases proctotomy, as described below, with division of the external parts, is by far the best procedure. This, however, cannot be practised when the stricture is high up or of great extent; here we must perform colotomy to save the patient's life. In these cases it is a most satisfactory operation. French surgeons have recently advocated and practised with success the extirpation of these severe forms of stricture (especially those which are syphilitic) by means of Kraske's operation. The results, according to reported cases by Quénu and Richelot, are excellent.

Proctotomy (*Linear*).—This is chiefly performed for stricture of the rectum, and should be performed only when dilatation has failed. The contents of the bowels having been thoroughly evacuated, the patient is placed in the lithotomy position, the finger introduced through the stricture, and a sharp-pointed knife inserted in front of the tip of the coccyx and pushed through the tissues until the finger is reached; a blunt-pointed bistoury now replaces the first knife, and all the tissues between the anus and tip of the coccyx are cut through. Some perform this incision with a Paquelin cautery or écraseur, but a knife is the best and speediest. The wound should be packed with iodoform gauze, and the whole supported by a T bandage. The after-treatment is the same as after excision of the rectum. This operation in simple stricture is often curative, and as the wound heals power of retaining feces will gradually return.

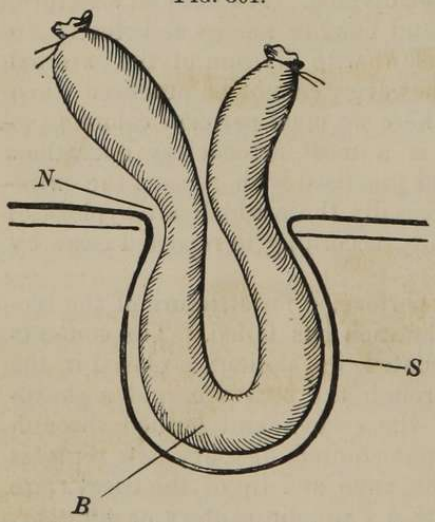
PART VII.—HERNIA.

By HERNIA is meant the protrusion of any viscus from its natural cavity through normal or artificial openings in the surrounding structures. Thus we have hernia cerebri, hernia testis, hernia of the lung, etc. But by the term *hernia* used *alone* we mean the protrusion of the abdominal contents through the parietes, and this is known by the popular term "**rupture.**"

The commonest forms of rupture protrude through one of the natural openings or weak spots in the abdominal parietes, as, for instance, the inguinal and femoral canals. Hernia may occur at the umbilicus or even at the obturator foramen. The contents of a hernia are bowel and omentum, separately or together. An omental hernia is called an **epiplocele**, and a hernia of the intestine an **enterocele**; a combination of the two is called an **entero-epiplocele.** The bowel involved in a hernia is usually the lower portion of the small intestine, but the large intestine is also found, even the whole cæcum; also the bladder (*cystocele*[1]), stomach (*gastrocele*), ovaries, gall-bladder, etc.

ANATOMY.—Covering the bowel or omentum we have the **sac**; this consists of the protruded portion of peritoneum, which has been pushed gradually through one of the canals (inguinal or femoral), or of the process of peritoneum, which has been carried down by the testicle in its descent, and the connection of which with the peritoneum of the abdomen still continues, not having been obliterated, as it usually is, before birth. The former is called an *acquired hernial sac;* the latter is called a *congenital hernial sac* (Birket), and is found only in inguinal hernia. After the hernia escapes from the canal through which it passes it enlarges greatly, and is covered, of course, still by its sac. This portion of the sac is called the **body,** the portion which lies in the canal is called the **neck,** and the opening in the abdominal cavity is called the **mouth.** The sac, taken as a whole, has somewhat the shape of a Florence flask (Fig. 301). In a hernia of long standing the sac becomes very much thickened and often adherent to the surrounding structures, so that even should the contents of the sac be wholly reduced the sac still remains, and is ever ready to receive its contents again on the slightest provocation. The sac of a recent hernia is thin and transparent, as it is peritoneum, and is easily reduced with its contents, no adhesions as yet binding it to the surrounding structures. The neck of the sac is thrown into pleats and folds, owing to the constriction produced by the stricture forming the hernial opening. The parts covering the hernia outside the sac vary according to the situation of the hernia; they usually consist of various fasciæ, tendons of muscles, and even portions of muscles themselves, and, lastly, superficial fascia and skin.

FIG. 301.



Hernial sac, with contained bowel: *N*, neck of sac; *S*, sac; *B*, bowel (original)

ETIOLOGY.—Hernia is more common in males than in females, and may occur at any period of life. The majority of cases, however, occur before middle age, and the largest number, according to Kingdon, during the first ten years of life, owing to the non-closure of the process of peritoneum which is carried down by the testicle. Frequently the hernia is congenital. Hernia is most frequently *strangulated* between the ages of forty and fifty.

Hereditary predisposition to hernia exists without doubt in many. Mr. Kingdon estimates that in about 34 per cent. there is an hereditary tendency to hernia, many of these patients being born with it.

Occupation predisposes, people who have laborious occupation being most

[1] This term is also applied to the bladder protruding or tending to protrude at the vulva.

liable to the acquired form; some assert, however, that it is more commonly seen in these individuals only because there are more of them. It is said that persons with abnormally long mesenteries are, on that account, predisposed to hernia. After abdominal section the patient is very liable to have rupture at the site of the wound, and stout women who have borne many children are especially subject to rupture. Certain diseases, as bronchitis, whooping-cough, stricture, and constipation, predispose to rupture by causing violent and prolonged use of the abdominal muscles. These affections occurring in old people with relaxed tissues not infrequently start a rupture.

Seat of Hernia.—This will be more fully discussed in treating of the various kinds of hernia. The most common seats of hernia are the inguinal, femoral, or umbilical regions, though occasionally protrusion occurs through the diaphragm, obturator foramen, ischiatic notch, vagina, etc. Out of every 100 cases of hernia, 84 are *inguinal*, 10 *femoral*, and 5 *umbilical*.

Diagnosis.—Hernia is first noticed at one of the rings (umbilical, inguinal, femoral) as a fulness or swelling, which is especially evident on standing. Coughing, lifting heavy weights, etc. make the swelling more tense and elastic. This swelling, which is smooth and uniform, will disappear on lying down, and after long rest in bed may not immediately reappear on standing. The surgeon can usually, in recent hernia especially, easily reduce the swelling by manipulation with the fingers (*taxis*). The bowel, as it is returned, often gives a gurgling sound and slips in quickly. On placing the finger in the ring through which the bowel has been pushed, and keeping it there when the patient stands up, there is no return of the hernia. As soon as the finger is removed, however, the tumor reappears. On making the patient cough the tumor becomes tense, and there is a decided impulse which does not occur in other tumors. Should the contents of the swelling be bowel, there will be a tympanitic note on percussion, but if the contents be omentum, the tumor will have a doughy feel, a dull note on percussion, and will be reduced with much greater difficulty. Hernial tumors which contain both bowel and omentum may be tympanitic at some points, dull at others, and when reduced give out a gurgling noise. Persons with hernia are conscious of a weakness at the seat of rupture, especially during exertion. There may also be uneasiness and griping pain, which are attributed to constipation or other cause.

Prognosis.—Provided the hernia can be kept reduced by a truss placed over the aperture of exit, the prognosis is favorable. The patient, however, always runs the risk of strangulation of the hernia should the truss get displaced during severe exertion or if it should fail through some defect to keep the hernia entirely reduced.

The prognosis is not so favorable in a very large hernia, for it is difficult to get a truss that will keep it in place, owing to the large size of the hernial ring; nor in irreducible herniæ, as they tend to increase in size. In very small herniæ the danger of strangulation by the entrance of an additional knuckle of gut into the sac renders the prognosis unfavorable.

In irreducible omental herniæ, where there is an occasional descent of small intestine, the prognosis is still less favorable, owing to the danger of the bowel suddenly becoming strangulated at the orifice of the sac.

Palliative Treatment.—Every individual, young or old, who is the subject of a hernia which is reducible should wear a properly-fitting truss. A **truss** is an instrument composed of a pad which fits over the site of the hernia, and a belt which surrounds the pelvis or body and keeps the pad in place; the belt is often made to act as a spring. A properly-fitting truss should keep in the hernia on all occasions without causing pain or discomfort. In

young infants a skein of Berlin wool may be made to do service for a truss by doubling and passing it around the abdomen, placing the loop directly over the outer abdominal ring, and then passing the free ends of the skein through the loop, thus making a knot opposite the site of the hernia: the ends which are passed through are then carried down the upper part of the thigh between it and the scrotum, brought round the external side of the thigh near the top of the great trochanter, and there tied or fixed with a safety-pin to the band of worsted already round the pelvis. The advantage of this truss is that it can be easily washed and easily applied.

A truss should be worn all day, and should be put on in the morning before rising and taken off at night after going to bed. It should never be removed except when the patient is lying down. Some individuals in whom the hernia tends to come down even when in the recumbent position require to wear a truss night and day. The night truss need not be so strong as the day truss. The wearing of a truss in the very young often results in cure by closure of the neck of the sac, but even in these cases it is unwise to leave off wearing a light truss, for it not unfrequently happens that on any sudden exertion the bowel will descend in the old channel, become strangulated, and thus endanger the patient's life, especially should he happen to be beyond the reach of skilled surgical assistance. Trusses are very difficult to adjust to the very fat, and some forms of hernia are from their situation, etc. extremely troublesome to fit with a truss—*e. g.* umbilical hernia. The pressure of the pad should always be in the direction of the hernial canal, and should cover the aperture through which the hernia protrudes. The pad should not be too convex, for this shaped pad has the effect of distending the aperture and so increasing the size of the rupture. The pad should be flat, and the shape should be suited to the form of hernia for which it is used. Pads are made of various substances—vulcanite, wood, india-rubber, etc.; water-bags and sand-bags have been used, and all have their advocates. The variety of trusses is innumerable. In some the spring is formed by the belt which encircles the pelvis, and in others is situated in the pad itself. Some pads are fixed solidly to the encircling belt, and others are attached by a ball-and-socket joint. The truss best suited to the patient is one which keeps in place in all the various movements of the body, and does not permit of the descent of the hernia whilst coughing, jumping, or straining. One of the best tests is to make the patient stoop forward, with his knees apart and his hands resting on his knees, and then direct him to cough. If the truss stands this test, it is one which is suitable to the patient. For the majority of cases it will be found that the circular spring truss is the best.

To Measure for a Truss.—The size of the aperture, the kind of hernia, and whether it is single or double, should be noted. The circumference of the pelvis one inch below the crest of the ilium, the girth of the body opposite the hernial aperture, and the distance of the hernial ring from the iliac spine should all be accurately measured. Instructions should also be given the instrument-maker as to the direction in which the pressure should be made, forward, backward, or inward.

Radical Cure.—The radical cure of hernia has for years exercised the ingenuity and talents of surgeons. Many operations have been devised, and have for a time been popular, and then have been forgotten or have fallen into disuse. The operation devised by Wützer is never practised now, and Wood's elaborate operation is so difficult and complicated that no other surgeon has been able to get such good results as the originator. These operations since the introduction of aseptic surgery have been entirely superseded by that of open incision.

There have been other methods which have met with a measure of success—viz. those which aim at the obliteration of the canal by the introduction into it of some irritant and astringent, such as the fluid extract of oak-bark, alcohol, iodine, etc.; but here, again, the result is often unsatisfactory, and the method is suitable for the cure of only the smaller varieties of hernia.

It is as well to state that, before recommending a so-called radical operation for the cure of hernia, the surgeon should consider the position of the patient. If he is a man past middle age or has a hernia that is not very large and is easily retained in place by a properly-fitting truss, no operation should be recommended. It is also, in most cases, unwise to attempt a radical cure of hernia by operation on an infant. But if the hernia is strangulated or very large and irreducible, or such that a truss will not keep it in place, or, perhaps, if the patient is desirous of entering some public service for which a strict physical examination is demanded, or desires to be rid of the serious annoyance of a truss, it is justifiable to recommend an operation for the radical cure of the hernia. In deciding this question it must also be remembered that a hernia which in youth is easily retained and gives little trouble may become a very serious source of annoyance and danger in later life.

The principles of the modern operations for the radical cure of hernia are much the same in all—viz. to dissect out the sac and excise it and to endeavor to close the hernial canal by sutures. There are many different operations for effecting this purpose, and it would be impossible in a work of this kind to describe them all. The operation practised by Czerny, Banks, Annandale, and others is very simple and one which gives as good results as any other. It is most important in order to secure a permanent and satisfactory result after the radical operation that three conditions be fulfilled: (1) Complete extirpation of the sac; (2) closure of the canal; and (3) immediate union of the wound. This latter is by far the most important. The most common form of hernia is the *inguinal*, and it is for this variety that the operation for a radical cure is most frequently performed, and for which it is most suitable, though it is also done in cases of umbilical and femoral herniæ.

Operation.—An incision is made over the hernial tumor and the parts carefully divided until the sac is reached. This, if old, is known by its white appearance. The sac should then be dissected out carefully, and cautiously separated from the spermatic cord. The bowel should be reduced before the sac is opened, but if it contains omentum which is adherent, the sac should be opened and the omentum tied and cut off. The sac should now be pulled down and a ligature of silk or catgut, preferably the former, applied to the neck as high up as possible, and the sac removed. Now the canal is closed by sewing the pillars of the ring together, or, better still, if the hernia be inguinal, suturing the conjoined tendon of the internal oblique and transversalis to Poupart's ligament by means of three or four silk sutures. The external wound is closed by several interrupted sutures and a drain placed at the lower end. It should be dressed like any other wound, the object, of course, being to get union by first intention.

In *femoral* hernia the operation may consist simply in dissecting out and removing the sac, no attempt being made to close the ring. Cushing of Boston after returning the gut fastens the sac as a pad in the femoral ring, doubling it on itself, as in Macewen's operation, and sewing it by ligatures which at the same time pass through Poupart's ligament and the pubic portion of the fascia lata, thus closing the ring. The saphenous opening is also closed by slipping the pubic fascia under the iliac fascia and suturing them together. Salzer removes the sac and then closes the external orifice by a flap formed by the

fascia covering the pectineus muscle. Watson Cheyne closes the crural canal with a flap taken from the pectineus muscle itself.

Bassini's Method.—The patient is placed on the back, with the pelvis raised, so as to bring the hernial tumor prominently forward. An incision should now be made directly over the tumor and parallel with Poupart's ligament. After cutting through the superficial structures and ligating all bleeding vessels, the sac is exposed, isolated, and opened. Any adhesions of bowel or omentum are broken down and the bowel returned; then the back of the sac is ligated, the sac cut off, and the stump returned into the abdomen. With a curved needle threaded with strong, moderately large silk the posterior and under portion of Poupart's ligament is sewed to the pectineal aponeurosis (pubic portion of fascia lata) close to its origin from the pectineal line, with three sutures. The first suture perforates the ligament immediately external to the pubic spine; the second is placed half a centimeter outside of this, and farther out still is placed a third. These sutures are left untied until the next are in position. Three or four sutures now are passed through the falciform border of the fascia lata and the corresponding part of the pectineal fascia, and over the internal saphenous vein. All the sutures are now tied; the upper ones draw Poupart's ligament backward to the pectineal line, and thus close the mouth of the crural canal; the other sutures close the saphenous opening. The skin is next sutured and no drainage is used.

Bassini had operated (when his paper was written) on 54 cases, and forty-one of them he had kept under observation for from two to nine years, and so far had observed no relapses.

In *umbilical* hernia the edges of the hernial opening may be pared and brought together, and the sac itself used as a plug to stop the opening.

Radical Cure in Congenital Hernia.—In congenital inguinal hernia the sac, being continuous with the tunica vaginalis, cannot be dissected out and removed in its entirety. It should first be separated from the surrounding structures in the inguinal canal, and then divided transversely without injuring the cord. The lower part is left behind and forms the tunica vaginalis; the upper part should be freed from the cord by splitting it up behind and the cord carefully separated. The sac itself should now be pulled down and ligatured high up, and cut off as in other forms of hernia.

FIG. 302. FIG. 303.

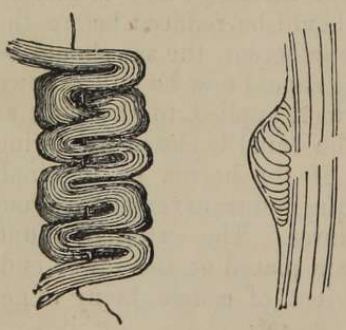


FIG. 302.—Macewen's Operation: the sac transfixed and drawn into folds.
FIG. 303.—The sac as a Pad covering the abdominal aspect of the internal ring in Macewen's operation.

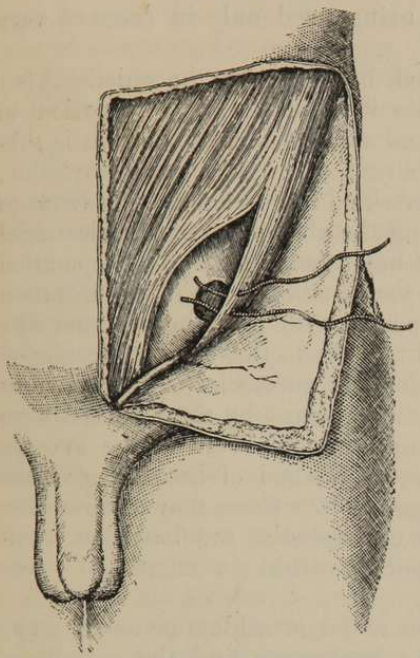
Macewen's Operation.—Macewen of Glasgow preserves the sac and returns it within the abdomen, where it is retained in a puckered-up condition by ligatures (Fig. 302), and acts as a pad placed against the abdominal aspect of the internal ring (Fig. 303). He also closes the canal by suturing the conjoined tendon to Poupart's ligament (Fig. 304).

Ball of Dublin, after dissecting out the sac, recommends torsion or twisting before suturing and cutting off the sac.

Barker of London dissects out only the neck of the sac, ligatures it, and cuts it off half an inch below the ligature, but does not dissect out the lower scrotal portion. The neck of the sac is fixed to the abdominal wall by the ligatures that close the internal ring; the canal is closed by several sutures, the wound dressed with dry dressing, and no drainage used (Fig. 305).

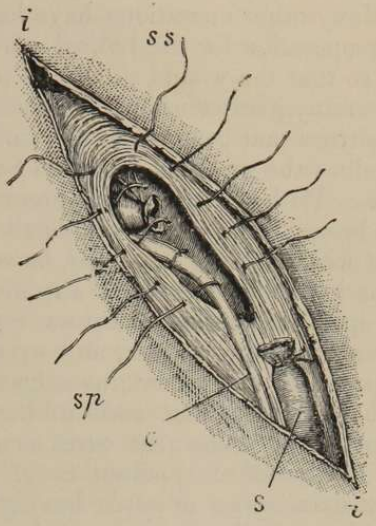
Halsted of Baltimore divides the muscles of the abdominal wall out as far as the level of the anterior superior spine; the walls of the sac are sutured by quilted

FIG. 304.



Macewen's Operation: the threads ready for tying.

FIG. 305.

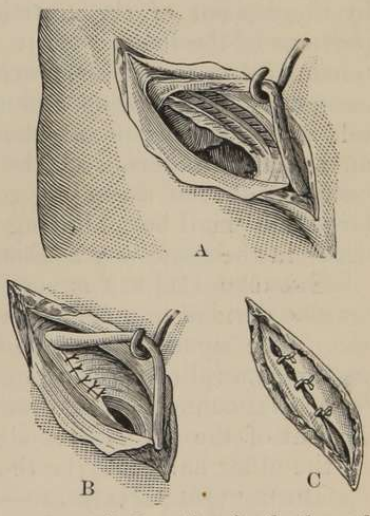


Barker's Operation for the Radical Cure of Hernia: *ii*, skin incision; *c*, spermatic cord: *s*, hernial sac; *ss*, suture for the sac; *sp*, sutures for drawing the walls of the canal together. All the sutures are represented *in situ*, ready to be drawn close and knotted.

sutures at as high a level as possible, and then the lower portion cut away. The spermatic cord is now transplanted to the outer angle of the wound. The divided muscles and pillars of the ring are stitched with very deep quilted sutures, and the skin wound closed with buried skin sutures. The dressing consists of a small pad of sterilized gauze, held in place by a bandage which has been soaked in alcohol, and the whole covered with celluloidin.

Bassini's Operation.—Bassini of Padua has devised the following operation, which is now largely adopted by surgeons: The aponeurosis of the external oblique and the pillars of the ring are first exposed, and then the canal is slit up, the aponeurosis of the external oblique being dissected from the tissues below so as to form two flaps. The cord is now drawn out and separated from the neck of the sac, the sac dissected out, opened, and its contents reduced. The neck of the sac is then ligatured after twisting, and the sac cut off below the ligature. The cord is held up and kept in the upper angle of the wound, whilst the border of the rectus and edges of the internal oblique, the transversalis, and transversalis fascia are united by a continuous suture to Poupart's ligament *underneath* the held-up

FIG. 306.



A–C, Bassini's Operation for the Cure of Inguinal Hernia (Esmarch and Kowalzig).

cord, thus forming the posterior wall of a new canal. The divided aponeurosis of the external oblique is now sutured over the cord, thus forming the anterior wall of the new spermatic canal. The wound in the skin is closed in the usual way, a drainage-tube being used only in cases of very large herniæ.

Many other operations have been devised, but these are the chief. After every operation for the radical cure of hernia it is well to keep the patient in bed, so that the wound should be perfectly and soundly healed before it is subject to any great tension. The wearing for a time of a light truss is advisable, but a truss that compresses the parts strongly should be avoided, as it tends to reproduce the previous condition by promoting the absorption of the cicatricial tissue. With strict antisepic precautions the immediate results of the operation have been good, especially in small hernia in young adults. Still, the operation is not without risk, especially in stout, old people with large herniæ and who are perhaps the subjects of chronic bronchitis. As to the curative results of this operation, many operators report wonderfully successful series of cures after six months, a year, and even two to three years, by some special form of operation, but recent investigations by impartial observers of the average number of permanent cures of hernia by direct method of incision give the proportion of permanent cures as about 50 per cent. Cases may relapse after even five years of apparent cure. Most of our statistics are based on insufficient data, series of cases having been reported within six months to a year after the operation.

Cæcal Hernia.—Hernia of the cæcum alone is seldom or never seen, for in nearly every case in addition to the cæcum we find the vermiform appendix, a portion of the ileum, and a portion of the ascending colon. According to the most recent observations, a cæcocele with an incomplete sac is rare. The sac is usually complete, and the cæcum and other portions of the intestines accompanying it are free within the lumen of the sac, and the walls of the sac are not reflected around any part of the intestine (Lockwood). Congenital cæcocele is the most common variety, and is usually caused by the descent of the testicle, which pulls down the cæcum, appendix, and portions of the ileum with it. This is due to the existence of a fold of peritoneum (plica vascularis) reaching from the globus major of the testicle to the cæcum, appendix, ileum, and mesentery, and which contains the spermatic vessels and gubernaculum testis. In acquired cæcocele there has usually been an antecedent hernia of the small intestines, but in some cases where the cæcum with the ascending colon float freely in the abdomen, owing to the large and small bowel having a common mesentery, hernia of the cæcum may occur in the same way as does hernia of the small intestines.

Sigmoid Hernia is very much like cæcal hernia, and in the same way may be divided into congenital and acquired, with an incomplete or complete sac. The sigmoid flexure, like the cæcum, has connected with it the fold of peritoneum (plica vascularis), which contains the spermatic vessels, and in fetal life connects the testicle with the sigmoid flexure. During the descent of the testicle the sigmoid flexure may be carried down with it, but on the other hand may be the cause of keeping the testicle from descending.

Irreducible Hernia.—A hernia is said to be irreducible when the protruded bowel cannot be returned into the abdominal cavity, and this without any symptoms of strangulation or obstruction. Irreducible herniæ are usually of long standing and large size. This condition is often caused by carelessness in the patient and neglect to keep in a reducible hernia with a truss. There is always a large amount of omentum in the sac, and this it is which

cannot be returned, the gut often slipping in without difficulty. The reason why the hernia cannot be reduced is that adhesions have formed between the omentum and sac and also between the omentum and the bowel itself. As time goes on, the neck of the sac thickens and becomes narrower, while the mass of omentum becomes larger. The hernia sometimes reaches an enormous size, preventing the patient from following any occupation. Even if it be small, it gives rise to much discomfort, and the patient is always in danger of strangulation of the rupture.

Treatment.—The reduction of an irreducible hernia can be satisfactorily accomplished by performing the operation for radical cure. The sac should be opened, the excess of omentum tied off with catgut or silk, and the bowel returned; then a radical cure should be performed. Should the individual be old and fat, the operation, even when performed with the strictest aseptic precautions, is not without danger. In very large herniæ in stout people it is well to prepare them by keeping them in bed for a couple of weeks or more, feeding them on a diet which will not make fat, such as lean meat and vegetables, and giving them no fats, sugar, starch, or alcohol. By this means the patient's size is reduced, and the bowel, which has perhaps not entered the abdomen for years, may sometimes be reduced without much difficulty. In some of these cases, where the ring is of large size, the radical cure may be made much more certain by the removal of the testicle and the cord of the affected side. Some surgeons advise attempting reduction without operation by keeping the patient in bed, with hips raised, ice to the scrotum, and on low diet. Taxis should be employed daily, and occasional saline purgatives should be given. By this means the fat is absorbed and reduction has been accomplished after a few weeks. Where operation is refused or is inadvisable owing to age, etc., this method may be tried. Trusses with a large concave pad have been devised for the support of this form of hernia.

Incarcerated Hernia.—By this term is indicated an irreducible hernia in old people, which becomes obstructed with gases, feces, or undigested food, and hence the passage through the bowels is blocked. It is most common in umbilical hernia. There may be eructation of gas and slight vomiting, with constipation, but there is no tenderness or tension of the hernial tumor and all the symptoms are subacute. Impulse on coughing is well marked. It is necessary in these cases to give large enemata of sweet oil with a little turpentine. Taxis may be tried, and in this way the gases and feces may be made to move on. The local application of ice or of hot fomentations aids in relieving this condition. A full dose of castor oil may be given after the above means have been tried.

Inflamed Hernia.—This is generally the result of violence or may be produced by pressure of a badly-fitting truss. The part is hot, red, painful, and tender, but there is not much tension; there may be increase in the size of the tumor. Pyrexia is always present, and there are all the symptoms of a local peritonitis. There may be vomiting and constipation, but no great constitutional depression, as in strangulated hernia, and there is still impulse on coughing. Irreducible herniæ are the most liable to become inflamed, especially irreducible femoral epiplocele.

Treatment.—Rest in bed, with the local application of an ice-bag, relaxation of the parts by position, and if there is much pain opium should be given. Should the condition go on to suppuration, an incision should be made and the pus in the sac evacuated. The effects of the inflammation are seen in the subsequent firm adhesions of the gut or omentum to the sac.

Strangulated Hernia.—A rupture is said to be strangulated when it is

so tightly constricted at its neck that it cannot be returned into the abdominal cavity and its circulation is interfered with; thus there is not only obstruction to the passage of feces, but also an arrest of circulation in the protruded portion of bowel which, if not relieved, results in gangrene and death. It occurs more often in old than in recent herniæ, and more often in congenital than in acquired.

Mechanism of Strangulation.—It is usually due to the descent of an additional fresh knuckle of bowel into an old hernial sac, or, in a case in which there has been no prior hernia, to a sudden descent of a knuckle of bowel during some violent exertion through some of the natural apertures of the abdomen. This sudden forcing of the bowel through a narrow aperture causes constriction, which, if it continues, is followed by strangulation. It does not always occur during violent effort, but may be produced by increased peristaltic action of the bowels in a patient who has been suffering from diarrhea, constipation, or what is commonly called "bowel complaint." At first there is merely constriction at the hernial ring: this leads to congestion of the part and arrest of return of venous blood, which results in engorgement and swelling of the protruded portion of gut. This swelling increases the constriction, strangulation ensues, and, if it is very severe, death of the part rapidly follows. In some cases where the strangulation is not so extreme the circulation is not entirely arrested; the progress of the disease is not so rapid, and ulceration of the constricted portion may be the result. This is followed by perforation, escape of feces into the peritoneum, and general peritonitis.

The seat of stricture may be at the hernial orifice or in the neck of the sac itself. It is most frequently outside the neck of the sac at one of the hernial rings. When it occurs at the neck of the sac, it is due to thickening at that point and the fusing together of the various pleats and folds into which a large sac is thrown where it passes through a small opening. The seat of stricture may be in the sac itself, produced by bands of adhesions which stretch across it. Cases are on record where the strangulation has been produced by the twisting of a loop of the protruded bowel in the sac.

Local Changes the Result of Strangulation.—First, *congestion* occurs in the protruded parts, produced by the arrest of circulation through the veins, but not the arteries; then engorgement and swelling occur, and the bowel has first a dark-red, then a purplish, appearance. At the same time there is effusion of serum into the sac, and now the circulation is completely obstructed and the bowel becomes almost black, and soon becomes gangrenous. When the obstruction to the circulation is not complete and has lasted some time, the effects of inflammation are seen: the bowel becomes dark in color, loses its glistening appearance, is covered with flakes of lymph, and becomes soft and less elastic, and the serous coat is covered with ashy-gray spots. Omentum, when strangulated, has first a dark-purplish, and afterward a yellowish-gray, color. In a hernia that has been strangulated for some time there are always evidences of inflammation. As the gangrene advances, gas is generated and the parts crackle, the gut ruptures, and fecal matter is extravasated. The fluid in the sac, which was at first clear, becomes reddish, turbid, and finally offensive. It is sometimes very difficult to tell positively whether the gut is so damaged as to be beyond recovery. It may be very dark colored and yet be sufficiently alive. The best test is the condition of the peritoneal coat, which peels off easily when it has lost its vitality. If the bowel is flaccid and inelastic, then, without doubt, gangrene has set in. The bowel may be ulcerated at the line of stricture and perfectly healthy elsewhere. Perforation may result

and feces escape into the abdominal cavity, leading to general peritonitis and death. Suppuration of the sac may occur as the result of strangulation, but this is rare. Gangrene of the intestine is more frequent in femoral than in inguinal hernia, but ulceration of the line of stricture is more common in strangulated inguinal hernia.

Symptoms.—In cases in which there is *sudden and complete constipation* with *persistent vomiting* a strangulated hernia should always be suspected, and the various *apertures* through which a hernia might protrude *should always be examined.* If at the site of a hernia is found a tumor which is tense, hard, and painful and irrreducible, there will not be much difficulty in making a diagnosis.

The symptoms of strangulated intestine are always the same, whether the strangulation occurs in the abdomen or outside of it—viz. faintness, collapse, severe abdominal pain, chiefly referred to the umbilical region, complete constipation, so that flatus ceases to pass, then vomiting, at first of food, then of bile-stained fluid, and finally of fluid with a fecal odor. The tongue is dry and brown and the pulse rapid. In strangulated hernia there are in addition, at first, pain at the seat of rupture, a greater degree of tension, the tumor having increased in size, dulness on percussion over the hernia, and absence of impulse on coughing, with the fact that the tumor is irreducible.

If unrelieved, the abdomen becomes much distended, retching is more frequent and thirst intense, hiccough sets in, the urine is much diminished in quantity, and the patient gradually sinks from exhaustion in eight or nine days, though in very acute cases he may die in forty-eight hours. The bowel by this time has become gangrenous or there is general peritonitis. With the onset of gangrene there is often a cessation of the more urgent symptoms, as vomiting and pain. The severe collapse, pain, and vomiting which set in early in a case of strangulation are due to the profound impression produced on the abdominal sympathetic plexuses by the pinching of the gut. This also accounts for the diminished excretion of urine.

Often the symptoms are not so severe as described above, especially in femoral hernia, where the patient may be unaware for some time that strangulation exists or even that he has a hernia. In recent herniæ the symptoms are much more acute than in old herniæ, and they are not so urgent when omentum is protruded with the bowel or when the tumor has for some time been irreducible. In cases of obturator or sciatic hernia it may be impossible to discover the tumor even by the most careful examination. A small knuckle of bowel may become strangulated behind a piece of omentum and be out of the reach of the surgeon: there is no impulse on coughing, not much tenderness, and the tumor may feel soft and lax. A knuckle of gut may become strangulated inside the sac of a large hernia, and yet the hernia as a whole may give no evidence of strangulation. Again, a hernial tumor may have all the symptoms and appearances of strangulation, and yet not be the seat of the obstruction. All these possibilities of error emphasize the need of exploratory operations, either herniotomy or abdominal section, in any case in which life is seriously endangered and the exact cause obscure.

Littre's Hernia (Partial Enterocele).—This was formerly described as the constriction of a pre-existent diverticulum in a hernial orifice, but the name is now applied to that form of hernia where only a part of the circumference of the bowel is constricted by the margin of a hernial opening. This artificial diverticulum looks like a nipple, and protrudes from the convex surface of a loop of bowel. On relieving the strangulation the nipple, as a rule, disappears, leaving a deeply indented ring of a dark-blue color in strong contrast to the

rest of the bowel. It occurs most frequently at the femoral ring, only a few cases being seen elsewhere. The symptoms are not so severe, on the whole, as when the whole circumference of the bowel is involved. The vomiting is not so persistent, and feces and flatus may continue to pass. The tumor itself is often so small as to be overlooked, and if the patient is stout even the most careful examination will fail to make it out.

The proper **treatment** of Littre's hernia is either herniotomy or, if there be every symptom of hernia and no tumor, an abdominal section.

STRANGULATED OMENTAL HERNIA.—When omentum alone is strangulated, as sometimes occurs, the symptoms are similar to those of strangulation of the bowel, but not so severe; the pain is less, vomiting not so persistent, and constipation not so complete. In fact, the symptoms are those of Littre's hernia, and some surgeons assert that in all cases of so-called strangulated omental hernia there is an error in diagnosis, and that a small strangulated knuckle of gut behind the omentum has been overlooked.

Diagnosis of Strangulated Hernia.—Usually the diagnosis of strangulated hernia presents but little difficulty. It may, however, be confounded with incarcerated or inflamed irreducible hernia.

In *incarcerated hernia* there is impulse on coughing and absence of tenderness; vomiting, when present, is not severe. Constipation exists in both, but in this form yields to treatment. In *inflamed hernia* the local inflammation is very marked, and elevation of temperature always exists; constipation is not complete, flatus and fluid feces readily passing, and there is no vomiting. When hernia is *double*, it sometimes requires a careful examination to determine which one is strangulated. Various *tumors*, glandular and others, have been mistaken for strangulated hernia and operated on. The local evidence of tumor would serve to diagnosticate strangulated hernia from *intestinal obstruction*.

Prognosis.—If unrelieved by reduction or operation, the prognosis is bad. In very acute cases the patient will die in forty-eight hours if the hernia is not reduced. Some cases which have been "left to nature" have lived a fortnight, and in others the bowel has become gangrenous and the sac and skin have sloughed, thus exposing the opening in the bowel. Recovery with an artificial anus may result.

Treatment.—*No delay is permissible*, for unless the strangulation be relieved the patient will surely die. There are only two methods of treatment —first, *taxis;* second, *herniotomy*.

Taxis.—This is the reduction of the bowel into the abdomen by means of manipulation with the fingers. When seen very early the hernia may be returned without the administration of an anesthetic; indeed, the patient himself frequently returns the hernia by assuming the recumbent position and pressing in the protruded bowel. If the patient is seen later and there is considerable tension of the part, an anesthetic should be administered before taxis is attempted. It is remarkable how simple the reduction of many herniæ becomes under ether or chloroform. A rupture that would not previously yield to taxis often goes in under anesthesia with the slightest amount of manipulation.

Method of Performing Taxis.—When fully under the influence of the anesthetic, the patient is placed on his back with the pelvis raised, and the thigh of the affected side flexed and rotated inward if the hernia be femoral or inguinal. Indeed, it is important that everything should be done to relax the parts about the hernial ring. The neck of the sac is then seized with the thumb and fingers of one hand, and thus fixed, while with the other hand the surgeon endeav-

ors to return the strangulated gut by gentle pressure in the proper direction. In femoral hernia this is at first downward, to bring the gut opposite the saphenous opening, then backward, and then upward. In inguinal hernia it is usually slightly upward and outward. The part which protruded last, presumably at the neck of the sac, is that first to be returned. The bowel should be coaxed rather than forced in. A kneading and squeezing movement or gently pulling the tumor from side to side or downward often proves successful, the gut returning with a *sudden gurgle* or rush, a sensation which is quite peculiar to hernia. Too prolonged or violent manipulation is strongly to be condemned, and may do an infinite amount of injury. If by moderate and gentle taxis for from five to ten minutes the surgeon fails to overcome the strangulation, he should *waste no further time, but proceed at once to the performance of herniotomy.*

When Taxis is Contraindicated.—Taxis should *not* be employed when it is suspected that the gut is already gangrenous, in cases where the hernial tumor is inflamed by previous manipulation, where stercoraceous vomiting has set in, or in many of the later stages of strangulation. If the strangulation occurs in an old irreducible hernia, herniotomy should be at once performed. The older methods of treatment by opium, ice-bag, or hot bath should be tried in those cases only where the symptoms are not urgent or the patient refuses operation.

Strangulation after Reduction.—It occasionally happens that after the reduction of a hernial tumor symptoms of strangulation persist, and when such an occurrence takes place it is due to one of the following conditions: (1) the return of injured or gangrenous bowel; (2) paralysis of the bowels, existing as the result of general peritonitis; (3) the presence of a second strangulated hernia; and (4) the reduction of the hernial tumor *en masse* or *en bloc.*

The treatment of all these conditions is the same—viz. abdominal section and the immediate examination of the condition of affairs. If the bowel is gangrenous, an artificial anus should be established, or, if the patient's condition warrants it, a resection and lateral anastomosis of the affected bowel should be performed. In the other cases the surgeon should be guided by the conditions found on opening the abdomen.

If the sac and its contents are returned, still strangulated, into the abdominal cavity, the condition is known as *reduction en masse.* The tumor disappears without any gurgling sound, and the constitutional symptoms are still unrelieved. Immediate incision should be practised, either in the median line or over the site of the hernia. This accident occurs most frequently in the inguinal variety of hernia.

In certain rare cases the sac is ruptured and the gut makes its escape into the subserous connective tissue, the protruded bowel still remaining strangulated. Treatment by herniotomy should be performed for the relief of the latter two conditions.

Remote Consequences following Reduction of a Strangulated Hernia.—Intestinal obstruction may ensue some time after a reduction of hernia: (1) owing to the formation of bands of adhesion; (2) from a displaced hernial sac; (3) from cicatricial stenosis, due to some sloughing of part of the injured bowel.

In all these cases exploratory laparotomy is called for, and in the last-mentioned resection of the stenosed portion of the bowel.

After-treatment.—After a strangulated hernia has been reduced the vomiting ceases and the patient feels greatly relieved. He should be kept in bed for some days, and fed on nutritious fluid diet until the bowels act sponta-

neously. It is well to fix a pad over the hernial ring by means of a properly-applied bandage, to prevent the return of the hernia.

Herniotomy.—Should taxis fail or the case be one where the conditions are adverse to taxis, the surgeon must at once proceed to perform herniotomy. Having shaved the parts and carefully cleansed them antiseptically, an incision about two inches long should be made over the tumor and the various structures carefully divided down to the sac. It is often very difficult to recognize the sac, it varies so much in character, sometimes being thick and fibrous, and at other times thin and translucent. It is often hard to distinguish it from bowel or omentum. Most commonly, in recently strangulated cases which have been previously reducible, it looks like a cyst, fluctuating and having a bluish color. When reached it should be pinched up between two artery forceps and divided; immediately there is an escape of fluid often having a fecal odor, and the bowel is seen lying within the sac. The constriction, which is usually at the hernial ring, should now be relieved by cutting. To effect this the finger is introduced up to the constricting point, a blunt-pointed bistoury pushed along it, and the constriction divided cautiously in the proper direction suitable to each form of hernia. The bowel should then be examined: if healthy and full of vitality, as evidenced by its elasticity and capacity to transmit its contents (the strangulation having been relieved), it may be at once returned into the abdomen with the omentum. If the protruded omentum be large in amount or adherent, it is better to tie it with silk or catgut in sections and then remove it. Any adhesions that exist should be freed and, if vascular, cut between two ligatures. The sac should then be treated as in operations for the radical cure of hernia, and the neck of the sac ligatured as high up as possible. If the sac be small, it should be dissected out and cut off half an inch below the ligature at its neck; but if it be large, it may be left, after cutting it through or excising a small part of the upper portion. The canal is closed, as in the radical cure of hernia. If the hernia is acquired, as is most commonly the case, the conjoined tendon should be sutured to Poupart's ligament with three or four stout silk sutures. The external wound is closed in the usual way with silkworm-gut or silk sutures, and the ordinary antiseptic dressings applied, fixed in place with a firmly-applied spica bandage.

The patient should have no fluid or food of any kind for twenty-four hours: there is, however, no objection to the administration of a small dose of morphia hypodermatically if there be much pain. The bowels may be allowed to act of their own accord, and if, at the end of a week, they are still constipated, they may be relieved by enemata, castor oil, and salines. If there be much distention previous to this, salines often prove beneficial.

Should the Sac be Opened in Herniotomy?—Before the introduction of antiseptic surgery the surgeon never opened the sac unless compelled to do so from inability to reduce the bowel without this procedure or from the fear of reducing into the abdomen strangulated or gangrenous bowel. The opening of the peritoneal cavity was dreaded on account of the frequency with which peritonitis resulted. For many years this question agitated the minds of surgeons. At the present time, however, surgeons, confident in their antiseptic or aseptic precautions, open the sac without fear of the result. In only a few cases of quite recent herniæ, where there is no reason to suspect that the bowel is anything but healthy, is it advisable to return the protruded bowel without opening the sac. Opening of the sac should always be the rule where the strangulation has existed for some time, where violent and prolonged taxis has been employed, and of course in all cases of irreducible herniæ. In every case the surgeon should use his own judgment as to opening the sac or not doing so.

In some cases it may not be easy to tell when the sac is opened, on account of its thickness, its dark-red color, or the absence of fluid in the sac. A cyst produced by pressure of the truss may be met with in front of the sac, or the sac may be so intimately united with the protruded omentum that it cannot be distinguished from it, and the dissection of the sac is an impossibility, or, at least, a proceeding which may result in the opening of the bowel. Again, there may be no sac or only a partial one (as in cases of cæcal herniæ), or the posterior wall of the sac may be the anterior peritoneal covering of the protruded cæcum.

Abdominal Section to Reduce Strangulated Hernia.—Tait has recently proposed to treat strangulated hernia by abdominal section and reduction of the hernia by traction from within the belly, aided by pressure from without, instead of the usual method of external herniotomy. In exceptional cases this may be commended; as, for instance, in a case of evident acute intestinal obstruction from a femoral hernia so small as not to produce any perceptible tumor externally, or in a pre-peritoneal hernia; but it will hardly replace herniotomy as a routine practice.

Gangrenous Intestine and its Treatment.—When on opening the sac the intestine is found to be gangrenous, what should be done? There are several methods advocated: (1) To resect the gangrenous gut, suture the cut ends, and return the bowel into the abdomen. (See Enterotomy.) (2) To fasten it outside the abdomen and open it at once. The patient recovers with an artificial anus or a fecal fistula, which can be treated at a later period when he has regained his strength. (3) If only a small portion of the bowel be gangrenous, to return it within the abdominal cavity, anchor it with a suture just inside the ring, and introduce a large drain through the ring in close proximity to the bowel. (1) Resection of the gut, owing to the weak condition of the patient, may not always be advisable. In such cases the use of Murphy's button, or some other means of rapidly uniting the ends of the divided bowel, is recommended. The second method is perhaps the safest for the general practitioner who has had no practice in resecting intestine. His patient will have a better chance of recovery, and later operative procedures for closing the fecal fistula can be undertaken. A method advocated lately by Helferich of Greifswald is worthy of mention—viz. to make an immediate abdominal section and establish intestinal anastomosis between the part of the intestine above the gangrenous gut and the part below it. The gangrenous gut is allowed to remain outside the hernial opening. By this means peristalsis is obtained from the first, and later the gangrenous gut may be resected without danger, the anastomosis favoring the early closure of the fecal fistula.

Sequelæ to Herniotomy.—(1) The wound may not unite by first intention, and if the sac has been very adherent the disturbance of the cellular tissue may cause some sloughing. In such cases the wound should be reopened and stuffed with iodoform gauze.

(2) Diffuse general peritonitis may set in; this is known by the persistence of the vomiting, the continuance of the pain, distention, and tenderness of the abdomen, with elevation of temperature. This may be due to leakage from a perforation, to a gangrenous condition of the bowel, or to the introduction of septic matter from without at the time of operation, as in any other abdominal section. Immediate laparotomy should be done.

(3) The reduced gut, which has been returned as suspicious, may become gangrenous and obstruction of the bowel still continue. If this condition be suspected, the abdomen should be opened and the gangrenous bowel sought for, and either resected or incised, and kept outside the abdomen with the object of forming an artificial anus.

(4) The bowel may not be gangrenous, yet be so injured that it may not be able to resume its proper functions, and the patient may die in consequence if not relieved by a laparotomy.

(5) The bowel may be temporarily paralyzed by local inflammation so as not to be able immediately to resume its functions, though after some days it may recover completely its normal condition. In such cases there is obstinate constipation, without vomiting or other signs of peritonitis.

(6) Cases of acute mania have followed the operation for strangulated hernia, some of which have proved fatal (Shepherd).

SPECIAL HERNIÆ—INGUINAL HERNIA.

This is the commonest form of rupture. More than two-thirds of the cases applying to the London Truss Society for trusses suffered from inguinal hernia.

By inguinal hernia is meant a rupture which is situated wholly or partly in the inguinal canal or in the inguinal canal and scrotum.

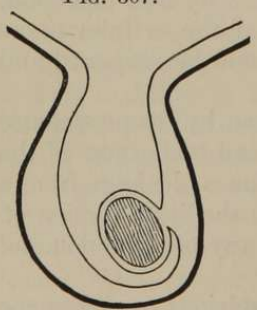
Inguinal hernia may be *oblique*, or external, and *direct*, or internal.

An **Oblique Inguinal Hernia** is one which passes through the spermatic canal, having the same course as the spermatic cord—viz. through the internal ring, along the inguinal canal, and through the external abdominal ring to the scrotum. In its course it passes to the outer side of the epigastric artery, and hence is also called *external inguinal hernia*. Oblique inguinal hernia consists of two forms, *congenital* and *acquired*.

Direct or **Internal Inguinal Hernia** passes directly through the abdominal walls to the external abdominal ring, and thence to the scrotum. It pushes in front of it or passes through the conjoined tendon, and is *internal* to the epigastric artery, passing through a triangle bounded internally by the rectus abdominis, externally by the epigastric artery, and below by Poupart's ligament (*Hesselbach's triangle*).

Congenital Inguinal Hernia.—The tubular process of peritoneum which accompanies the testicle in its descent to the scrotum becomes obliterated at its upper part during the later months of fœtal life. The lower part remains, envelops the testicle, and is called the *tunica vaginalis*. The previous connection of the tube with the peritoneum is marked by a dimple at the internal ring. Occasionally this obliteration does not take place, and the tube remains continuous with the abdominal peritoneal cavity, so that a hernia may suddenly descend in this tube to the scrotum. The hernia is in the tunica vaginalis, which forms its sac. This is the form of hernia which is named congenital (Fig. 307). It is said to occur most frequently on the right side.

Fig. 307.



Congenital Hernial Sac (original).

Method of Obliteration of the Tubular Process.—There are two points at which the obliteration takes place—viz. at the *internal ring* and a little above the epididymis (Fig. 308). The obliteration begins first at the higher point, and takes place later at the lower point, thus leaving a serous tube between them. This tube soon shrinks into a fibrous cord; but on the other hand the process of obliteration may not go on, and while the two ends are closed the tube remains patent, and in it a hydrocele of the cord may subsequently form.

Infantile or Encysted Hernia.—In certain cases the tubular process of peritoneum closes only at the *upper* end, thus leaving only a thin layer

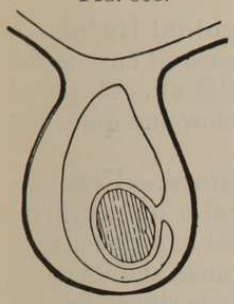
1

2

1. Femoral hernia. 2. Inguinal (scrotal) hernia.

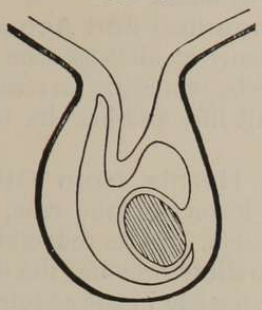
of membrane between the peritoneal cavity and the tunica vaginalis. When a hernia occurs, as it sometimes does, even in adult life, suddenly, the hernial sac is pushed into the tunica vaginalis, carrying the septum before it, and hence in front of the gut there will be three layers of peritoneum (Fig. 309). Occasionally the septum is ruptured, and the gut may, as in true congenital hernia, descend into the sac of the tunica vaginalis.

Fig. 308.



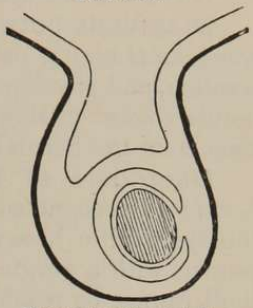
Infantile Hernial Sac, first stage (original).

Fig. 309.



Infantile Hernial Sac, second stage (original).

Fig. 310.



Funicular Hernial Sac (original).

Hernia into the Funicular Process.—When the tubular prolongation of peritoneum closes at the *lower* point only, there is a funicular process of peritoneum which passes through the internal ring, down the canal, and into the scrotum. The gut gets into this process, and, as in congenital hernia, passes down into the scrotum, but the testicle remains quite distinct from the rupture (Fig. 310).

Congenital hernia, as its name implies, appears at birth or soon after, developing suddenly; at once descending into the scrotum, it envelops the testicle. This form of hernia is much more liable to strangulation than the *acquired*, and is very difficult to reduce when strangulated, because the neck of the sac remains long and narrow (Fig. 309).

Congenital inguinal hernia is almost the only form of hernia seen in female children. The bowel protrudes into the canal of Nuck, a process of peritoneum which descends along the round ligament in the female fœtus.

Acquired Inguinal Hernia (Plate XIX, Fig. 1).—This form is rarely or never seen before puberty, and is more common in men than in women. It may be either oblique or direct.

The *oblique* form descends along the inguinal canal to the outer side of the epigastric artery, and is the most common variety of hernia. Its coverings from within out are the peritoneum, infundibuliform process of the transversalis fascia, cremaster muscle, intercolumnar fascia, superficial fascia, and skin. As it emerges from the external ring and enters the scrotum it becomes much larger, and in some cases is of enormous size (Plate XX, Fig. 1). In the female it enters the labium majus (Plate XX, Fig. 2).

In old cases of acquired oblique hernia the rings become much enlarged and are approximated, so that the internal ring lies directly behind the external. This, of course, has the effect of shortening the neck. Whilst an oblique hernia is in the inguinal canal it is called a **bubonocele.** It always forms slowly, and in this is very different from the congenital form. It is always in front of the spermatic cord, and when it reaches the scrotum the testicle is always below and distinct from the hernia.

In *acquired direct inguinal hernia* the hernial sac protrudes directly through the external ring to the scrotum. It either passes through the conjoined tendon

or to the outer side of it, and there is no long neck, as is the case in the oblique variety. When reduced, the finger can be pushed directly through the external ring into the abdominal cavity, whereas in the oblique form the finger passes along the inguinal canal to the internal ring and then into the abdominal cavity. In old herniæ, however, as mentioned above, where the rings are large and opposite each other, the contrast is not so marked, and in fact a diagnosis cannot always be made.

Direct herniæ are never congenital.

Diagnosis between Congenital and Acquired Inguinal Hernia.—*Congenital* hernia occurs suddenly at birth or soon after, passes at once to the scrotum, and envelops the testicle, rendering its recognition difficult. *Acquired* hernia comes on slowly in adult life, and has the testicle below and quite distinct from the hernial sac.

Diagnosis of Inguinal Hernia from Other Tumors.—Usually a *hernia* is recognized by the history of the case, the impulse on coughing, the tympanitic note on percussion, and its reducibility. The intestine always returns with a gurgle. The swelling occupies the inguinal canal, and its upper limit cannot be reached. The testicle in the acquired variety is situated at the bottom of the sac, and the spermatic cord is obscured. There is always an impulse on coughing, even in an irreducible hernia. When the sac contains omentum it is dull on percussion, has a doughy, knotty feeling, and returns without a gurgle.

Hydrocele.—History of a tumor, beginning below and extending upward; is dull on percussion, pyriform in shape, gives no impulse on coughing; is translucent; the testicle is behind and at the middle.

Hematocele comes on suddenly after injury; is dull on percussion, gives no impulse on coughing; is opaque, with a doughy feel.

Congenital Hydrocele.—Is translucent, dull on percussion, gives an impulse on coughing; the testicle is behind the tumor; the tumor disappears when the patient lies down, and returns slowly on standing, and fills from the bottom, whereas in hernia the tumor is opaque and reappears quickly on standing. When hernia and hydrocele coexist the diagnosis is not so easy.

Hydrocele of the Cord.—This appears as a tense, fluctating swelling in the inguinal canal, having distinct limits above. On pulling the cord it moves with it.

Varicocele.—Is dull on percussion, but may have an impulse on coughing; feels like a bag of worms. It can be reduced by pressure, but returns even if pressure be made on the ring sufficient to retain any hernia.

Undescended Testicle.—In every case of inguinal swelling the surgeon should look at the scrotum and see if it contains two testicles, and then he cannot mistake an undescended testicle for a hernia, as has been frequently done.

Treatment.—The treatment by trusses has already been described. In some cases of congenital hernia a cure is not infrequently effected in a year or two by a properly-fitting truss, but in the acquired variety it is very rarely safe to leave off the truss.

Taxis.—In reducing an inguinal hernia the pressure in the oblique variety should be in the direction of the canal, whereas in the direct variety and in old oblique herniæ the pressure should be directly backward. Before employing taxis the thigh should be adducted and flexed.

Herniotomy.—In performing herniotomy for strangulated inguinal hernia the only vessel in danger of being wounded is the deep epigastric, and to avoid this the incision of the constriction should be directly upward. In

Large labial hernia.

Large scrotal hernia.

oblique hernia the constriction is usually at the internal ring, and in direct hernia the conjoined tendon is the cause of the strangulation.

The treatment of the various forms of irreducible, inflamed, obstructed, and inguinal herniæ must be based on the principles already laid down when treating of hernia generally. The radical cure of inguinal hernia has been sufficiently described.

FEMORAL HERNIA (PLATE XIX, FIG 2).

Femoral or crural hernia occurs when the bowel escapes from the abdominal cavity under Poupart's ligament, passes through the femoral ring, and enters the femoral or crural canal.

The **femoral canal** commences at the femoral ring and ends at the saphenous opening in the fascia lata. It is about half an inch long, and wider at its termination than at its commencement. The peritoneal sac in femoral hernia is always acquired, never congenital. The hernia first of all passes through the femoral ring, pushing in front of it peritoneum and the septum crurale (Cloquet's fascia); then it descends along the femoral canal, lying on the pectineus muscle and covered by the sheath of the vessels and fascia lata; finally, it reaches the lower border of the saphenous opening, passing outward under the falciform border, and pushes in front of it the cribriform fascia. When it escapes from this opening it passes upward beneath the loose superficial fascia and over Poupart's ligament, and becomes very much larger. So its direction from within outward is first downward, then forward, and then upward. A fully-developed femoral hernia has somewhat the shape of a retort. From without inward the coverings of a femoral hernia are: skin, superficial fascia, cribriform fascia, sheath of the vessels, septum crurale, and peritoneum. The neck of the hernia is always situated at the **femoral ring**, which is bounded externally by the femoral vein, internally by Gimbernat's ligament, above by Poupart's ligament, and below by the pubes covered by the pectineus muscle. When strangulated the stricture is usually at the femoral ring, the sharp edge of Gimbernat's ligament being the constricting point.

To the outer side of the neck of the sac we have the epigastric artery, and above the spermatic cord. In about one in three and a half cases the obturator artery arises from the epigastric and passes down to the obturator foramen. In 10 per cent. of such cases it passes to the inner side of the femoral ring, and would be in danger of being wounded when the edge of Gimbernat's ligament is cut to relieve a strangulation.

About 10 per cent. of all cases of hernia are femoral. Femoral hernia is much more common in females than in males, and rarely occurs before adult life. It is much more liable to become strangulated than inguinal, it being not uncommon to find a femoral hernia strangulated at the time of its first descent. The hernia is rarely of large size, and its contents consist usually of a portion of the ileum. Omentum is never found in large quantities, but is frequently irreducible.

Diagnosis.—It is not always easy to distinguish femoral from inguinal hernia in stout females when it has mounted above Poupart's ligament. Femoral hernia can always be pushed to the outside of the spine of the pubes, whilst inguinal hernia always lies to the inner side. In stout people the spine can always be felt by abducting the thigh, and thus bringing into prominence the adductor longus tendon, which arises immediately below the pubic spine. To assist in the diagnosis the line of Poupart's ligament should always be marked by a string, and not by the eye.

Femoral hernia is usually seen as a small, tense, round tumor situated in the groin, inside the vessels and outside the pubic spine. In some rare cases it has been seen outside the vessels.

Diagnosis from Other Tumors.—*Psoas Abscess.*—This is very apt to simulate hernia, as it has an impulse on coughing and partially or wholly disappears on the patient's lying down, though without the gurgle of a hernia. It is always situated to the outside of the vessels, and is accompanied, usually, by some angular deformity of the spine.

Fatty Tumor has a lobulated feeling, no impulse on coughing, is dull on percussion, and irreducible.

Varix of the Saphena Vein may simulate hernia, but on reducing it and asking the patient to stand whilst the finger presses on the ring, it will always return, while a femoral hernia will not.

Enlarged Lymphatic Glands, when inflamed, have sometimes been mistaken for strangulated femoral hernia and operation has been performed. In some cases the crural branch of the genito-crural nerve has been found stretched tightly over an enlarged and inflamed gland, giving rise to such reflex symptoms as vomiting and constipation. A strangulated hernia and an enlarged, inflamed gland may coexist. In some cases the diagnosis cannot be made without incision.

Cysts in the Femoral Canal are very difficult to diagnosticate; they are always irreducible and have no impulse on coughing.

Treatment of Femoral Hernia.—When reducible, a properly-fitting truss should be worn. A truss will never cure a femoral hernia, and in some cases cannot be made to keep in the hernia.

When *strangulated*, **taxis** should first be employed, the thigh of that side being flexed, adducted, and rotated inward. In this way the margin of the saphenous opening is relaxed. If the hernial tumor has reached above Poupart's ligament, it should be lifted and drawn downward before pressure is employed. Not the slightest violence should be used, and if taxis fail, resort should be immediately had to herniotomy.

Herniotomy.—The parts having been shaved and rendered aseptic, an incision should be made over the inner side of the tumor in the direction of its long axis, and the tissues cautiously divided until the sac is reached. It is often very difficult in femoral hernia to distinguish the sac, owing to its altered appearance from the pressure of a truss or from the accumulation of fluid outside the sac. In most cases there is no fluid in the sac, and the sac is often opened before the surgeon is aware of the fact. It may be recognized by its smooth lining and the presence of bowel. The sac having been opened, the seat of stricture, which is usually the sharp edge of Gimbernat's ligament, is sought. The finger is introduced into the sac, the pulp facing inward, until the edge of the ligament is felt; a hernia knife or a blunt-pointed bistoury is passed along the finger with its edge down and gently insinuated beneath the ligament, and then the edge, turned inward, nicks a few of the constricting fibers until the stricture is relieved. The stricture having been relieved, the bowel is examined, and if normal is reduced with omentum. If the omentum is adherent, it should be tied and removed. If the condition of the patient is good, the sac should next be dissected out and its neck ligatured as high up as possible. It is then cut off a little below the point of ligature. In some cases it is wise to fix the neck of the sac at the femoral ring by ligatures. The wound should be closed with silkworm-gut sutures and a small drain introduced at its lower angle. The dressings should be carefully applied, so that they will not be soiled by contact with urine or feces.

The results of this operation are usually remarkably good. A radical cure does not always take place, but the life of the patient is saved and recovery is generally rapid. In case an abnormal obturator artery is wounded, it would be well to enlarge the incision upward and look for the bleeding point. The artery when cut completely through usually retracts to such an extent that it is most difficult to secure. In some cases a needle has been successfully placed beneath it and the hemorrhage arrested. Wounding of the obturator is an accident which will rarely happen if the knife is dull and the incision is not too free.

UMBILICAL HERNIA.

There are three forms of this hernia—viz. (1) congenital; (2) infantile; and (3) adult.

(1) CONGENITAL UMBILICAL HERNIA occurs most frequently in female children, and is due to an arrest of development whereby the abdominal walls do not properly close. It is sometimes of large size, and contains not only the intestines, but various organs, as the spleen, liver, etc. In some monsters all the abdominal contents are contained in the hernia. This form of hernia may be small, and is seen as a tumor at the root of the umbilical cord. The sac protrudes into the cord, and cases are on record where the bowel has been included in the ligature applied to the cord at birth. In some cases where only a small diverticulum of gut is included recovery may proceed uninterruptedly, but in others a fecal fistula may result. If a large amount of intestine is included, a fatal issue is inevitable

As a rule, the coverings of the hernia are so thin that the contents of the sac can easily be seen.

Treatment.—The hernia should be returned and kept in place by strips of plaster encircling the abdomen, so as to bring the recti muscles close together; over this a tight binder should be applied. A flat cork pad the size of a silver dollar under the strapping is sometimes advised. Occasionally umbilical hernia has been operated on successfully.

INFANTILE UMBILICAL HERNIA.—This form is very common, and comes on after separation of the umbilical cord, and is caused by the stretching or yielding of the cicatrix at the umbilicus. It never reaches a large size, and tends to undergo a spontaneous cure.

Treatment.—The hernia can be easily reduced, and kept so by the application of adhesive or porous plaster. Plaster is objectionable, however, because of its tendency to produce troublesome eczema on an infant's skin. A truss may be applied. Infantile umbilical hernia never becomes strangulated.

ADULT UMBILICAL HERNIA.—This form of hernia very rarely commences in infancy; it is almost always acquired rather late in life. It is seen most commonly in stout women who have borne many children; also in men with pendulous bellies. It sometimes reaches a large size, but usually is not larger than the closed fist. The contents are commonly the transverse colon and omentum. The stomach has been found in herniæ of very large size, and even the gravid uterus. Umbilical hernia is very liable to become obstructed or inflamed, but is rarely strangulated. It is often irreducible.

Treatment.—When reducible, it should be kept in place by a belt surrounding the abdomen. When irreducible, a cup-shaped pad kept in position by a belt or bandage should be applied. Trusses or belts are very difficult to fit so as properly to retain this form of hernia, and the stouter the individual the more difficult it is to apply a suitable truss.

Should the hernia become *strangulated*, taxis should first be employed, and

it often succeeds; but should it fail, herniotomy should be performed without delay, as gangrene sets in very rapidly. It is well to remember that the skin and the sac in this region are very thin, and the operator may open the sac before he is aware of it. The contents also are commonly adherent. The patient is frequently old and feeble, and perhaps suffers from a chronic bronchitis. Altogether, the subjects of strangulated umbilical hernia are not usually in a very favorable condition to bear well a severe operation.

After reaching the sac, it should be carefully opened and the hernial ring divided at its lower border, and if necessary at one or two other points. The gut should be examined, and if in good condition returned; the adherent omentum separated, ligated, removed, and the stump also returned. The sac should now be dissected out, the neck drawn down a little, and either sutured with a continuous suture and amputated half an inch below, or ligatured with stout silk and removed, as in other forms of hernia. The pillars of the ring should be freshened a little and sutured with strong silk. The wound should then be closed and a drainage-tube inserted. If the gut be gangrenous, an artificial anus should be established.

In cases of strangulated umbilical hernia where the assistance is poor and the condition of the patient is unfavorable, no time should be wasted in separating large intestine from its adhesions or in ligaturing omentum; the recently descended intestine which has become strangulated should be returned as quickly as possible, and the operation completed without delay.

The *radical cure* of umbilical hernia may be undertaken and fairly good results as to permanent cure may be obtained; that is, if the hernia be not too large. In performing the operation the neck of the sac should be well separated from the surrounding structures, the bowel returned into the abdomen, and the sac tied off. The pillars of the ring should then be brought together with silkworm gut or strong silk sutures; the external wound closed with horsehair or silkworm gut and the dressings applied. In many cases, owing to the protruded omentum having an attachment to the sac, it is necessary to open the sac and tie off the protruded omentum in sections. The sac is afterward ligatured and cut off. Some surgeons recommend that the hernial ring should be dissected out (omphalectomy) and the new ring brought together with deep sutures of catgut and silkworm gut. By this more radical operation it is held that cure is much more likely to be permanent.

Ventral Hernia.—This term is applied to any hernia coming through the abdominal walls in regions not the usual sites of herniæ. It is frequently seen in the scar following operations for ovarian tumors, appendicitis, etc. It may also follow injury or abscess in the abdominal walls. Ventral hernia is usually large, and rarely or never becomes strangulated, owing to the size of the opening. Most of the cases are found in the linea alba.

Treatment.—The application of a suitable abdominal belt or truss is generally all that is required, but in some cases, where the protrusion causes great discomfort and inconvenience, and the general condition of the patient is good, reopening the wound and suturing afresh may be advised. In cases not due to operation the sac has been dissected out, ligatured, and removed with success.

Lumbar Hernia.—This variety is very rare. The rupture occurs through a triangle bounded by the external oblique, latissimus dorsi, and crest of the ilium (Petit's triangle). Lesshaft states that the triangle is constant only in women, and is not seen in young children. Before reaching this triangle the sac passes through the lumbar fascia near the outer border of the quadratus lumborum muscle. It may follow wounds, contusions, strains, or abscesses. In

old people it may come on without any apparent cause. It is easily reduced, and never attains any large size. Cases are on record where it has become strangulated. This form of hernia has been mistaken and incised for tumor, abscess, hematoma, etc. Males and females are equally liable to lumbar hernia. A well-made abdominal belt is usually sufficient to retain it properly in position.

Perineal Hernia.—This form descends in front of the rectum, and is most often seen in females. The protrusion escapes between the fibers of the levator ani muscle. It may be due to traumatism, and in males to constipation. Ebner thinks that perineal herniæ are congenital. The prominence may appear in males in the perineum near the anus or scrotum, and in females may descend into the labium majus (pudendal hernia). When this hernia appears in the vagina or labium, it may be mistaken for mucous cyst, but it is always reducible. In females it may contain the bladder.

Ischiatic Hernia.—This is a protrusion of gut through the great sacrosciatic foramen, most commonly above, but sometimes below, the pyriformis muscle. It has over it the gluteus maximus muscle, but may escape beneath its lower border. When small and strangulated it may be overlooked, owing to its great depth. It is one of the rarest forms of hernia.

Obturator Hernia.—This also is rarely seen, and still more rarely recognized before death. The gut protrudes through the obturator foramen, usually at its upper part, where the canal is situated. It pushes before it the obturator fascia, and perhaps a portion of the obturator externus muscle, and is covered by the pectineus muscle. It is internal to the femoral vessels. The neck of the sac is deeply situated in the obturator canal, and may have the obturator artery to its outer or inner side. It is rarely recognized unless strangulated, and even then it is often overlooked. There is a prominence to the inner side of the vessels in the region of the pectineus muscle. When strangulated, in addition to the usual signs of strangulated hernia, there is a tender, hard swelling at the upper and inner part of the thigh, and severe pain down the inner side of the thigh as far as the knee in the course of distribution of the obturator nerve. It is most common in females, rarely occurs before fifty, and may be mistaken for femoral hernia.

Treatment.—Taxis is not usually successful, but should be tried with the thigh flexed, adducted, and rotated outward. Herniotomy should be performed if the seat of the strangulation be recognized. The stricture is always at the neck of the sac, and should be relieved by cutting downward. The saphena vein may give trouble. In some cases the hernia might be easily reduced by performing median abdominal section, thus relieving rapidly and safely the strangulated gut by traction from above. This hernia has sometimes been recognized by vaginal examination.

Diaphragmatic Hernia.—There are two forms of this hernia, *congenital* and *traumatic*.

The *congenital* form is due to the defective development of the diaphragm, whereby it is imperfectly closed, and thus some of the abdominal contents are protruded into the thoracic cavity. The stomach is the viscus most often displaced, next the colon, and then the small intestines. The spleen and liver have also been found in the thoracic cavity. The deficiency nearly always occurs on the left side.

The *traumatic* form is due to rupture of the diaphragm by violence or to stab wounds. It occurs most commonly on the left side, and the stomach is the organ most frequently displaced. It is rarely recognized before death. Of 250 cases collected by Leichtenstern, only 5 were diagnosticated. After

severe crushing injury Bryant of London refers to excessive thirst as a prominent symptom.

Hernia into the Foramen of Winslow occasionally occurs, and gives rise to symptoms of abdominal obstruction. It can be recognized only by abdominal section or after death.

Properitoneal Hernia is a form of hernia which occupies an abnormal position within the abdominal or pelvic wall and in front of the peritoneum. It may lie between the parietal peritoneum and the muscles, between the planes of the abdominal muscles, or outside of them and just beneath the skin and superficial fascia. The former of these varieties is the true properitoneal hernia.

As a rule, these cases are originally inguinal herniæ: they are usually congenital, and are apt to be associated with an undescended and more or less atrophied testicle. After they have for a time occupied the inguinal canal the resistance to their descent offered by the testicle forces them out during a muscular effort on the part of the patient into the connective tissue between the peritoneum and the muscles or into one or other of the spaces above mentioned.

The cause of this peculiarity in the congenital form, according to Trendelenburg, is the persistence of a cavity which must exist at a certain stage in the descent of the testes—an instance of arrested development. In acquired cases, according to Krönlein, the cause is mechanical, the pressure of a badly-fitting truss or repeated attempts at taxis forcing the internal away from the external ring, and dilating the sac or canal into a pouch between the layers of the parietes.

Properitoneal herniæ are found just above Poupart's ligament and are parallel with it, extending upward and outward as far as the anterior spine. Sometimes they are large and overlap Poupart's ligament, extending downward to the upper portion of the thigh. There is apt to be thinning of the abdominal wall at the seat of swelling.

In case of strangulation taxis may be apparently successful, and yet the abdominal pain will become more intense and the symptoms will not disappear. The tumor will not go back with the characteristic gurgle, and the symptoms will continue unabated, or even aggravated, by attempts at reduction. If the scrotal tumor or that occupying the canal disappears, the swelling above Poupart's ligament will become more tense and increase in size. Upon operation the loops of gut lying in the scrotum cannot be reduced as usual, or if reduced persistently descend again or lie fixed in close proximity to the internal abdominal ring.

The treatment should consist in a free incision, such as would be proper in a strangulated inguinal hernia, followed by dilatation with the finger or by division of the ring through which the hernia protrudes; or Trendelenburg's method may be adopted and an incision made through the linea alba, and reposition of the bowel effected by traction from within.

Retro-peritoneal Hernia (*Mesenteric Hernia of Cooper*).—This rare form of hernia is caused by the lodgment of small intestine in the fossa duodeno-jejunalis.[1] The intestine pushes its way onward, forcing the fold of peritoneum forming the fossa before it. In time there is quite a large sac filled with bowel behind the posterior layer of peritoneum. In one case Sir Astley Cooper found the whole of the small intestines, with the exception of

[1] This fossa is seen if the transverse colon be thrown upward and the small intestine drawn to the right. It is formed by a fold of serous membrane passing from the parietal peritoneum to the left of the terminal part of the duodenum (Treves).

the duodenum, hidden from view, occupying a large sac in the middle of the abdomen and surrounded by large intestine. As a rule, these cases are only diagnosticated post-mortem. On opening the abdomen and entering the peritoneal cavity, a second sac containing the small intestine is found. This sac is clear and free from blood-vessels, being composed of mesentery which has been pushed forward by the herniated bowel.

The **symptoms** in extreme cases have been severe pain, vomiting, weakness, and collapse.

Treatment.—By opening the abdomen the condition could be easily recognized, and the intestine might be pulled out of the enlarged fossa duodeno-jejunalis. No successful cases of treatment have been reported.

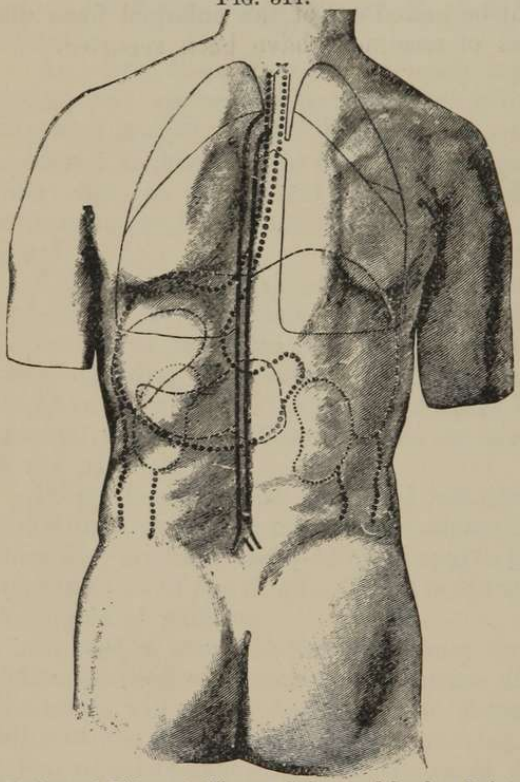
CHAPTER VII.

SURGERY OF THE GENITO-URINARY TRACT.

PART I.—DISEASES OF THE KIDNEYS AND URETERS.

Surgical Anatomy.—The kidneys are seated in the right and left hypochondriac regions. Their lower levels are somewhat above the umbilicus. The right kidney is three-quarters of an inch lower than the left. Their upper borders are about on the level of the interval between the eleventh and twelfth dorsal spines. The lower edge of the left kidney is about two inches above the crest of the ilium; of the right kidney, one and a quarter inches. The hilum is on the level of the first lumbar spine, and is two inches from the middle line (Fig. 311).

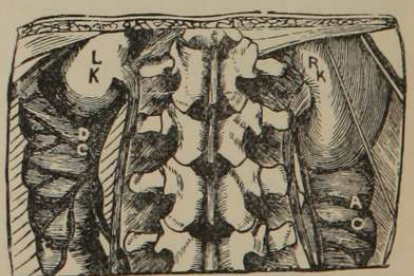
Fig. 311.



Relations of Kidney to Viscera, Spine, and Surface Points (Godlee and Thane).

The kidneys are only partially covered with peritoneum. Portions of the anterior surface are in relation with the back of the ascending and descending colon, some cellular tissue intervening, and with the duodenum and pancreas. The posterior surface is uncovered. The external border is sometimes partially covered with peritoneum. The kidneys are usually surrounded with a large quantity of fatty tissue poorly supplied with blood-vessels. The ureters are about 14½ to 16 inches in length and of the caliber of an ordinary goose-quill, narrowing where they pass through the bladder-walls. Their walls are comparatively thick and muscular, but are susceptible of great dilatation without rupture when the dilating force is gradual. They are entirely retro-peritoneal (Fig. 312).

Fig. 312.



Kidneys, Ureters, Ascending and Descending Colon from behind; *L K*, left kidney; *R K*, right kidney; *D C*, descending colon; *A C*, ascending colon (Holden).

Anomalies.—The kidneys may occupy a position in the pelvis in front of the spine, or the one on the left side may rest above the spleen. They may be altered in shape and size by arrest of development, or one kidney may be entirely absent, in which case the remaining organ is apt to be of unusual size. Occasionally they are united at their extremities (usually the upper) and form the "horseshoe" kidney.

Floating Kidney.—Either kidney, especially the right, may be unnaturally movable and constitute the "floating kidney." The kidneys are held in place normally by the connections of the peritoneum with the perinephric fat. If the latter is absorbed during acute disease or from long-continued ill health, the organ can move more freely, and by its weight elongates the peritoneal folds, which in other cases are abnormally long and lax. The kidney may also be dislocated by traumatism, and become a floating kidney.

Movable kidneys are most common in poorly-nourished females who have borne children, the scarcity of the fat and the relaxation of the abdominal walls following pregnancy acting as predisposing causes.

Symptoms.—The symptoms may vary from a slight uneasiness referred to the lumbar or the hypochondriac or sometimes the umbilical region, to agonizing pain, which when paroxysmal has been supposed to be due to a strangulation by twisting of the renal nerves and vessels. The length of the latter limits the degree of mobility of the kidney, which can only describe the segment of a circle of which the vessels are the radius.

Physical examination may show undue lumbar resonance (a fallacious and uncertain symptom), or may reveal a movable tumor in the hypochondrium or in the umbilical or even the iliac region. The depression of the hilum, and sometimes the pulsation of the renal artery, may be recognized, and if the tumor on manipulation plainly recedes toward the loin and is of the size and consistence of the kidney, the diagnosis becomes reasonably certain. Malignant omental growths, solid tumors of the ovaries, growths of the abdominal wall, beginning enlargement of the spleen, and distention of the gall-bladder may usually be easily excluded.

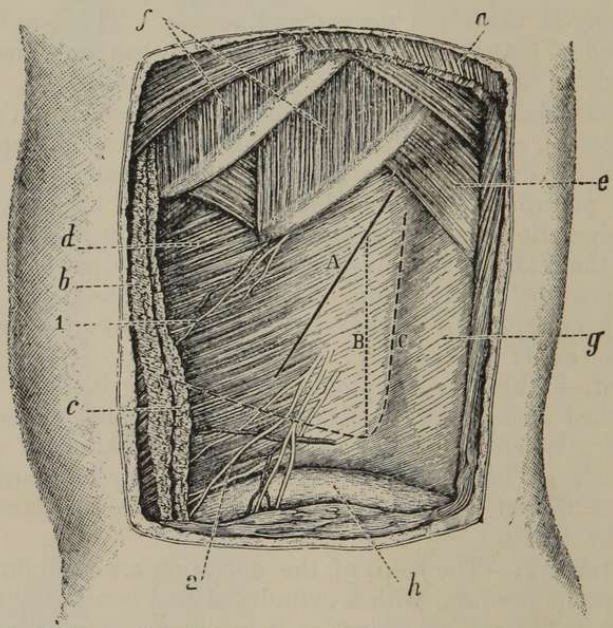
Treatment.—When the symptoms are moderate in degree, the use of a compress attached to a broad, neatly-fitting elastic bandage will often suffice for their relief. When of greater severity, the operation of *nephrorrhaphy* should be considered, but only after the treatment by belt and compress has failed, and after thorough attention has been paid to the general health and condition of the patient.

Nephrorrhaphy.—The steps of the operation are as follows: Place the patient in the prone position, with a cylindrical pad beneath the abdomen, the ilio-costal space on the side of operation being turned upward and made prominent. Define carefully the position of the twelfth rib, so that accidental opening of the pleura may be avoided; make an incision parallel to it and about half an inch below it, and four inches in length, beginning two and a half inches from the spines of the vertebræ (Fig. 313, *A*). Divide the latissimus dorsi, the external oblique, the internal oblique, the transversalis, and the lumbar fascia; separate the perinephric fat, which will bulge into the wound, with the fingers, or with two pairs of dissecting forceps, and thus expose the capsule of the kidney. Up to this point the operations of nephrorrhaphy, nephrotomy, nephro-lithotomy, and nephrectomy are identical. In the case of nephrorrhaphy the surgeon next proceeds to pass by means of curved needles four to six sutures of medium-sized plaited or twisted silk through the capsule, including a portion of kidney tissue, and then through the adjacent lumbar fascia and muscles, knotting them and cutting them off short. If there has been but little disturbance of the fat, the wound may be closed without drainage; otherwise it is well to leave in a rubber drainage-tube for a day or two.

The ultimate results of this operation have been favorable in most of the reported cases. There is no means of estimating, however, the unsuccessful cases not reported. Performed with proper antiseptic precautions, the mortality should be very trifling.

Nephralgia.—The urine, as a consequence of overwork, of errors in diet, of the rheumatic or gouty diathesis, etc., may become a positive irritant and give rise to various forms of nephritis, more appropriately considered in text-books on medicine. If it is persistently acid, it may give rise to *nephralgia*, a deep-seated unilateral lumbar pain, of a dull aching character, with exacerbations of sharper pain extending along the course of the ureters toward the groin or into the testicle. The best time to test the urine in making the diagnosis of this condition is about two hours after a meal, preferably breakfast, when it is normally mildly alkaline. This pain may be diagnosticated from that accompanying the more serious conditions of renal calculus, pyelitis, disease of the bladder or prostate, etc. by the absence of the symptoms character-

Fig. 313.



Operations upon the Kidney: *A*, incision for exploration for nephrotomy, nephro-lithotomy, and nephrorrhaphy; *B*, additional incision for nephrectomy; *C*, König's lumbo-abdominal incision for nephrectomy; *a*, latissimus dorsi; *b*, external oblique; *c*, internal oblique; *d*, transversalis; *e*, serratus posticus inferior; *f*, intercostals; *g*, lumbar fascia over erector spinæ; *h*, crest of ilium; 1, intercostal nerve and artery; 2, twelfth dorsal nerve and artery (Treves).

istic of those ailments and by the relief afforded by attention to the general health, to the diet, and to the hygiene of the sexual organs. Alkalies, such as potassium citrate or potassium acetate, Vichy, or, if there is constipation, Friedrichshall water, regular baths followed by friction, great moderation in the use of meats, sweets, and alcohol, are clearly indicated.

The very similar pain due to myalgia of the lumbar muscles is generally rheumatic or gouty, and may be cured by the use of belladonna in ointment or liniment, and by the administration of the salicylates.

Phosphatic Urine, in which the opposite condition of over-alkalinity prevails, is found most commonly in nervous, overworked persons of sedentary habits and feeble digestion. It is associated with general lassitude, occipital headache, and depression of spirits. In young males it is a constant source of sexual hypochondriasis, the patient referring his symptoms to early masturbation or to sexual excess, and often mistaking the milky deposit of phosphates for seminal losses. Dilute mineral acids, strychnia, a regulated diet, and rest or change of scene will effect a cure.

Oxaluria is often an unsuspected cause of a variety of genito-urinary symptoms. It may be found in young persons, overfed, of indolent habits, with ungratified sexual desires, or may follow sexual excesses, especially in gouty or rheumatic persons. In the latter case it is frequently the cause of persistent and distressing sexual feebleness or even of entire impotence. It is always well in patients with the vague genital symptoms, ill-defined lumbar or hypogastric pains, mental depression, etc. so constantly found in sexual hypochondriacs to examine the urine for the octahedral or dumb-bell crystals of calcium oxalate, with which will often be found an excess of uric-acid crystals, and of amorphous phosphates or urates.

Here, again, the mineral acids in infusions of vegetable tonics, and a rigidly restricted diet, with an occasional course of sodium phosphate (20 grains four times daily) in some alkaline diluent, such as Vichy or Lithia water, will cause a rapid disappearance of all the annoying symptoms. Change of air and scene will often effect a cure when drugs alone have failed.

Gravel.—When the crystalline substances naturally held in solution in the urine are deposited in the uriniferous tubules or elsewhere, the condition known as *gravel* exists. It is due to too great concentration of the urine, caused by lack of exercise, high living, excess of meats and sugars in the food and of malt or sweet effervescing liquors in the drink. It is due also to the gouty diathesis, to excessive sweating, and much more frequently than is supposed to an insufficiency of water in the daily diet, a common but often unsuspected cause of many chronic kidney diseases. The deposit may be uric acid, urates, or calcium oxalate, the relative frequency corresponding to the order of mention. The symptoms of gravel are those of hyperacidity of the urine, with marked vesical and urethral symptoms superadded, increased frequency of micturition and ardor urinæ being especially noticeable. The treatment is the same as that for nephralgia or oxaluria.

Renal Calculus.—If the crystalline particles or the amorphous powder deposited become glued together by colloid material derived from mucus or blood-clot, they form a nucleus on which further depositions of salines from the urine occur, and constitute a **calculus,** which may soon attain a size that prevents its passage through the ureter. It may, and most frequently does, consist of uric acid; next in frequency is calcium oxalate, and much more rarely the stone is composed of calcium carbonate or of the mixed phosphates. Calculi may form in the tubules or in one of the calyces, and may vary in number from one to hundreds.

When the stone finds its way into the ureter it may exceptionally escape almost unnoticed, but as a rule its entrance into and passage through that duct give rise to a group of symptoms known as **nephritic colic,** which are as follows: A person who has been entirely comfortable and in perfect health is seized instantaneously with a violent pain, felt first in the lumbar or hypochondriac region, but at once extending down the line of the ureter toward the scrotum and the end of the penis. The testicle is strongly drawn upward by spasm of the cremaster. The pain follows the branches of the lumbar plexus into the groin, thigh, and hypogastrium. The patient is apt to prefer a sitting position, stooping over so as to relax the ilio-psoas and lumbar muscles—those in closest relation to the ureter. Vesical irritation and tenesmus are frequent. Faintness, cold sweating, and even collapse are not uncommon accompaniments of such an attack. It may cease as suddenly as it began, but the relief is not permanent until the stone has either receded into the pelvis of the kidney or more luckily has passed onward into the bladder. In the latter case no further attacks may follow. If the former event has occurred, the next paroxysm

may be indefinitely postponed, but as long as the stone is in the ureter (and its passage sometimes requires several days) the attacks of colic succeed one another at intervals ranging from a few minutes to an hour or more. The urine is high-colored and scanty, or may even be almost completely suppressed; fever supervenes, and occasionally, especially if there is organic renal disease, the patient succumbs, though this is very rare.

The immediate treatment should consist of the hypodermatic use of morphia and atropia in small doses, warm baths, and diluent drinks; the use of ether by inhalation is occasionally necessary.

The most serious termination is *impaction* of the calculus in the ureter, in which case a prolongation of the symptoms in lessening acuteness results, but with the gradual development of hydronephrosis, pyonephrosis, and (if the other kidney be diseased) uremia and death. Occasionally, as a result of ulceration, the stone escapes into the cellular tissue of the loin, giving rise to a lumbar or pelvic abscess. If the diagnosis of impaction can be established with any reasonable degree of certainty, operation is clearly indicated, and should be performed, as follows:

Ureterotomy or *Uretero-lithotomy.*—The position of the stone may be indicated by a distinctly localized area of tenderness in the course of the ureter, associated with the symptoms of obstruction. If, as is often the case, the stone is impacted in the lower end of the ureter, a rectal or vaginal examination will usually suffice for its recognition. If its position is uncertain and the symptoms are both persistent and threatening, abdominal section to permit of palpation of the ureter becomes justifiable, although its extraction should even then be undertaken by the extra-peritoneal route through the loin. Under these circumstances a hand in the abdomen by fixing the calculus or by pushing it backward may be of great assistance. Two successful cases in which this method was employed have recently been reported.

If the calculus is in the upper portion of the ureter, a curved incision on a line beginning just below and parallel to the twelfth rib, then directed toward the middle of Poupart's ligament, and then, again, toward the external border of the rectus abdominis, would seem to give ample room for extraction of a calculus situated in the abdominal portion of the ureter (Israel). It has been shown that the ureter is adherent to the peritoneum, and accompanies it when the latter is stripped up from behind. This renders its recognition more easy. A stone impacted in the pelvic portion of its course may often be extracted in the female through a vaginal incision which opens neither the bladder nor the peritoneum.

In the male it has been proposed to reach the same region by an incision on the border of the sacrum with removal of its lower portion with the coccyx, but no operation of the sort has been recorded.

If the calculus projects into the bladder, suprapubic cystotomy is indicated in the male and urethral dilatation in the female. It is probably wise not to attempt to suture the wound in the ureter, but to trust to its spontaneous closure; but further observations are needed upon this point.

If the stone remains in the kidney until it acquires a bulk that prevents it from entering the ureter, it will give rise to some or all of the following symptoms, their severity varying greatly in different cases: lumbar pains and uneasiness just below the twelfth rib and external to the quadratus, aggravated by movement and extending down the cord to the testicle and thigh; vesical irritation, shown by frequent micturition rather than by tenesmus; hematuria, irregular both as to quantity and time of appearance; pyuria; of these the

hematuria is the most valuable. There is often a history of personal or family predisposition to oxaluria or to lithemia.

Direct exploration with a needle will sometimes reveal the existence of stone, and if done with care is not a dangerous procedure. Rarely in emaciated persons and in cases of excessively large stone it may be recognized by direct bimanual palpation.

Diagnosis.—Early *tubercular pyelitis* will be associated with an excess of pus, a slighter hematuria, a strumous rather than a lithemic history, bacilli in the urine, etc. *Spinal caries* may be associated with a degree of renal irritation that is misleading, especially where the abscess is close to or presses upon the kidneys. Usually the deformity or tenderness of the spine will suffice to differentiate the condition. *Nephralgia*, *lithiasis*, *oxaluria*, *hydronephrosis*, and *pyonephrosis* should be carefully eliminated.

Nephro-lithotomy.—Operation should be decided upon when the diagnosis is reasonably certain, the patient is disabled by pain or exhaustion, previous treatment has failed, and there is no reason to fear grave organic disease of the other kidney. A moderate amount of albumin, with casts, is to be expected, and in the face of distinct symptoms of stone should not deter the surgeon, as the results without operation are so unpromising. The preparatory treatment should consist in the free use of diluents, restricted diet, the administration of a laxative and of an enema, and rest in bed for some days.

The position of the patient and the incisions until the kidney is exposed are the same as in the operation of nephrorrhaphy. (See page 811.) If more room is needed, the edge of the quadratus may be incised. Firm counter-pressure should be made on the anterior surface of the abdomen by an assistant while the lower ribs are elevated by another. The different surfaces of the kidney should then be examined by the finger of the surgeon and compressed between the finger and thumb, and if no stone is disclosed an exploring needle or long acupressure pin may be inserted in several directions. Howse has compared the sensation given to the finger by a stone imbedded in the kidney to the outline of the last joint of a finger; Morris, to the uncut end of a pencil. It varies, of course, with the size and shape of the stone and its distance from the surface. Instances have been recorded of large stones so situated that they could not be felt even when the kidney was removed and was lying on a table, and were disclosed only when it was laid open. If the above means fail, therefore, in a case with well-marked symptoms, a linear incision may be made large enough to admit the end of a finger, the pressure of which usually stops the hemorrhage, which is apt to be free at first. If a stone is found, it may be shelled out with the finger-nail, or if very large and branched, with light adhesions, it may be broken by forceps and the fragments removed with the finger and curette. The cavity should be syringed forcibly with antiseptic lotions, sponged with fine small sponges, and packed with iodoform gauze around a drainage-tube. The operation may be a very difficult one, owing to the thickening and adhesion of all the perinephric tissues, to hardening of the kidney itself, to the small size of the stone, or to its situation near the anterior surface of the kidney. Death may result from hemorrhage, septicemia, or uremia.

Nephrectomy.—During an operation begun for the removal of a stone it may be thought advisable to take away the kidney itself, on account of its disorganization, the existence of multiple abscesses, or the impossibility of taking away all fragments of the stone. As a rule, however, a free nephrotomy with thorough drainage gives the patient the best chance for recovery from the immediate danger of the condition and operation. This will leave the patient with a urinary fistula, which, if it does not close spontaneously in two or three

months, may necessitate a secondary nephrectomy. Removal of the kidney may also be indicated in tubercular or calculous pyo-nephrosis, or even hydronephrosis, nephrotomy and free drainage having first been tried.

Nephrectomy for malignant disease in both adults and children has been thus far a very fatal and a very unsuccessful operation. The best results have been obtained in nephrectomies for sarcoma in adults, but even in these the mortality has been very large. The kidneys may also require removal for wounds, ruptures, tears of the ureter, and occasionally for movable kidney, after failure of nephrorrhaphy.

Catheterization of the ureters is performed in the female with moderate ease, and is possible, but far more difficult, in the male. It may enable the surgeon to advise or reject nephrectomy in a given case by demonstrating the presence or absence of a functionally active and sound kidney on the opposite side.

The lumbar operation is performed through the same incisions as those already described (p. 811), special care being taken to secure sufficient room. Incision of the quadratus and a vertical slit downward (Fig. 313, *B*), making the original cut irregularly T-shaped, will often be required. König's method (Fig. 313, *C*) may be needed in cases of exceptionally large or very adherent kidneys. The soft parts are divided vertically along the border of the erector spinæ; the incision is then continued anteriorly in the direction of the umbilicus, ending at the outer border of the rectus; the muscles are divided down to the peritoneum, which should be pushed forward. Or the kidney may be reached by direct incision along the outer edge of the rectus, or through the linea alba, both methods, as a rule, opening the peritoneal cavity; sometimes the peritoneum can be stripped off the abdominal wall and the kidney be removed without opening the abdomen. The lumbar incisions are to be preferred, except in cases of neoplasms of large size. When the kidney is reached it should be enucleated from its capsule, or, if the latter is adherent, should be separated with it from the perinephric fat and surrounding tissues. The ureter should be tied separately and the stump curetted and disinfected. The vessels should be tied by one stout silk ligature, or, better, in two bundles, by passing a pedicle needle carrying a double ligature between them, tying the two halves separately, and then "tying back" around the whole mass.

The pedicle should then be cut through with scissors at least a half-inch from the ligature. Further hemorrhage may be arrested, if serious, by hemostatic forceps left *in situ*, or, if moderate, by plugging with iodoform gauze around a drainage-tube.

INFLAMMATORY AND SUPPURATIVE AFFECTIONS OF THE KIDNEYS.

Interstitial Nephritis as a surgical affection is due either to some inflammation or ulceration of the urinary tract below the kidney or to some reflex irritation, such as that from catheterism, acting upon a kidney which has already long been subjected to pressure caused by anterior obstruction, such as urethral stricture or prostatic hypertrophy. A rigor may usher in the attack if it is acute and follows instrumentation, or the symptoms may be very insidious in the subacute variety due to associated chronic obstruction or irritation. In either case there are likely to be moderate fever, thirst, anorexia, dry tongue, and gradual exhaustion. In the absence of inflammation of the bladder, prostate, or urethra the urine contains merely a trace of albumin. Hyaline casts are present, but may be scanty. As a rule, this condition runs into suppuration of the kidney, or, if it has arisen acutely from catheterism with a septic instrument, is associated with a suppurative *pyelitis* or *pyelo-*

nephritis. These conditions have the same causes as the non-suppurative affection, with the additional factor of infection by the pyogenic bacteria.

A patient who has had chronic inflammation or atony of the bladder, or prostatic disease with residual urine, or an old tight stricture with occasional retention, or who has recently had an operation upon the urethra or the bladder, or who has a renal calculus, or tubercle or carcinoma of some portion of the urinary tract, may suddenly develop a high temperature, drowsiness, a dry, furred tongue, a sallow color, and rapid loss of flesh; or such a case may run a more chronic course, with pain in the back, frequent micturition, evening rigors, quotidian or tertian, and a variable quantity of pus in the urine. Often the lumbar pain and the fever are in inverse proportion to the percentage of pus while it accumulates in the dilated and often sacculated kidney; tension and pain are great, septic absorption and fever are marked. The discharge of the pus is followed by a subsidence or temporary disappearance of these phenomena.

Pyo-nephrosis.—If a considerable accumulation takes place, the kidney becomes converted into a mere sac or bag containing pus, and forming a tumor most prominent in the ilio-costal space posteriorly, moderately tender to the touch, diminishing sometimes in size coincidently with an increase of pus in the urine, obscurely fluctuating, and dull on percussion; on the right side its dulness may be separated from that of the liver by a line of resonance over the colon, but this is not constant, as the kidney and liver may have become adherent at various points.

This condition of *pyo-nephrosis* is most apt to occur when, in addition to the usual causes of pyelo-nephritis, there is some anterior obstruction, as stricture or enlarged prostate, or still more constantly if the obstruction is in the ureter, as from contraction of its vesical orifice or from an impacted stone.

Hydro-nephrosis when not congenital is due to similar conditions. Although the cause of hydro-nephrosis is always mechanical and obstructive, it is congenital in a large proportion—nearly one-third—of the cases, and is then due to various pathological conditions of the ureter, such as twists or kinks or stenosis, or to its compression from some abnormality of surrounding structures, or to obstruction at its point of emergence from the kidney or at that of its entrance into the bladder.

Among the causes which exert their influence later in life, malignant disease of the pelvic viscera is one of the most common. Then, of course, the hydro-nephrosis is merely a symptom altogether secondary in importance to the underlying disease, but it may serve as an important aid to diagnosis in doubtful cases in the rather exceptional instances where it forms a distinct lumbar swelling. Impaction of a calculus in the ureter, which has been found in 40 per cent. of acute cases, is of much more practical significance, and may require operative interference by the method already described. An accumulation of urine in the kidney from obstruction in floating kidney may also be the cause of acquired hydro-nephrosis.

It should not be forgotten that frequent micturition is in itself a competent cause for the production of hydro-nephrosis, acting through the oft-repeated interference with the escape of the urine from the vesical ends of the ureters, which, owing to their oblique course through the walls of the bladder, are compressed each time that that organ contracts. In this way vesical calculus or papilloma or chronic cystitis or even phimosis may produce hydro-nephrosis. Hydro-nephrosis may affect either kidney, and in about 15 per cent. of the reported cases both kidneys have been involved.

Symptoms.—While the case is a simple one of hydro-nephrosis, *i. e.*

before infection with pyogenic microbes has occurred, there may be almost no evidence of disease of the kidney until a distinct swelling is apparent in the loin, or, more rarely, in the abdomen. In children frequency of urination may be the only noticeable symptom, and may lead to an ineffectual search for vesical calculus and to circumcision. In adults it is even more difficult of early recognition, on account of the greater thickness of the abdominal walls.

It should not be forgotten that the frequency with which hydro-nephrosis causes a visible or palpable tumor in the loin or abdomen is very slight, compared with the great number of cases found at autopsies. In advanced cases the concomitant disturbance of the renal function may give rise to thirst, to nausea or vomiting, to persistent headache, to dryness and sallowness of the skin; yet these are symptoms common to many affections of the kidneys. If there is a rapid rate of growth, lumbar aches, obscure abdominal pains, and frequent micturition may be added to the symptoms, and if the disease is bilateral there may be intermittent anuria of varying degrees, followed by uremia. Constipation from pressure on the descending colon is an occasional symptom. When the swelling appears, it will present the characteristics which distinguish growths involving the kidneys; *i. e.* it will first show in the flank, and will have the colon in front of it, and often the small intestine also. It will, in addition, be dull on percussion, more or less distinctly fluctuating, and rounded or irregularly lobulated. A history of a lumbar tumor varying in size is almost pathognomonic, but it should be remembered that patients with other cystic swellings, and even with solid tumors, will often innocently make very misleading statements as to changes in size which they imagine they have noticed. If, however, the variation was unmistakable, and especially if a diminution in size was associated with an increased outflow of urine, the diagnosis may be made with much positiveness. The symptoms of pyo-nephrosis, which may at any time supervene in such a case, will be easily recognized. The development of rigors, fever, sweating, and increased local pain and tenderness, together with the appearance of pus in the urine, will often clear up the case at once. If these symptoms are wanting, as they sometimes are, the diagnosis may be impossible.

Hydro-nephrotic tumors have been mistaken for ovarian growths with considerable frequency, a number of cases having been submitted to laparotomy before the error was recognized. If an accurate history is obtainable, the direction of the growth of the swelling, its association with some renal symptom, the relation to the colon, and the negative results of vaginal and uterine examination will usually clear up all doubts.

It might be thought that an examination of a small portion of the fluid withdrawn by means of an aspirator would be conclusive, but such is not invariably the case. It is never pure urine, but usually contains urea, with acid and a little albumin. Sometimes, however, these ingredients are wanting, and the tapping may simply furnish a thick, purulent, putrid fluid, which could scarcely be distinguished from that of a perinephric abscess (*q. v.*).

Prognosis.—The prognosis varies with the cause. If that is not malignant or in itself necessarily fatal, if the tumor is of but moderate size and is stationary, if only one kidney is affected, and if the lower urinary organs are not the seat of suppurative disease, there is but little risk to life. If both kidneys are involved, uremia commonly results.

Treatment.—The administration of drugs is of no avail. Frictions and manipulations have seemed to be successful in a few cases, all of them young children, but obviously little dependence can be placed on such methods, which might even be dangerous if vigorously employed. Tapping is followed by cure

in a certain proportion of cases, but usually has to be repeated a number of times. It is better to use a small needle and to remove the fluid by aspiration. If the right kidney is affected, the best point for the insertion of the needle is halfway between the last rib and the crest of the ilium, and about two and a quarter inches posterior to the anterior superior spine. On the left side the absence of the liver makes it safe to go a little higher, and a spot just below the last intercostal space may be selected.

A simple aspiration may effect a complete cure, either by the relief of tension or by permitting the unfolding of a twist of the ureter. If repeated tappings fail to bring about a cure, nephrotomy, stitching of the edges of the cyst to the parietal wound, and drainage and irrigation should next be employed. Nephrectomy should be used only in cases in which a permanent fistula with offensive purulent discharge indicates great disorganization of the renal tissue and threatens the development of sepsis. If at the first tapping the fluid is found to be distinctly purulent, nephrotomy should be done either at once or as soon as the tumor re-forms.

Weir has suggested that in cases of acute septic invasion of the kidney an exploratory incision on one or both sides might relieve the acute interstitial invasion, and, if a large and well-defined focus of pus were found, might do still more good. He did a nephrectomy successfully in one case of septic pyelo-nephritis, but the frequency with which both kidneys are involved in such cases makes it improbable that the operation would often result favorably.

Perinephritis.—Inflammation in the loose connective and fatty tissues surrounding the kidney is of very frequent occurrence. It is most frequently found in adults, and is not uncommon in children.

Etiology.—Perinephritis may be simple and idiopathic, or may be the result of an affection of the kidney itself. Occasionally its exciting cause is to be found in some neighboring or remote organ or structure, or it may be due to traumatism.

Symptoms.—When it is not the result of infection, it has but little importance from a surgical point of view. The symptoms are vague, the most noticeable being localized tenderness and pain, relieved somewhat by flexion of the thigh upon the abdomen; stiffness of the spinal column; inclination of the trunk toward the affected side; inability to bring the ham to the surface on which the patient lies supine, or at least inability to do so without much pain. There is also fever, sometimes quite marked.

Diagnosis.—This condition is often mistaken for coxalgia or for Pott's disease in the early stage. Perinephritis should be recognizable by the localization of the tenderness, the absence of the characteristic deformities of either the spine or the lower extremity, and the failure to elicit pain or tenderness by pressure on the trochanter or by crowding together the vertebræ. Occasionally pain in the knee increases the resemblance to coxalgia.

Treatment.—Rest is most important. Stimulating liniments applied with deep friction may be useful; leeches or wet cups followed by hot stupes have been employed with apparent benefit. Laxatives are indicated, and small doses of opiates and of belladonna, by relieving the spasm of the psoas, may be of much value. The case may terminate in resolution, but much more commonly runs on to suppuration.

Perinephric Abscess.—The infective inflammation in these cases may extend to the loin from any portion of the urinary or intestinal tract in relation by contiguity or continuity with the retro-peritoneal connective tissue. Thus it has been known to follow lithotomy, internal urethrotomy, castration,

prostatic abscess, appendicitis, etc. It may result from perforation of the diaphragm by an empyema. In many cases it is secondary to suppurative pyelitis, usually calculous in its origin. Actual, or at least demonstrable, perforation of the capsule of the kidney is not a necessity in these cases, the inflammation appearing to spread by contiguity, although doubtless all such cases indicate true microbic infection of the area secondarily invaded.

Symptoms.—The indications of the formation of pus in a case of perinephritis are similar to those which accompany deep-seated suppuration anywhere. Rigors, sweats, high temperature, etc. are apt to be marked. If the abscess is consecutive to disease of the kidney and the result of the escape of urine through a renal fistula, the debilitated condition of the patient and the putrescible and highly poisonous character of the extravasated fluid are factors which give the case peculiar gravity; an intense primary septic intoxication (sapremia) immediately resulting, often soon followed by well-developed septicemia. In other instances the case runs a slow course, the constitutional symptoms being vague and ill defined. In these cases the following group of local symptoms will be of chief diagnostic importance: deep-seated, paroxysmal lumbar pain extending into the thigh and the hypogastrium, sometimes into the groin and scrotum; tenderness on direct, and especially on bimanual, pressure upon the loin, one hand being in front, the other behind; increased resistance and fulness in the lumbar region, followed by brawniness of the skin and later by œdema; lameness, flexion of the thigh upon the abdomen, inclination of the body toward the affected side, are, as in simple perinephritis, of great value; œdema of the lower limb on the same side is of frequent occurrence; the formation of a distinct fluctuating swelling, vague in its outlines, would ordinarily be conclusive as to the character of the case, but if doubt remains the use of a hollow needle will resolve it.

Diagnosis.—Nephralgia and renal calculus lack the inflammatory and constitutional symptoms which accompany abscess; lumbago could be recognized by the absence of fever, of flexion of the thigh, and of lateral bending of the trunk; hip disease and vertebral caries, by the characteristic deformities and by the gait of the patients; appendicitis and pericæcal abscess, by the site of original pain and by the concomitant intestinal and abdominal symptoms; psoitis and psoas abscess, by the situation of the pain, which is apt to be anterior to a line drawn from the front border of the axilla to the crest of the ilium, while in perinephritis and perinephric abscess the local symptoms are apt to be posterior to such a line (Morris).

Prognosis.—The probability of entire recovery of course varies greatly with the cause. In simple cases treated by early incision recovery is prompt and complete. In cases dependent upon suppuration along the urinary or intestinal tract, extending to the retro-peritoneal connective tissue, early operation is likewise followed by cure in the great majority of instances. In cases secondary to pyelo-nephritis, renal calculus, etc. fistula often follows, and the final outcome is greatly influenced by the character of the renal disease.

Treatment.—In all cases operation should be resorted to as soon as the condition is recognized, or even as soon as there are distinct localizing symptoms showing the presence of an acute inflammation with no tendency to disappear by resolution. An incision on the outer edge of the quadratus, in the costo-iliac space, vertical or oblique, and opening up the post-renal space, is of no gravity whatever. Delay may mean extensive burrowing, perforation of the diaphragm with consecutive empyema, and opening of the abscess into some of the contiguous viscera or into the peritoneal cavity. An explora-

tion by means of a hollow needle should certainly be made, therefore, whenever the earlier symptoms of perinephric inflammation are followed by fulness, hardness, and tenderness, and especially if in addition there are heat and redness of the skin. Failure to find pus in this manner may warrant further delay, but a persistence of the same symptoms would certainly justify a free incision long before fluctuation could be felt through the thick abdominal parietes. Six pints of pus were found and evacuated in one such case, although, owing to the thickness of the subcutaneous fat, no fluctuation could be made out.

After evacuation of the pus the finger should explore the kidney, and if a renal fistula is found it should also be probed. If there are grounds for believing the disease to be of calculous origin, the kidney should be carefully palpated, or even pierced with an exploring needle or probe, in the endeavor to locate a stone. If one is found, nephro-lithotomy may be proceeded with at once if the condition of the patient warrants it. As a rule, nephrectomy even in cases of real disorganization of the kidney should be postponed, as statistics show a much lower mortality after secondary operations for removal of the kidney than after those done at the time the loin is opened for abscess or to permit of the extraction of a stone.

The cavity should be thoroughly and forcibly sponged out, so as to remove all shreds of necrosed connective tissue, the débris of the abscess, and much of the infected granulation-tissue. If it is limited in extent, it may be well to curette the walls. Free irrigation with sublimate solution, the insertion of a drainage-tube, the inner end of which may be carried directly into the opening in the kidney if there be one, and the packing of the wound with antiseptic gauze, complete the operation. Only a few sutures at each angle of the wound are allowable. Nutritious food, tonics, and often stimulants, are urgently needed by the patient during convalescence.

Tuberculosis of the Kidney is usually associated with evidences of tubercular disease elsewhere, and occurs chiefly in broken-down persons, often of middle age or younger. It has been differentiated into "scrofulous kidney" and "miliary tuberculosis of the kidney," etc., but there is no important clinical or pathological distinction between the varieties, which differ only in the extent of the renal involvement. If the tuberculosis assumes the miliary or disseminated form, it is apt to affect both kidneys, and, as a rule, reveals an intense degree of constitutional infection. The other form is a tubercular pyelo-nephritis, sometimes local and primary, oftener secondary to other visceral tuberculosis, and more especially to ulcerating tubercular disease of the bladder or prostate. The symptoms are those of pyelo-nephritis plus the evidences of general tubercular disease. The patient often has a strongly marked family history of tuberculosis.

It has been said that vesical irritation is the most usual, and often the most prominent and distressing, symptom. Dickinson asserts that in a case containing pus from the kidneys the absence of bladder symptoms excludes renal tuberculosis. It is more probable, however, that the frequent micturition and vesical tenesmus depend on a beginning tubercular deposit about the lower end of the ureter or in the bladder itself. There may not be a lumbar tumor. The prominence of the vesical symptoms and the coexistence of tubercle elsewhere are most to be depended on for diagnosis.

The **prognosis** is unfavorable.

The **treatment** in advanced cases should be palliative. In primary cases which have gone on speedily to suppuration and to the production of pyonephrosis or perinephric abscess, and in which the condition of the kidney is

therefore discovered during the operation for these conditions, and before the general health is much affected, operation may be considered. If but one or two caseous foci are found and the kidney is not much enlarged or nodulated, incision, curetting, and drainage may suffice. In more extensive disease nephrectomy offers the only hope of cure.

Cysts of the Kidney may be congenital or acquired. In the former case they are sometimes of enormous size, and may even interfere with delivery. These are thought to be due to defective development of the tubules, as in such cases there are often other imperfections arising from developmental failure. In the adult they are often found in large numbers scattered through the parenchyma of the organ or sometimes occupying chiefly the cortex. They cannot be diagnosticated during life, as they produce no distinctive symptoms and often no symptoms at all.

More rarely, however, simple or serous cysts form and constitute a noticeable tumor. They begin in the cortical portion of the organ and grow toward the surface, the rest of the kidney remaining normal. The precise origin of these cysts is uncertain. They grow toward the loin, increase slowly and at first painlessly, and have the usual characteristics of renal tumors: as they enlarge the cyst-wall thins, and a tumor which at first may have been mistaken for a solid growth becomes evidently fluctuating. Hemorrhage may take place into the cavity of the cyst, or it may become the starting-point of a malignant neoplasm.

The **diagnosis** is difficult, and it is often impossible to distinguish such a cyst from one of the spleen, liver, pancreas, omentum, or mesentery, or indeed from any other intra-abdominal growth.

Prognosis.—If unrelieved, death may result from the interference with nutrition caused by the immense size of the growth and its pressure upon other parts, or may be caused by exhaustion from repeated hemorrhages into the cyst-cavity.

Treatment.—Frequent tapping will often effect a cure. If it fails to do so, the cyst should be cut down upon and opened and its edges attached to those of the parietal wound. Complete collapse and cure often follow. If a persistent fistula is left, nephrectomy will offer the only prospect of cure, but the fact that the kidney is probably healthy and functionally active must weigh strongly against operation if there be the least reason to doubt the condition of the opposite kidney.

Hydatid Cysts are found in the kidneys more frequently than in any other organ except the liver and the lungs. They are sometimes secondary to hydatids of those organs. They give rise to the same general symptoms as do other renal cysts, but, owing to their tendency to rupture into the pelvis of the ureter and to discharge their contents by that route, the **prognosis** is more favorable. In 52 out of 53 cases collected by Roberts the cysts were evacuated in this manner, and there is no authentic case recorded in which such a cyst emptied itself through the loin.

The **diagnosis** can be made with certainty only when the vesicles or hooklets are recognized in the urine, or after removal through a trocar. Their passage along the ureter excites the usual symptoms of renal colic.

The **treatment** should consist in incision, suture of the edges of the cyst to the parietal wound, and drainage. Daily irrigation and dressing will be required for a long time. Tapping may be employed previous to incision, but is usually unsuccessful.

Solid Tumors of the Kidney.—Most of these are malignant, and the majority are carcinomatous. The greater number, again, are secondary to

cancer of the testicle or to cancer of some other organ. The most frequent form of renal cancer is the soft, or medullary, which is oftenest found in young children or in persons of advanced age.

Hematuria and pain in the loin, succeeded by the development of a hard, nodulated tumor attaining an extremely large size in a comparatively short time, and occurring before the age of five or after that of sixty, would constitute a group of symptoms justifying the diagnosis of renal cancer. Occasionally the passage of small cancerous masses per urethram admits of a positive microscopical diagnosis. If this were made very early, nephrectomy would offer some chance of cure, otherwise the treatment must be palliative. Butlin reports 2 cases out of 18 free from recurrence at the end of three years after operation.

Sarcoma presents the same clinical symptoms. It occurs chiefly in the young. The only chance of cure lies in the early extirpation of the organ.

INJURIES OF THE KIDNEY.

Subparietal Injuries.—Injuries of the kidney without wound of the abdominal parietes may result from direct violence, as from crushes and blows upon the loin or upon the ilio-costal region of the abdomen, or from indirect violence, as in falls from a height, accompanied by sudden bending of the trunk at the time of alighting. They are by far the most frequent of all forms of injury to the kidney. They may be very severe up to rupture or even actual pulpefaction of the organ, or may consist of an extremely slight contusion with few symptoms.

Symptoms.—The history of an accident or traumatism sufficient to have produced the injury, lumbar pain and tenderness shooting down toward the groin, testicle, or thigh, frequent and painful micturition, and hematuria, are the symptoms most commonly present. In severe cases with extensive lacerations of the substance of the kidney there are superadded the constitutional symptoms of hemorrhage and shock, and sometimes of collapse. As to the hematuria, which is perhaps the most distinctive sign of injury of the kidney, it must not be forgotten that it may be marked in a case of strain or simple contusion in which there has been a sudden congestion in some portion of the urinary tract, or may be absent in cases of laceration of the kidney in which the ureter is plugged and occluded by a coagulum.

Prognosis.—In simple contusions the prognosis is favorable, and even in injuries attended with a certain degree of laceration there is a larger proportion of recoveries than after rupture of other abdominal viscera. If death occurs speedily, it is usually due to hemorrhage or collapse; later, to peritonitis or to diffuse suppuration in the loin, with septicemia or pyemia, or, if the opposite kidney happens to be diseased, to uremia.

Treatment.—The patient should be kept absolutely at rest; the diet limited to liquids; gallic acid or ergot or opium and lead administered if hematuria is extreme. Strapping the affected region so as to limit the movements, as in cases of fractured rib, will often give great relief from the pain. Enemata may be given at first if required. Purgatives should be avoided. Vomiting, by encouraging hemorrhage, is especially dangerous. If persistent, the patient should for a time be fed entirely by enemata. The chief difficulty often consists in the accumulation of blood-clots in the bladder, followed by vesical tenesmus and by retention of urine. If the blood-clots are small, they will probably be spontaneously evacuated. If they are somewhat larger, causing retention and tenesmus, a large catheter with two good-sized lateral

openings should be introduced and the bladder injected with some non-irritating antiseptic solution with moderate force. If this fails, one of the evacuating tubes used in litholapaxy may be inserted and connected with the evacuator, and fluid thrown into and drawn out from the bladder by that means.

Occasionally all these methods fail, and in such cases a median urethrotomy is indicated, both to evacuate clots and to relieve retention, and also to avoid decomposition of the blood and urine and the subsequent pyelo-nephritis from which many such patients have died. In cases of profound shock with or without hematuria, but with an increasing tumor in the loin, an incision should be made as if for lumbar nephrotomy or nephrectomy; the kidney should be thoroughly examined, and if torn across or pulpefied should at once be removed. Resection of a portion of the kidney in such cases has been proposed, but seems likely to be attended with a larger mortality than nephrectomy.

Penetrating Wounds of the Kidney.—A wound extending through the soft parts to the kidney may be either extra- or intra-peritoneal. In *extra-peritoneal* wounds of the kidney the posterior surface of the organ is involved, and the wound extends through the tissues of the loin. Exploration with an aseptic finger is proper and will often establish the diagnosis. The appearance of urine in the wound would of course be conclusive, but its absence does not disprove the existence of a renal wound, as the latter may involve only the cortex, neither the pelvis of the ureter nor a renal calyx having been opened. Hematuria may be due to coincident contusion, but it always points strongly to involvement of the kidney. Perinephric abscess is a common sequel.

If the wound is on the anterior surface and is *intra-peritoneal*, the symptoms will include those due to extravasation of blood or urine into the peritoneal cavity.

Prognosis.—In the latter class of cases the prognosis is very unfavorable, but in extra-peritoneal wounds of the kidney, uncomplicated by injury to other structures, recovery may be expected in the majority of cases.

Treatment.—In *extra-peritoneal* wounds, rest, low diet, ergot, and small doses of opium, and thorough antisepsis in and around the wound, are clearly indicated. Hemorrhage may be arrested by packing, accompanied, if necessary, by enlargement of the wound, so as to prevent urinary infiltration. Drainage should be secured by the introduction of a large rubber tube down to the wounded surface.

In *intra-peritoneal* wounds abdominal section, with nephrectomy, will almost always be required.

WOUNDS OF THE URETERS.

There are very few recorded instances of uncomplicated wounds of the ureters. In the historic case of the archbishop of Paris, who was shot in the loin during the revolution of 1848, and who died in eighteen hours, the ureter was divided close to the pelvis, but there were also fracture of the third lumbar vertebra and division of the cauda equina.

The ureter has been wounded during the removal of uterine, ovarian, and other abdominal tumors. Occasionally it has been divided purposely on account of its incorporation with a malignant growth (Morris). The divided or torn end should in any event be brought to the surface of the loin or of the vagina and sutured there. The first successful nephrectomy was performed by Simon for the relief of a urinary fistula following an accident of this character.

STRICTURE OF THE URETER is of very rare occurrence, except as a result of compression from without by pelvic or abdominal new growths.

Watson of Boston has, however, reported two cases of stricture, in both of which a ureter was nearly or quite obliterated by a dense mass of connective tissue. In one case there was a doubtful history of the passage of a renal calculus years previously. The condition was associated with pyo-nephrosis in both instances. He has collected four other cases from medical literature.

PART II.—DISEASES AND INJURIES OF THE BLADDER.

Congenital Deformities.—Occasionally, but rarely, *the bladder is absent*, and in that event the ureters may open directly into the urethra, rectum, or vagina, or upon the surface of the body in the middle line. The condition is usually associated with other abnormalities, such as undescended testicles, imperforate anus, etc.

Supernumerary bladders are also rare forms of congenital deformities, most of the reported cases having been really examples of multilocular or sacculated bladder. A few authentic instances exist, however, in one of which there were said to be five separate bladders.

CYSTOCELE, or hernia of the bladder, is usually secondary to obstructive disease. The dilatation of the organ, the thickening and weakening of its coats, and the straining during the frequent efforts to evacuate the urine constitute powerful factors in bringing about a protrusion of the viscus. This is also favored by weakness or relaxation of the abdominal walls, as from ascites or senility, or by the existence of a broad cicatrix following abdominal section. The bladder in these cases will protrude in the line of the linea alba, but in others it may follow the track of the cord or of the great blood-vessels through the walls of the abdomen, and appear in the inguinal or femoral or obturator region. In the female prolapsus frequently takes place into the vagina, the bladder protruding between the labia.

Symptoms.—The presence of a rounded fluctuating tumor in any of the above situations, increasing in size during the intervals of urination, markedly reduced in size by catheterization or after micturition, and lacking the characteristic signs of epiplocele or enterocele, should serve to establish the existence of a hernia of the bladder. In case of doubt a grooved needle or an aspirator will remove all difficulty. It should not be forgotten that in a case of cystocele, especially if it be irreducible, the interference with the evacuation of the urine tends to favor the formation of calculi, and that one or several may exist in the protruding pouch and may be mistaken for nodules of malignant growths.

Treatment.—When the tumor is reducible, a truss should be worn to retain it in place. When it is irreducible, a support or truss with a concave pad may be used to prevent its increase. Operative treatment has, as a rule, been unsatisfactory, except sometimes in vaginal cystocele.

EXSTROPHY is the most frequent of all the congenital defects of the bladder. It occurs in males in from 80 to 90 per cent. of all cases. It results from an arrested development of the lateral portions of the uro-genital cleft, which fail to come together to form the front of the bladder and the anterior parietes of the abdomen. The pubic symphysis is absent. The posterior wall of the bladder, covered with mucous membrane, bulges forward through the unnatural opening, and is usually covered with tenacious vesical mucus. The penis is the subject of complete epispadias. The prostate is rudimentary. There is

usually complete double inguinal hernia, the presence of which in the two halves of the scrotum, already separated by the unnatural interval between the pubic bones, causes the parts to resemble the labia of the female. If the scrotum is absent, the testes are found in the inguinal canal.

A similar condition in the female causes a separation of the labia and nymphæ and converts the vagina into a shallow fissure, but the disability produced is not so great as in the male.

Patients with exstrophy are usually found with marked cystitis from exposure of the mucous membrane to the air and from its friction against the clothing. The urine is fetid and ammoniacal; the skin of the abdomen, thighs, perineum, and buttocks is excoriated or eczematous. The general nutrition is often affected, and the child is apt to be feeble and sickly.

Treatment.—Appliances intended to collect the urine and protect the exposed surface of the bladder have thus far been entire failures. Some operative procedure is necessary as a preliminary. Of the many methods which have been devised, Wood's operation, which consists in turning down a flap from the abdomen above the opening (between it and the umbilicus) and covering it by two others taken from the inguinal region, is perhaps the most generally applicable. In the male, Roux's operation as modified by Maury of Philadelphia is often most useful, and sometimes has the advantage of curing at the same time any inguinal hernia which may coexist. It consists in turning up a large convex flap from the scrotum, the groin, and the perineum, slipping the penis through a small opening near the base of the flap, and sliding the edge of the latter beneath a second flap raised from the tissue above and to each side of the opening. The flaps are held in place by the "tongue-and-groove suture."

Successful operations for exstrophy greatly diminish the annoyance of the condition, concentrating the outflow of the urine at a single point, and thus permitting the use of a urinal and preserving the surrounding skin-surfaces from irritation. Of course in the case of the male sexual potency is never acquired, the penis always remaining rudimentary.

GENERAL CONSIDERATIONS IN THE DIAGNOSIS OF GENITO-URINARY DISEASE.

Pain.—The pain of genito-urinary disease may be considered in relation to the region in which it is felt and the time at which it is felt. In regard to the first subdivision, it may be remarked that the *region* to which the pain is referred should not be considered as necessarily the seat of the trouble. A stone in the bladder causes pain which is felt at the under surface of the penis a short distance back of the meatus; disease of the kidneys constantly gives rise to pain which is felt chiefly in the groin, down the thigh, or in the testicle; while disease of the testicle in its turn produces pain radiating along the inguinal line. In the majority of instances, as in those mentioned, reflex pain is due to the irritation of a nerve-trunk, the abnormal sensation being referred to the point of termination of the nerve: pain, however, may, of course, be felt at the seat of trouble itself, as, for example, in urethritis, where the pain is felt in the inflamed urethra; in retention of urine, where it is referred directly to the bladder and hypogastric region; or in prostatitis, where it is felt in the rectum and perineum. In some cases of the last-mentioned trouble the pain is duplex in character, being both localized and referred, a patient with a threatened prostatic abscess having rectal pain and urethral pain at the same time, the latter closely resembling that produced by vesical calculus.

The second subdivision in regard to pain refers to the *time* at which it is felt. Pain during micturition may be due to cystitis, prostatitis, or urethritis, or to the passage of gravel, or to a small calculus. Pain before micturition, which is relieved by that act, may be due to cystitis or to retention of urine. Pain which is increased at the end of micturition may be caused by vesical calculus or by acute prostatitis; if it is markedly increased during defecation, it points to the latter trouble; if relieved by rest and much increased by movement, it indicates the former condition.

Frequency of Micturition.—Increased frequency of micturition is a diagnostic sign which is of value only when considered carefully in its relation to other symptoms. Normal micturition depends upon the healthfulness of a certain nerve-tract, which, beginning in the peripheral extremities of the nerves distributed to the genito-urinary apparatus, extends to a certain portion of the lumbar enlargement of the spinal cord, and thence along other nerves to the muscles of the bladder and urethra. If the sensory nerves are unduly irritated, frequent micturition results. This is seen in phimosis, contracted meatus, urethral stricture, urethritis, cystitis, prostatitis, and vesical or renal calculus. If, on the other hand, the stimulus to these sensory nerves remains normal, but the spinal center becomes irritable, the same effect is produced as in cases of sexual excess or spinal concussion. The nerve-supply may remain normal, and yet frequent micturition be produced either by an excessive secretion of urine, as in diabetes, or by such contraction of the bladder as renders it disproportionately small, so that it is over-distended by even a normal amount of urine. Or, again, micturition may be too frequent from some obstructive cause, such as hypertrophy of the prostate, or when from weakness of its muscular walls the bladder fails entirely to empty itself, always retaining several ounces of urine. A condition which seems to combine the hypersecretion of urine with intolerance of the bladder is that known as "nervousness," or in its most aggravated form as hysteria.

It is evident, therefore, that we know but little which is of value so long as we simply know that the patient urinates too often. Further light, however, may be thrown upon the subject by a question as to whether or not the frequency is increased by movement or by rest. If the former, a stone in the bladder or a pedunculated growth of the bladder may account for it. If the latter, it may result from retention of urine due to atony or to an enlarged prostate. The patient with these last-mentioned troubles will find that he urinates at shorter intervals at night than in the daytime.

There are other points in relation to this act which will help in arriving at a conclusion. If the size of the stream is diminished, it suggests the existence of a stricture, a contracted meatus, or an inflammatory swelling somewhere along the urethral tract. If the force of the stream is diminished, it suggests obstruction, as from stricture or prostatic disease, or muscular weakness, as in atony. If the time required for the act of urination is increased, it likewise suggests obstruction or weakness.

Hematuria.—Bloody urine may result from a solution of continuity attended with hemorrhage and affecting any portion of the genito-urinary tract.

When the blood is derived from the kidneys, there will usually have been a history of renal disease and coexisting evidence in the shape of albuminous urine, granular or hyaline casts, œdema, retinal degeneration, etc. Or there may be the characteristic symptoms of renal calculi, or the symptoms of wound or contusion of the kidney, or of tumors, or tubercle of that organ may be present. In the majority of cases the blood which is derived from the kidneys is found when the urine is passed to be uniformly distributed through it, giving

it a dark smoky hue, but in cases of wounds or of malignant growths of the kidney it is passed out in such quantities that it may fill the bladder with clots (p. 824). Long, narrow cylindrical ureteral clots will often be voided.

Hemorrhage from the ureters is almost always the result of the presence or passage of a calculus, and is attended with all the symptoms of that occurrence, intense pain in the back and loins extending into the testicle on the affected side, retraction of the testicle, vomiting, cold sweat, and profound prostration.

Hemorrhage from the prostate, if non-traumatic, is usually the result of tubercular or carcinomatous ulceration, and is attended with marked enlargement of that gland and with the usual symptoms of obstruction to urination. Hemorrhage from the urethra is rare, except as a result of instrumentation. In both urethral and prostatic hemorrhage the blood is discharged in clots, sometimes tubular or cylindrical in shape, which precede the stream of urine.

Hemorrhage from the bladder may be suspected whenever the symptoms do not point to any of the above conditions, and, of course, may be recognized with certainty when its immediate cause can be discovered. A vesical calculus or tumor (usually a papilloma), a tubercular or carcinomatous ulceration, may be recognized by the sound, the presence of fragments of the neoplasm in the urine, the cystoscope, etc.

In acute cystitis or prostato-cystitis the symptoms of frequent and painful urination, with tenesmus, will point to the cause. Obstructive disease in the form of hepatic enlargement or abdominal tumors by pressing on the vena cava may give rise to a degree of congestion in the vesical plexus which results in hemorrhage.

Certain drugs, as cantharides and turpentine, in full doses produce the same conditions. Diseases attended by profound alteration of the blood, as purpura, scurvy, and occasionally some of the exanthemata, may be accompanied by vesical hemorrhage. The invasion of the coats of the bladder by the *Bilharzia hæmatobia* is a possible cause of hematuria in some Eastern countries. All these conditions are easily recognized by their concomitant symptoms.

Treatment.—Of course when the cause can be definitely ascertained it should be removed. In moderate hemorrhage without great distention of the bladder, and with no serious interference with urination, the clots may safely be left to the processes of nature if the bladder is a non-infected one. They will gradually become disorganized and will pass out in shreds or dissolved in the urine. If, however, they fill up the entire bladder and become obstructive, or if such bleeding occurs in a case in which there is already ammoniacal and fetid urine, it will be necessary to wash them out and to irrigate the bladder with antiseptic and hemostatic solutions. A full-sized catheter with very large eyes should be used, and boric-acid solutions should be injected and drawn out again by suction. The evacuating tube and washing bottle used in litholapaxy will be found very serviceable in such cases. After the bladder is free from clots, nitrate-of-silver solutions, from 1 : 10,000 to 1 : 500, may be carefully employed with great advantage. In case of failure with the catheter, a cystotomy, suprapubic or perineal, is indicated. In the majority of cases the former is preferable, as permitting at the same time a more satisfactory exploration of the bladder, and possibly the removal of the cause of the hemorrhage, as by excising a tumor, curetting a tubercular ulcer, etc.

RETENTION OF URINE.

The bladder may fail to empty itself on account of various causes:

(1) *Obstructive causes* are found in urethral stricture, spasmodic or organic; hypertrophied prostate or acute prostatitis; impacted calculus; tumors of the urethra and bladder; congenital atresia of the urethra or of the preputial orifice; constriction by a string tied around the penis; pressure by the gravid uterus; or fecal impaction.

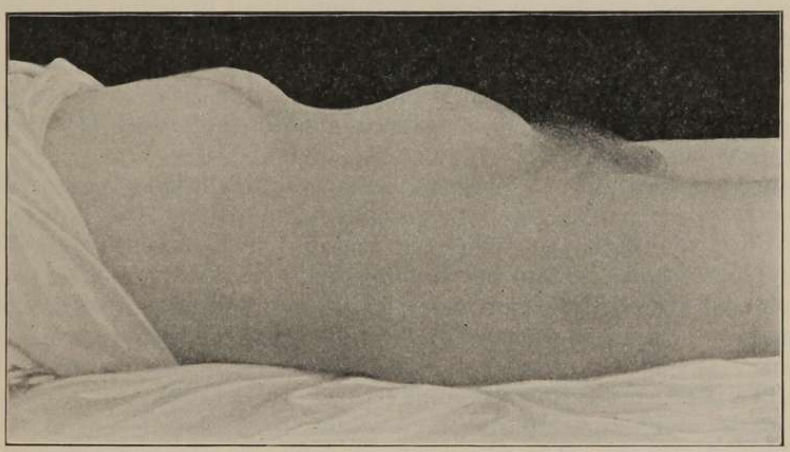
(2) *Defective expulsive force* may result from paralysis; from disease or injury; from atony; from reflex inhibition, as after the ligature of hemorrhoids; from shock or great muscular weakness in low fevers, etc.; or from the toxic action of drugs, as belladonna, opium, or cantharides.

Symptoms.—In either event the symptoms of retention are easily recognized. The local signs are the gradual formation of a hypogastric tumor rising into the abdomen and sometimes extending above the umbilicus. The elongation of the vesical fascia caused by this rise of the viscus is accompanied by a similar elongation of the urethra, so that, as in prostatic hypertrophy, an ordinary catheter may not be long enough to reach the bladder.

The tumor is rounded in outline, and in thin persons can be seen through the abdominal walls. It is most prominent when the patient is erect. It is dull on percussion and fluctuates; the flanks are resonant.

Fig. 314 shows the swelling caused by a distended bladder. This has not

FIG. 314.



Distended Bladder mistaken for an Abdominal Tumor (original).

seldom been mistaken for an abdominal tumor. A catheter will instantly clear up any doubt.

The subjective symptoms vary with the cause. In acute retention the desire to micturate is extremely urgent, the distress and anxiety great; the patient makes constant efforts to empty the bladder, with violent straining, often accompanied by escape of the contents of the lower bowel. If the retention is complete, these symptoms continue with increasing severity until the patient passes into a condition of toxemia, with rigors, fever, failure of circulation, dry brown tongue, delirium, hiccough, stupor, and finally death. If the retention is incomplete and the distention of the bladder is fairly relieved by the escape of a few drops of urine from time to time, these symptoms may be slower in making their appearance, and the case will run a more chronic but very similar course.

The most insidious cases, however, are those in which either from paralysis or from the very gradual production of the condition it is not attended with any unusual sensations, the patient often complaining only of the dribbling of urine, which is almost constant, and which results from the overflow from a bladder already distended to its fullest capacity when fresh drops of urine enter it from the ureters. This dribbling—the "incontinence of retention"—is too often carelessly or ignorantly regarded as evidence that the bladder is emptying itself, and many fatal cases have resulted from this mistake on the part of patient, nurse, or physician. The condition is most frequent in cases of prostatic enlargement, of vesical paralysis, and of old stricture. The secondary effects of retention of urine in such cases are those of obstructive disease already described. (See section on Diseases of the Kidneys.) If long continued, it results in disorganization of the secreting structure of the kidneys from the backward pressure. If acute and complete, it may produce fatal *suppression* of urine from the same cause.

Treatment.—The management of a case of retention of urine will depend upon the cause and the acuteness and urgency of the symptoms. When catheterism is possible, it is the surgical procedure obviously appropriate to the great majority of cases. In urethral or vesical spasm occurring during acute urethritis, or in the retention due to a gonorrheal prostatitis, a short delay may be justifiable, during which warm baths, opium, enemata, leeching to the perineum, etc. may be tried, but even in these cases the catheter should be resorted to promptly if the symptoms are at all urgent. The special treatment applicable to the other conditions before mentioned will be found described under their respective headings.

In some cases, however, catheterism is found to be impossible, and it is evident that immediate relief should be given the patient. Three routes for entering the bladder have been described and employed: (1) suprapubic; (2) perineal; (3) rectal.

Of these, the first is to be preferred in the vast majority of cases. The needle of an aspirator, or a small trocar and canula, should be inserted in the median line just above the symphysis and the urine withdrawn. The usual antiseptic precautions, including shaving of the pubes, should be taken: the operation requires no skill in its performance and is attended with remarkably little danger. The small puncture should be closed at once with iodoform and collodion.

(2) The perineal route has been advocated by Howlett, and also by Harrison, in cases of enlargement of the prostate (*q. v.*), but is not to be recommended simply for the relief of retention.

(3) Rectal puncture, by which the bladder is opened by a large curved trocar and behind the base of the prostate, has been employed in many instances, but is even less desirable than the perineal route.

INJURIES OF THE BLADDER.

The bladder may be wounded directly, as in stabs, gunshot wounds, etc., through the hypogastrium, the vagina, or the rectum, or even from the posterior aspect through the sacro-sciatic foramen; or it may be punctured by one of the pelvic bones, usually the pubic, in cases of fracture of the pelvis; or it may be involved in the rent occasioned by a violent disjunction of the symphysis pubis.

When there is a wound communicating with the surface of the body through the abdominal wall, the diagnosis is usually easy. The escape of

bloody urine in some cases, or in others the digital exploration of the wound, will at once reveal the character of the injury. But in cases arising from fractures or in those in which the bladder is ruptured, the recognition of the condition may be much more difficult. In cases where a violent compressing force is applied during distention, as where a wheel of a heavy wagon passes over the lower part of the abdomen, the healthy bladder, if distended at the time, may be ruptured. An atrophied or atonied or ulcerated bladder may give way under a much more insignificant force, such as involuntary contraction of the abdominal muscles during vesical tenesmus.

In the former class of cases the rent in the bladder is usually in the posterior wall, running downward from the urachus; in the latter it occurs at the region of greatest weakness, sometimes involving a sacculus or diverticulum (Plate XXI, Fig. 1) consisting only of mucous membrane and cellular tissue and protruding between the muscular ridges of an hypertrophied bladder, sometimes passing through a spot which has been thinned by the pressure of a calculus or infiltrated by tubercular, syphilitic, or carcinomatous deposits.

Symptoms.—If there is a history of a severe fall or of the application of a compressing force during distention of the bladder, followed by collapse, with inability to micturate, wound or rupture of the bladder should be strongly suspected. The introduction of a catheter will usually be followed by the escape of only a little blood or bloody urine. If a known quantity of a warm boric-acid solution be injected with moderate force into the bladder, the gradual rise of that viscus from behind the pubes into the abdominal region, which should occur when it contains from eight to ten ounces of liquid, does not take place, and on permitting the escape of the fluid through the catheter a diminished quantity will be found to have returned. Filtered air can also be injected into the bladder by an ordinary Davidson syringe over the outer end of which cotton has been tied. If the bladder be intact, it will become distended as a suprapubic tympanitic tumor, and the air will escape through the catheter; if it be ruptured, the air will distend the general peritoneal cavity and will not escape through the catheter to any extent. If the rupture is extra-peritoneal, emphysema of the cellular tissue will be produced.

In the presence of this group of symptoms it will be certain that there is a wound or rupture of the bladder, but it must not be forgotten that a minute perforation or puncture, followed by leakage, may exist and be of grave importance, while none of the above phenomena can be elicited, and that occasionally, though rarely, the opening in the vesical wall has been valvular in character, and has permitted the bladder to contain a considerable quantity of urine under pressure, though allowing it to trickle through when the organ has collapsed.

The two chief varieties of wounds or ruptures of the bladder are: (1) the extra-peritoneal; (2) the intra-peritoneal.

In the first variety the urine escapes into the pre-vesical connective tissue or into the vesico-rectal or vesico-uterine space. If not removed by operation, cellulitis and sloughing follow, involving the neighboring parts and often extending to the anterior wall of the abdomen or opening the rectum or vagina. The patient dies from septicemia.

In the second variety (the intra-peritoneal) there may be one or even two days during which no special symptoms manifest themselves. The more nearly normal the condition of the urine the longer the interval, but sooner or later general peritonitis occurs, and the patient dies quickly with a distended abdomen and symptoms of shock. Intra-peritoneal rupture may be suspected in the interval if on catheterization the instrument seems to enter a large

cavity, like a capacious bladder, and can be moved freely, and yet little or no urine can be withdrawn.

Treatment.—Whenever there is good ground for suspecting a wound or rupture of the bladder, operative interference is imperative. An incision should be made through the hypogastrium, as in suprapubic lithotomy, the rectal bag having first been introduced and distended, as in that operation. The peritoneum should be gently rolled up, with the pre-vesical fat, and the parts carefully inspected. If a rent is visible or if an extravasation of blood and urine leads to one, it may be sewn up and the surrounding region irrigated and drained. If the edges are much lacerated or contused, it would be better to put a large drainage-tube into the bladder. If the urine has found its way into the scrotum or perineum, free incisions must be made in those regions to give it exit. If the rent is not discovered by inspection and palpation, it is well to open the bladder and explore its inner surface with the finger.

If an intra-peritoneal opening is found, the abdominal incision should be extended upward, the peritoneal cavity opened and the wound in the bladder closed by means of Lembert sutures, fine silk being the best material and the stitches being inserted through only the muscular and peritoneal coats, and not through the mucous membrane. They should be about one-eighth of an inch apart. They may be tested by distending the bladder before the abdominal wound is closed. The peritoneal cavity is then irrigated, and if there is any peritonitis a drainage-tube is inserted. Some modifications are advised by different surgeons, but on the whole it may safely be said that prompt operative interference, suture of the bladder, antiseptic irrigation, and drainage have greatly lessened the mortality after injuries of the bladder. The adoption of Trendelenburg's position simplifies these procedures.

The results of laparotomy for intraperitoneal rupture of the bladder, as shown in the cases of MacCormac, Holmes, Halstrom, Grant, Blum, and others, are in the highest degree encouraging, 7 out of 16 cases having recovered, while in 8 of the 9 fatal cases the average time between the operation and the injury was twenty-eight hours, and in the ninth case the vesical sutures were faulty. In Blum's case recovery ensued, though the operation did not take place until forty hours after the rupture.

ATONY OF THE BLADDER.

The condition known as atony of the bladder is by no means uncommon, and may even be said to exist in a minor degree in almost all persons past middle age. Every male adult who will carefully observe his own experience will in all probability find that he is unable to eject as forcible a stream of urine from the bladder as when he was a boy; and the slight enfeeblement increases very distinctly when middle age is past. This form of atony may be said to be physiological.

There is another variety, which is a true muscular paresis, an actual loss of tone, as the name implies, in the muscular walls of the bladder, and which is dependent upon well-recognized causes. There is a distinct thinning and weakening of the muscular coat of the bladder, associated sometimes with fatty degeneration of the muscular fibers, sometimes with a fibroid change resulting in contracture precisely similar to that which occurs in disused muscles elsewhere. In the one case the bladder is a mere flaccid pouch capable of distention to a large extent, but quite incapable of completely emptying itself. In the other it will hold only a few ounces of urine, but cannot completely evacuate that quantity.

Between these two extremes and a condition of health there are all degrees of atony. A common cause of these retrograde changes in the bladder, apart from senility, is over-distention, which may be chronic and dependent upon some obstructive condition, such as enlarged prostate, vesical tumor situated near the neck of the bladder, tight urethral stricture, etc.; or it may have resulted from true paralysis of the bladder, which is very apt in neglected cases to be followed by secondary atony; or it may have been due to persistent neglect of the calls of nature on the part of the patient, whose occupation or whose pleasures were so preoccupying as to lead him habitually to postpone the emptying of the bladder until the need of doing so became imperative. Or the cause may have been acute over-distention happening on some one occasion when for a long period it was impossible for the patient to find an opportunity to urinate. In these instances the over-stretching of the muscular fibers is probably the active factor. In any event, the result is that the patient is unable to void his urine, and that a certain quantity is retained after each act of micturition.

It is this "residual urine," as it is called, which, both in cases of prostatic disease and in vesical atony, constitutes at the same time a serious difficulty and a guide to the proper treatment. If allowed to accumulate, it will sooner or later result in over-distention of the bladder, or it may decompose and set up a troublesome cystitis. It should always be evacuated by regular catheterization, which should be performed two, three, or four times daily according to the quantity of residual urine. This is, of course, a form of retention of urine, but that expression is usually associated with the idea of complete retention the result of obstructive disease of the urinary tract or of an absolute paralysis of the bladder-wall. When this is acute, it is readily recognized by the history of non-evacuation of urine and by the presence of the characteristic hypogastric tumor, which soon becomes abdominal if no relief is afforded. But there is a partial retention of urine which, though not so immediately dangerous, is, by reason of its greater frequency, a far more important surgical condition. In its lower grades it is often not recognized, and the symptoms of frequent micturition, loss of force in the stream, dribbling of urine, etc. are referred to cystitis and treated accordingly. Of course there may be a combination of various conditions associated with atony and with partial retention; in other words, the original lesion may have been a stricture of the urethra or an acute prostatitis or a prostatic growth or an impacted urethral calculus, or it may occur after certain operations, particularly those upon the lower end of the rectum, as the ligation of hemorrhoids, when there is often a reflex inhibition of the micturition-center of the spinal cord, followed by retention of urine. But in all these cases it is the over-distention and atony which constitute the most efficient cause of partial retention of urine, and this is true even in cases of prostatic enlargement in which there is a permanent obstacle to the free passage of urine.

The methods of treatment which are worthy of trial may be grouped under four heads, it being premised that if there is marked cystitis a preliminary course of treatment may be necessary before the other methods can be fairly put into application:

(1) *Catheterization.*—The patient should be instructed in the use of a catheter, and should also be told how to keep that instrument aseptic, and, for greater precaution, how to disinfect it before each insertion. In cases where four ounces of urine are retained he should use it twice daily, night and morning; if the residual urine reaches six ounces, he should use the catheter once every eight hours; and if it amounts to eight ounces, catheterization should be employed every six hours. (2) Irrigation of the bladder with cold

boric-acid solutions, beginning at a temperature of 90° to 100° and gradually reduced, or permanganate of potassium, in the strength of three grains to the ounce, will sometimes be found of great use. (3) Electricity is often of considerable benefit, and may be applied in the manner long ago suggested by Sir Henry Thompson. An insulated electrode is carried into the bladder and the other moistened electrode placed over the hypogastrium, a weak current being passed directly through the walls of the bladder. The strength is gradually increased until slight sensations of discomfort are experienced. The application may be varied occasionally by putting the other electrode in the rectum. In mild cases which come under care immediately after the occurrence of overdistention this is of much benefit, and in later and more serious cases it may be a useful adjuvant. (4) Strychnia is the only drug which produces beneficial results in these cases, and even upon it but little dependence can be placed. It may be given in combination with ergot, cantharides, or tincture of the chloride of iron.

URINARY CALCULUS.

The normal urine is a watery solution of various organic and inorganic materials dissolved in water, the latter constituting about 90 per cent. of the whole. The important organic constituents are urea and uric acid; the inorganic consist of the bases, chiefly sodium, potassium, and magnesium, with which the uric acid unites. Other acids, especially phosphoric and sulphuric, form salts with the same bases. These with the chlorides make up the bulk of the inorganic substances contained in urine.

There is, of course, also mucus derived from the kidneys and bladder, and a certain amount of renal and vesical epithelium. When urine is entirely normal and has been recently passed, it shows no sediment except a little of this mucus containing a few epithelial cells. After fermentation various forms of amorphous urates form and settle, and the urine becomes turbid from the presence of the products of decomposition.

Uric acid, although normally present in the proportion of only about 1 : 1000 in the urine, is of great importance in the formation of calculi, and with the urates, especially those of sodium and ammonium, makes up the bulk of most urinary deposits.

Oxalic acid is sometimes found in the urine in combination with lime in the shape of octahedral or of dumb-bell crystals.

The *phosphatic deposits* in the urine are composed of admixtures of the alkaline phosphates, those of sodium and potassium, with the earthy phosphates, the bases of which are calcium and magnesium. In fermenting urine in which the urea has been decomposed into ammonium carbonate the phosphoric acid unites with the ammonium, and deposition of the triple phosphates takes place, the sediment containing the ammoniaco-magnesium phosphate and calcium phosphate. The alkaline phosphates, being soluble, do not occasion deposits.

Cystine is found rarely among urinary sediments, and is in the form of hexagonal crystals, smaller than those of uric acid. It contains a large amount of sulphur (25 per cent.). It is never found anywhere else in the body, and the mode of its formation and the circumstances which favor it are unknown.

The general conditions which favor the formation of an excess of urinary deposits do not vary greatly for these different forms. They indicate, as a rule, defective digestion and assimilation, insufficient oxidation, disproportion between the solid and the fluid constituents of the diet, excess of meats, fats, and sugars, insufficient exercise, etc. But, while these are important factors, they do not of themselves, as a rule, bring about the formation of calculi. The

presence of the colloids is necessary, and these are furnished in the shape of mucus and muco-pus whenever any catarrhal condition of the urinary tract is superadded to the excess of solids contained in the urine. In addition to these chief predisposing causes there are others of minor importance, such as age, sex, race, etc. These may be briefly considered:

Age.—Children are especially liable to the formation of uric-acid calculi (primary calculi); old persons, to the development of phosphatic stones (secondary calculi). In the former the uric acid, which is in feeble combination with the alkaline bases, is liberated by an excess of acid of any sort in the urine, and the uric acid crystallizes in the presence of the renal mucus or of the vesical mucus, which binds the crystals together, forming a concretion which makes the nucleus of a stone. The same process takes place in the majority of cases whenever stone forms in acid urine, the stone growing by fresh accretion of uric acid or of the urates. Oxalate of lime may in the same manner crystallize and be deposited in either of its forms.

In old persons, especially in old men with enlarged prostates, residual urine, and cystitis, the urine, which has become alkaline from fermentation and decomposition of urea into ammonium carbonate, contains all the materials for the formation of stone around a given nucleus of any sort. Sometimes, especially in gouty or rheumatic individuals, the nucleus is a small uric-acid concretion descending from the kidney; sometimes it consists simply of a number of phosphatic crystals glued together by the thick, stringy vesical mucus; sometimes it is a blood-clot, a spicule of bone, a piece of bougie, or a foreign body introduced into the bladder by the patient. In any event, continued precipitation of the phosphates in the alkaline urine goes on, and secondary stone-formation occurs.

Sex.—Owing to the shortness of the female urethra, its large caliber, the absence of obstructive disease, and the comparative infrequency of vesical disease in women, they are very rarely the subjects of stone. It is estimated that only about 5 per cent. of all cases of stone are seen in females.

Race.—Negroes seem especially free from the liability to urinary calculi. Statistics show that in this country less than 4 per cent. of the cases operated upon for stone occur in negroes.

Constitutional disease, particularly gout and rheumatism and the associated condition known somewhat vaguely as lithemia, favors the formation of calculi, especially of the uric-acid variety.

Local Disease.—As already stated, prostatic hypertrophy with consecutive bladder-changes is a common cause of secondary stone-formation. Urethral stricture is much more rarely a cause, probably because the expulsive power of the bladder is unimpaired. Atony of the bladder favors the retention of small fragments of gravel or of urinary deposits of any description, and thus often leads to the development of calculi. Any disease of the kidney producing excessive secretion of renal mucus, and indeed any catarrhal disease of any portion of the urinary tract, will favor the formation of calculi.

Varieties of Urinary Calculi.—Stones may be classified either according to their chemical composition or with relation to the circumstances attending their formation.

Those forming in acid urine (the mucous membranes of the urinary tract being usually unaffected by disease) are chiefly, in the order of frequency, the uric-acid calculi, the oxalate-of-lime calculi, the urates, and the rarer forms of cystine, xanthine, indigo, etc. Those forming in alkaline urine (secondary to catarrhal disease of the kidneys or of the bladder) are the phosphate or carbonate of lime, which usually originates in the kidney, and the phosphatic cal-

culi—the ammoniaco-magnesian variety—formed only in ammoniacal urine, and therefore almost always originating in the bladder.

The majority (probably two-thirds) of all stones have nuclei of uric acid; of the remainder, a considerable proportion have nuclei or crystals of oxalate of lime or of the urates; others contain lumps of inspissated mucus or blood; and in addition an endless variety of foreign bodies introduced by accident, finding their way into the bladder from disease of neighboring bones or cavities (as after ulceration of a dermoid cyst, or after the formation of vesico-rectal fistula), or foreign substances, such as portions of whip-lashes, shoe-strings, pen-holders, etc., which have usually been introduced by the patient under the influence of morbid erotic desire. Such patients are commonly either boys at about the age of puberty or old men with waning sexual powers.

The *form*, *size*, and *density* of a calculus depend upon its chemical composition, the condition of the bladder, and the length of time during which the stone has been growing. Usually, however, it may be said that stones are either oval or rounded in shape, flattened on several surfaces, and, if there are other calculi in the bladder, presenting facets worn by attrition of one stone against the other. The surface of a calculus may be very rough and irregular or may be smooth and uniform.

In size it may vary from that of a bird-shot or a pea to one measuring many inches in circumference and weighing several pounds. In this country the largest stone extracted without fragmentation, without sloughing of the parts, and with recovery of the patient, weighed nine and a half ounces and measured eight and a half inches in circumference (White of Philadelphia).

Symptoms of Vesical Calculus.—In many cases before the development of vesical symptoms the descent of the nucleus from the kidney will have been announced by the characteristic phenomena already described under the head of Nephritic Colic. (See p. 813.) A history of this sort is therefore an important indication in cases of suspected stone, and if clear and unmistakable should lead the surgeon to repeated examinations if the further group of symptoms now to be detailed, or the majority of them, be present. The most important of these symptoms of vesical calculus are as follows:

(1) *Frequent urination*, more marked by day than by night. The patient is obliged to empty the bladder at intervals varying from two or three hours to every few minutes. The desire to do so is irresistible and sudden. It is much increased by active motion, as on walking or riding over rough roads or streets. It varies with the size and shape of the stone, and is often greater when the stone is of small size than when it is large, as in the former case the degree of motion imparted to the calculus during movements of the body is greater than when the stone is of large size and has made for itself a place in the bas-fond of the bladder. Frequent urination is also more marked if the stone has an irregular surface than if it is smooth and uniform. A stone may be of very considerable bulk, but if partially encysted or if held in place by bands of organized lymph it may give rise to astonishingly little disturbance. Frequency of urination is more marked in young than in old persons. In the latter there is often some prostatic enlargement, and the stone is apt to lie in the bas-fond of the bladder, removed from contact with its most sensitive portion. In these cases the usual nocturnal frequency of urination will continue unmodified by the presence of the calculus. It is for this reason that in every case of enlarged prostate a careful examination for stone should be made even when special symptoms of its presence are not to be noticed.

(2) *Pain.*—The characteristic pain of stone is darting and burning in character, is felt during micturition, but is most severe at the termination of the

act, when the irritated or inflamed mucous membrane of the empty bladder comes in contact with the calculus. The pain is rarely referred to the bladder itself, but is commonly felt on the under surface of the penis a short distance behind the external meatus. It often continues for a long time or until sufficient urine has collected to remove the walls of the bladder from close contact with the stone. It is more apt to be present in children than in old men, for the reason given above—namely, the lessened liability of the stone to come in contact with the vesical neck in old men. Boys will often present an elongated and inflamed prepuce from traction upon it to relieve this pain. It may be almost entirely absent in cases of encysted stone. It is aggravated by roughness of the calculus and during exacerbations of cystitis produced by improper food or drink. After having existed for some time, it may gradually lessen in severity, and finally almost disappear. In these cases the stone has probably become fixed to a particular spot in the bladder by the formation of inflammatory adhesions or by becoming lodged in a sacculus or diverticulum, or partially-organized lymph may have filled up the inequalities of its surface, or the same effect may be produced in the case of a rough and irregular calculus through the deposition of phosphatic material, making it smooth and regular. In chronic cases of atony of the bladder and in cases of vesical paralysis neither pain nor frequency of micturition is marked.

(3) *Sudden Interruption of the Stream during Urination.*—During the early period of stone, while the calculus is still small and movable, it is often swept into the neck of the bladder and acts as a ball valve, completely obstructing the vesical orifice of the urethra. For the reasons already given, this symptom is more common in children and young persons than in old men. The patient often learns the best method of obviating the difficulty himself, and will assume some peculiar or unusual position which experience has taught him will dislodge the stone and permit the completion of the act.

(4) *Hematuria* as a symptom of stone is of value only when associated with other symptoms. It is due to the wounding of the congested mucous membrane by contact with the calculus; hence it is aggravated by exercise and is most noticeable at the end of micturition. It is commonly present in adults, less so in children, and is rarely found in old persons.

(5) The presence of *muco-pus* in the urine, like that of blood, is merely a corroborative symptom due to the concomitant cystitis, and has no special diagnostic value.

(6) *Priapism.*—This symptom is often absent in adults, and of course is rare in old persons. It is of considerable diagnostic value in young children. It is due to congestion of the vessels of the prostato-vesical region. In boys it may lead to the formation of the habit of masturbation.

(7) *Reflex pains* in distant parts of the body may be associated with stone. In many cases these pains will be felt in the rectum or in the perineum; sometimes, however, in portions of the body far removed from the seat of trouble, as, for example, in the upper extremities, the back, thighs, stomach, or lungs. A peculiar pain in the foot, known as podalgia or pododynia, may result from irritation of the prostate or of the neck of the bladder, and is occasionally indicative of the presence of stone. It is located in one of the phalanges, or more frequently in the neighborhood of the ball of the great toe. It may extend over the whole sole of the foot, and is apt to be associated with a variety of other conditions, especially gout or rheumatism. When it is due to stone, it disappears immediately after the extraction of the latter.

Various forms of vesical, urethral, and prostatic disease are accompanied

by symptoms which more or less closely simulate those of stone. The differentiation is not difficult in many cases, but in others it is impossible.

The existence of the entire group of symptoms given above cannot justify a positive diagnosis of vesical calculus unless a further examination is made and the stone found and touched by the surgeon. Even then its presence must be made evident to the sense of hearing, as under no other circumstances can all possibility of error be eliminated.

Different forms of the vesical sound have been recommended, but the best and simplest has a straight steel shaft, with a short curve near the tip and a smooth flattened handle. Two forms should be used habitually, one with a very slight curve, and the other with a short abrupt curve, permitting it to be carried into the pouch behind the prostate. They should be about twelve inches in length, and of a caliber of about 13 of the French scale. In using these sounds the patient should be in a recumbent or semi-recumbent position, the abdominal muscles well relaxed by slight elevation of the shoulders, the knees drawn up, and the thighs somewhat separated. During the exploration the bladder should be moderately distended with water. The sound is well warmed and oiled, and is introduced in the same manner as a catheter, remembering, however, the fact that its curve does not correspond with the normal curve of the fixed part of the urethra, and that therefore it is especially important at the time that the point of the sound is made to traverse this region that downward pressure should be made with the fingers at each side of the root of the penis near the pubes, so as to elongate and straighten out the urethral curve. It will be found that strict attention to this will greatly facilitate the introduction of the instrument. Once in the bladder, the cavity should be explored in a systematic manner. The sound should be partially withdrawn and reinserted in a straight line, the handle being slightly raised and depressed from time to time. The beak of the sound should then be turned toward one side of the bladder, and should be made to traverse the arc of a circle sweeping transversely through the bladder from above downward. It should then be turned to the opposite side and the same manœuver repeated. If the stone is not found in this manner, the searcher should again be introduced to its full length, and the tip turned gently toward the floor of the bladder and then rotated from side to side, while the instrument is gradually withdrawn until it comes in contact with the vesical neck. If the stone is not detected with the first instrument, the second one, of different curve, should be introduced and the search repeated. Some surgeons prefer a hollow searcher, so that during the exploration the urine can be withdrawn or water injected (Fig. 315).

Various plans may be adopted for increasing the thoroughness of this examination. The surgeon may press down the anterior wall of the abdomen, so as to bring the upper wall of the bladder well within the reach of the tip of the instrument. With the finger in the rectum the bas-fond of the bladder may be elevated, so as to be brought more closely in contact with the searcher. The patient may be instructed to stand upright, and the fluid from the bladder gradually withdrawn through the hollow searcher, the tip of which is at the same time gently turned from side to side and brought from the base toward the vesical neck. This is an excellent plan for discovering small fragments which elude the ordinary method. In cases of enlarged prostate the stone may often be more easily discovered if the buttocks are raised so as to roll back the stone toward the fundus.

Some difference of opinion exists as to the degree of evidence which is necessary before an operation is undertaken. A few surgeons consider it sufficient to feel the stone with the tip of the instrument. The majority prefer to

demonstrate its presence by eliciting the characteristic click. The latter is certainly by far the most definite and satisfactory symptom it is possible to obtain, and, although even that does not entirely exclude the possibility of error, it reduces it to a minimum.

Now and then a papilloma or other growth will become encrusted with urinary deposits, and will give a most deceptive sensation both to touch and to hearing. Occasionally a small scale of calcareous matter will form, which can be felt or heard once by the sound and cannot again be found. With these exceptions, however, the click which is elicited by the touch of the sound upon the calculus is pathognomonic, and may serve as a basis for a positive diagnosis. The statement that "if the surgeon's hand is not delicate enough to detect the contact of his searcher with the stone without the aid of hearing, it will be wiser for him not to attempt to deal further with surgery of the bladder," is misleading. We prefer rather to accept the teaching of Agnew, who states that too much importance cannot be attached to the testimony furnished by the ear, which is far more reliable than the sensation communicated by touch; and he is certainly quite within reason when he adds that if all the circumstances attendant upon the errors of diagnosis in consequence of which patients have been cut without a stone being found in the bladder could be learned, it would doubtless be found that the operators proceeded more on what was felt than on what was heard.

A fasciculated condition of the bladder will sometimes cause a very deceptive sensation to be communicated to the hand of the surgeon as the tip of the instrument sweeps over the ridges of the organ, and occasionally bony growths developed from the pelvis, tumors, fecal impaction in the rectum, undue prominence of the promontory of the sacrum, etc. have given rise to similar error. In all these cases, however, no sound is elicited.

Sources of failure in the detection of stone may be enumerated as follows: (1) a more or less completely encysted condition of the calculus, leaving little or nothing of its surface exposed to the immediate touch; (2) the presence of a diverticulum containing the stone and communicating with the bladder by a small aperture, the calculus in such a case being practically extra-vesical; (3) the stone may be suspended by a thread of lymph from the summit of the bladder, or may even be fastened to the anterior wall of the bladder by fibrinous adhesions; (4) the surface of the calculus may be so covered with blood-clot or with lymph as to prevent the characteristic sound from being elicited. In the majority of these cases, however, the symptoms will be such as to warrant at least an exploratory operation, when the true character of the case will be revealed. In doubtful and obscure cases never less than two examinations should be made before the surgeon gives a positive opinion, and if there is much pain or spasm excited by the necessary manipulations on the first examination, the second should be conducted while the patient is anesthetized. The various plans suggested of approximating the walls of the bladder should be carefully tried, and the patient put in different positions with the object of dislodging the stone and bringing it within the reach of the searcher. The bladder should be kept fully distended during the examination, and the urine should be gradually withdrawn later. In some cases straight sounds will prove more useful than those with even a slight curve; occasionally a very small stone can best be detected by means of the Bigelow evacuating tube connected with a wash-bottle, as in evacuation of the bladder after litholapaxy.

The size of the stone may be estimated if a Thompson's searcher (Fig. 315) is used by slipping the collar on the stem of the instrument to the meatus after

the stone is first touched, and then marking the point at which the sound ceases to come in contact with it as it is slowly withdrawn, gentle tapping being kept up

FIG. 315.

Thompson's Searcher.

during this procedure. The measurements on the scale of the searcher between the collar and the meatus will then indicate approximately the diameter of the stone. In females the search for stone should be conducted with a straight sound, and, if there is any doubt remaining, the urethra should be dilated and the little finger of the surgeon inserted for digital exploration.

Some idea of the composition of a calculus may often be obtained from the fragments passed during urination, and more definitely from those adhering to the blade of a lithotrite if the latter is introduced for the purpose of measurement previous to selecting the form of operation. Frequently, however, the urinary deposit, and even the superficial layer of the calculus, are phosphatic and derived from the sediment of the ammoniacal urine of cystitis, while the nucleus and the bulk of the underlying stone may be of uric acid or of oxalates, and very dense.

The Treatment of Vesical Calculus.—The *non-operative treatment* of vesical calculus is of chief importance in its relation to prophylaxis. The attempt to procure solution of a stone already in the bladder has been persevered in by the profession since the earliest days, but without practical result. Neither drugs by the mouth nor vesical injections can be used in sufficient strength to exert any material influence upon a calculus. It is conceivable that a very small and very soft phosphatic stone might be affected by acid solutions weak enough to permit of their being thrown into the bladder, but litholapaxy for such stones is so immensely superior in safety and certainty and promptitude of cure that no other method need be considered, least of all one of such doubtful utility.

When it comes to the *prevention* of stone, however, the case is different. The advice given to a lithemic patient who has perhaps had one or more attacks of renal colic, or who is habitually passing urine of high specific gravity containing an excess of uric acid, is of the utmost importance. With such a patient it is essential to regulate the diet, the exercise, and the mode of life generally. The free use of water as a beverage both at and between meals, and especially on going to bed and on rising, should be insisted upon. The particular sort of water to be used is a matter of minor importance, as the results are equally good whether ordinary cistern- or rain-water or distilled water, or Poland, Bedford, or any other of the still spring-waters, is employed. The dilution of the urine, and the consequent increased solvent power, seem to be secured as well by one as by the other, provided only that a sufficient quantity be taken. Many other beneficial effects follow the habitual use of large quantities of water. In persons whose general strength is below the average, and particularly in thin or emaciated patients with imperfect digestion, milk may to a large extent take the place of water. It should be used always with special care as to the effect upon the gastro-intestinal tract, and may have to be peptonized or skimmed, or diluted with plain water or with lime-water to meet the needs of the particular patient. In the majority of persons who

habitually pass concentrated urine it will be found to be in some shape the best of all articles of diet, and a persevering effort to secure its employment should be made even when, as is so frequently the case, the patient protests that milk does not agree with him.

As to the general dietary, the most important articles to cut off are the sugars and fats, and the most important to restrict are meats and alcohol. Such patients should be directed to eat meat but once daily, and then sparingly; to take a minimum of sugar and of butter or other fats; to drink little but water or milk or weak tea, or if wine be taken to select a light claret or white wine and drink it largely diluted. Green vegetables, salads, and fruits, bread, eggs, and light fish, with a little poultry, may be said to constitute the staple of the diet in these cases.

The occasional use of a mild laxative or of small doses of calomel and soda in patients who are inclined to torpidity of the liver and defective bile-secretion will be found advantageous, but the prolonged use of the saline purgatives, such as Epsom or Glauber salt, or of the waters containing them, Friedrichshall, Carlsbad, Hunyádi, etc., is distinctly contraindicated, favoring rather than preventing concentration of the urine.

Moderate exercise is extremely beneficial, especially if it can be taken in the open air and systematically. Excessive exercise to the point of great muscular fatigue and profuse sweating should be avoided.

As to drugs, it may be necessary to use either alkalies or acids, according to the reaction of the urine and the character of the sediment. In acid urine with excess of uric acid and of the urates, phosphate of sodium in full doses, taken with a large quantity of fluid, often seems to be of great benefit, but occasionally has no effect whatever. The magnesium salts have been recommended, especially the boro-citrate, where the indications for alkalies were persistent. If the oxalates or phosphates are the predominent elements in the urine, or are intermingled, which is often the case, the mineral acids, especially muriatic and nitro-muriatic, and to a less extent phosphoric, are of extreme value; and this is increased if they are given in conjunction with nerve-tonics and with bitter stomachics. In these cases special attention must be paid to the surroundings of the patient, to securing proper hygienic conditions, plenty of exercise and fresh air, absence of mental strain or overwork, and, more important still, avoidance of worry and trouble as far as possible. Attacks of stone are sometimes coincident with a certain degree of nervous break-down attributed to the pain and distress of renal colic and of the vesical irritation, but are rather to be regarded, in many cases, as a precedent etiological factor of much importance.

In the preventive treatment of stone of whatever variety the avoidance of catarrhal conditions of the urinary tract is of the greatest importance. In the absence of the colloids, the crystalline deposit of even the densest urine will remain in the shape of fine dust or sediment, and will have little or no tendency to adhere or consolidate in large particles. The formation of stone depends in the great majority of cases upon the presence of agglutinating material binding together the urinary deposits. This is found in the vesical mucus, which is in great excess in all chronic catarrhal diseases of the bladder, and the production of which is favored by the existence of stricture or of hypertrophied prostate or vesical atony with residual urine.

The treatment of these conditions and of the chronic cystitis which so often accompanies them is therefore of the utmost value in the prophylaxis of vesical calculus.

A stone having once formed, the **operative treatment** applicable for its

removal varies according to a number of factors, chief among which are—1, the size of the stone; 2, its composition; 3, the condition of the kidneys; 4, the presence or absence of obstructive disease, as urethral stricture; 5, the condition of the prostate and bladder; 6, the age of the patient.

The possible methods of removing a given stone from the male bladder are—1, perineal lithotomy, *a*, lateral, *b*, median; 2, suprapubic lithotomy; 3, litholapaxy. The remarkable change brought about in the treatment of calculus by the introduction of the last-named method has greatly reduced the field of the first two. The limitations of their employment since the development of litholapaxy, and especially since its extension to children, may well be indicated by the experience of Thompson, who in former days found it necessary to cut one in every four patients with calculus, and who now cuts but one in thirty.

It is safe to say that in adults *perineal lithotomy* should be done chiefly under the following circumstances: 1. In cases of deep urethral stricture rebellious to dilatation, in which by selecting the median method the stricture may be divided at the same time. 2. In cases of stones of moderate size and of such hardness and density as to make too great demands on the strength of the lithotrite or of the operator. This condition occurs very rarely. 3. In cases of atony of the bladder where there is little or no expulsive power, where there is already a chronic cystitis, and where the stone is of medium size. In some cases a preliminary crushing of a few minutes' duration may make the operation the preferable one even when the stone is of considerable size.

Suprapubic lithotomy should be selected—1, when the stone is an unusually large one, and at the same time is believed to be of exceptional hardness; 2, in cases of marked prostatic hypertrophy with pouched bladder, chronic cystitis, and large stone; and 3, sometimes when the kidneys are diseased.

Litholapaxy is the method appropriate to nearly all other cases, though a few exceptions to the above rules may result from the presence of such complications as advanced renal disease, vesical tumor, etc.

Preparatory Treatment.—Whatever operation is to be performed on a patient with vesical calculus, certain preliminary examinations and preparations are invariably necessary. The general health of the patient, especially in regard to the condition of the kidneys, should be carefully looked into. The quantity of urine passed daily should be measured for some days. The presence of albumen, of blood or pus, of fetor, etc. should be carefully noted. Both the choice of operation and the prognosis and post-operative treatment will be influenced by the results of this inquiry.

The patient should be put to bed for two or three days previous to operation, to reduce as much as possible the irritation of the bladder produced by motion. If the urine is extremely fetid and ammoniacal, as in old cases of atony or of enlarged prostate, it is well to draw it every eight hours and irrigate the bladder with strong boric-acid or weak nitrate-of-silver or potassium-permanganate solutions. At the same time salol or boric acid in five-grain doses four times daily should be administered by the mouth. A milk diet is advisable, though light meals may also be allowed, especially in old persons.

The pubes and perineum should be shaved, no matter which operation is to be performed, as it reduces the risk of infection even during a litholapaxy, permitting thorough asepsis of the parts that have to be handled during the introduction and manipulation of the instruments. A laxative should be given the night previous to, and an enema about four hours before, the operation.

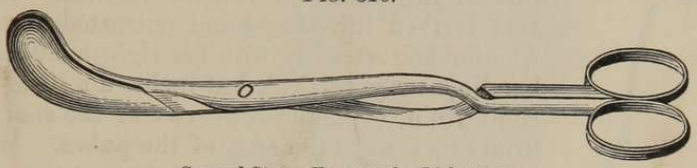
These various methods may now be described.

Perineal Lithotomy.—1. *Lateral Lithotomy.*—This operation, popular-

ized about the end of the seventeenth century by Frère Jacques, and placed on an enduring scientific basis by the labors of Cheselden in the early part of the eighteenth century, is still the operation of preference in certain cases in adults and with some surgeons in almost all children. In performing it the incision is made in the left side of the perineum, extending through the left lobe of the prostate to the neck of the bladder.

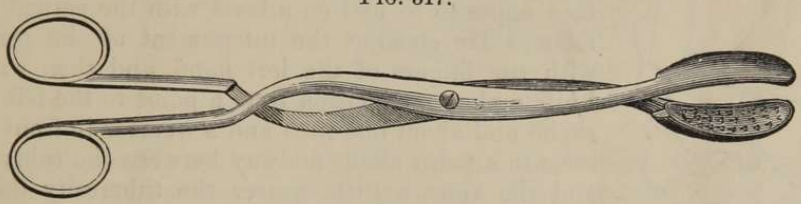
The following *anatomical points* bear upon the performance of all forms of perineal lithotomy: The perineum is a lozenge-shaped space, the four angles of which are at the symphysis pubis, the tuberosities of the ischia, and the tip of the coccyx. The anus is in the middle line between the tuberosities, and its center is about one inch and a half from the tip of the coccyx. Midway between the perineo-scrotal junction and the center of the anus is the "perineal center," which corresponds to the middle of the lower edge of the triangular ligament. The bulb with its artery lies in front of the point. The middle

FIG. 316.



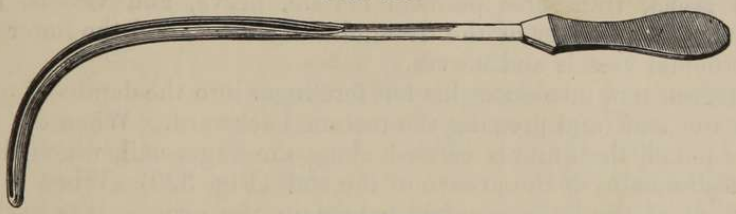
Curved Stone Forceps for Lithotomy.

FIG. 317.



Straight Stone Forceps for Lithotomy.

FIG. 318.



Lithotomy Staff.

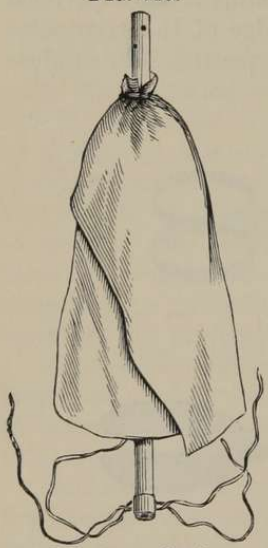
line of the perineum is not crossed by any vessels, and, like the median line of the neck and abdomen, is comparatively bloodless. The pelvic fascia and the levator ani muscles separate the perineal space from the cavity of the pelvis. The distance from the skin to the floor of the pelvis represents the depth of the perineum and varies with the amount of subcutaneous fat. It varies also with the point of measurement, being from two to three inches in the posterior part and less than one inch in the anterior part of the perineum. In an adult of ordinary size the distance from the skin to the bladder when the limbs are in the lithotomy position is from two and a half to three inches. The membranous urethra is about three-fourths of an inch below the symphysis.

The *instruments* needed in the performance of lateral lithotomy are a

lithotomy knife, a grooved staff, a probe-pointed bistoury, lithotomy forceps (Figs. 316, 317), scoop, a large-sized gum catheter, and a catheter *en chemise* (Fig. 319). The staff should have a large curve with a lateral groove, and should be of moderate size, so as not to interfere with the introduction of the finger (Fig. 318). Various forms of knife are preferred by different operators.

A lithotrite should be at hand in case an unexpectedly large stone is met with. The patient having been placed upon a narrow table and fully anesthetized, a searcher is introduced into the bladder and the presence of the calculus demonstrated by eliciting the characteristic sound. The bladder is emptied and washed out with warm boric-acid solution, six to eight ounces of which are left in it. The thighs are flexed on the abdomen and the legs on the thighs, the lower limbs being then given in charge of two assistants, who steady them in that position, keeping the median line of the perineum exactly vertical. The grooved staff is then introduced and entrusted to an assistant, who holds it steadily with his right hand, keeping the handle nearly vertical, but inclined a little toward the right groin, while the concavity of the staff is brought firmly up against the arch of the pubes. With the left hand the assistant draws up the scrotum. The operator then takes his place kneeling or sitting with his face opposite to and on a level with the patient's perineum. He steadies the integument of the perineum with the fingers of the left hand, and then with the knife makes an incision from a point to the left of the raphé and about one inch and a quarter in front of the anus to a point about midway between the tuber ischii and the anus, a little nearer the tuberosity than the gut, so as to avoid wounding the rectum.

Fig. 319.



Catheter *en chemise*.

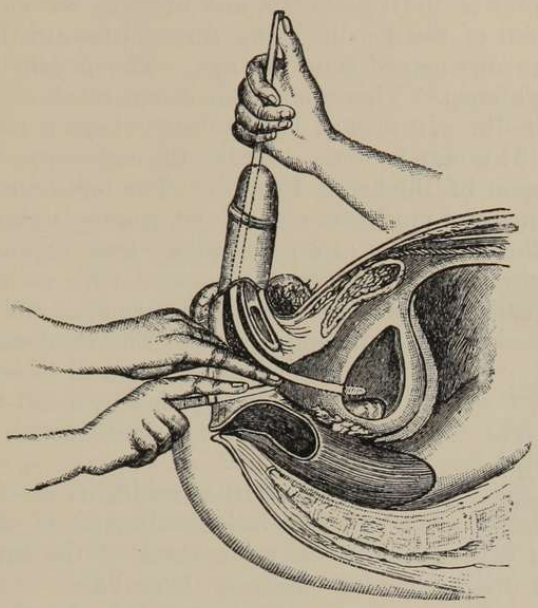
This incision is deepest at its anterior extremity. It divides the skin, superficial fascia, transverse perineal muscle, nerve, and vessels, the lower edge of the anterior layer of the triangular ligament, and the lower or external hemorrhoidal vessels and nerves.

The surgeon now introduces his left forefinger into the depths of the wound, feeling for the staff and pressing the rectum backward. When the groove in the staff is found, the knife is carried along the finger-nail, which should rest against the inner lip of the groove of the staff (Fig. 320). When it is *certain* that the point of the knife is safely lodged in the groove, it is pushed along it with the blade inclined so as to be parallel with the external wound, and is made to enter the bladder. This will usually be announced by a gush of urine. As the knife is withdrawn, the incision in the neck of the bladder and in the prostate, which is directed obliquely downward and outward, is gently enlarged. By this cut the membranous and prostatic portions of the urethra are opened and the compressor urethræ, the posterior layer of the triangular ligament, a few of the anterior fibers of the levator ani, and the left lobe of the prostate are divided.

The surgeon now carries the left forefinger along the groove of the staff into the bladder and feels for the stone. When the finger is in contact with it, and not before then, the staff is taken out, the forceps are introduced alongside of the finger, and the stone is seized and withdrawn. The latter portion of this operation, the seizing and extraction of the

stone, should be done systematically, the forceps being fully introduced before they are opened, and the blades then separated and closed while a rotary motion is given to them. If they fail to grasp the stone after they have been gently swept from one side of the bladder to the other, it may

FIG. 320.



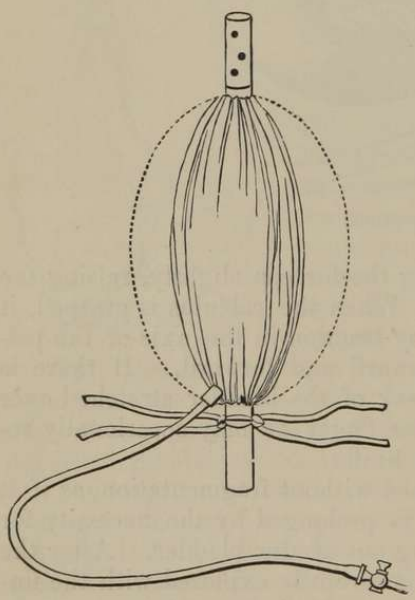
Lateral Lithotomy (Tillmanns).

be sought behind the prostate by withdrawing the forceps slightly, raising the handle, and then opening and closing them. When the calculus is grasped, it should be withdrawn slowly and gently and by traction in the axis of the pelvis,—that is, in the recumbent position, upward and forward. If there is much resistance from the tissues near the neck of the bladder stretched over the stone, they may be pushed back with the finger or may occasionally require further division by a light touch of the knife.

If possible, the calculus should be extracted without fragmentation, as if it crumbles or breaks into pieces the operation is prolonged by the necessity for the use of the scoop and for repeated washing out of the bladder. After the stone has been removed the bladder should be carefully explored with the finger to make certain that it does not contain a second calculus. A gum or soft-rubber catheter should be introduced through the wound into the bladder, and a stream of warm boric-acid solution sent through it forcibly a few times until it comes back clear. If there is no hemorrhage, the patient may then be put in bed with the hips and knees flexed, and the wound lightly covered with antiseptic absorbent cotton frequently changed or with a large soft sponge wrung out of warm carbolic solution. The slight hemorrhage which invariably follows this operation, coming from the transverse perineal and hemorrhoidal vessels, usually ceases spontaneously. If they bleed very freely, they are seized with pressure forceps as soon as the stone is extracted, and upon their removal when the patient is prepared for bed the hemorrhage will usually be found to have ceased permanently. If not, they can readily be tied. Hemorrhage from the artery of the bulb may cause considerable trouble, but will usually admit of a ligature, or at least of arrest by forceps, which may be left in position for a day

or two. The internal pudic, although protected by the lip of the tuberosity and the margin of the ramus of the ischium, has occasionally been wounded as the result of carrying the incision too far externally. It may be seized with forceps, which are left in position, or, better, ligated by means of a strong awl-shaped needle with an eye near the point of the needle carrying a strong thread. The needle is passed along the inner side of the ramus of the ischium half an inch in front of the tuberosity, and brought out on the inner side of the artery, the point of the needle being directed toward the surface, so that the thread may be disengaged from the eye. The needle is then withdrawn and the thread tightened. This would also command the circulation through the artery of the bulb. In case of venous hemorrhage it may be necessary to pack the wound. This may be done either by the catheter *en chemise* (Fig. 319) or by the air tampon of Buckston Browne. The former is made by cutting an opening in a square of muslin or stout linen, passing a gum catheter through it, and fastening them together at a point about three inches from the end of the catheter by a thread. The projecting portion of the catheter is then passed into the bladder, and the space between the instrument and the inner portion of the muslin is packed with antiseptic gauze. The Buckston Browne tampon consists of a central tube acting as a catheter surrounded by a soft-rubber bag, which admits of distention with air or water (Fig. 321).

Fig. 321.



Buckston Browne's Tampon.

Other accidents may occur during the operation. Wound of the rectum is usually the result of the knife not being sufficiently lateralized, or is sometimes the consequence of sloughing following the withdrawal of an exceptionally large calculus. In either case it ordinarily heals spontaneously, but sometimes a fistula is left. The urethra has occasionally been missed altogether, and still oftener in children has been torn completely across. In them the bladder is higher and more mobile than in adults. The connective tissue of the region is delicate and easily lacerated. The wound is necessarily a small one, and during the effort at introduction of the finger, therefore, it has happened even to very skilful lithotomists that the urethra has been torn across and the finger has been pushed onward into the loose cellular tissue of the recto-vesical space, where by its pressure an artificial cavity is formed which is then mistaken for the interior of the bladder. This accident is likely to be followed not only by immediate failure of the operation, but by pelvic cellulitis, peritonitis, and death. It may be avoided by making the incision into the urethra sufficiently large at first, and by observing that as the finger is passed through it is tightly grasped by the prostatic urethra and the neck of the bladder, giving a sensation very different from that experienced if it is in the loose, unresisting tissue of the recto-vesical space. When the mistake is made and is recognized in time, it can be remedied by withdrawing the finger, reinserting the knife into the groove of the staff, and carefully enlarging the incision toward the neck of the bladder. If, however, the latter has been pushed

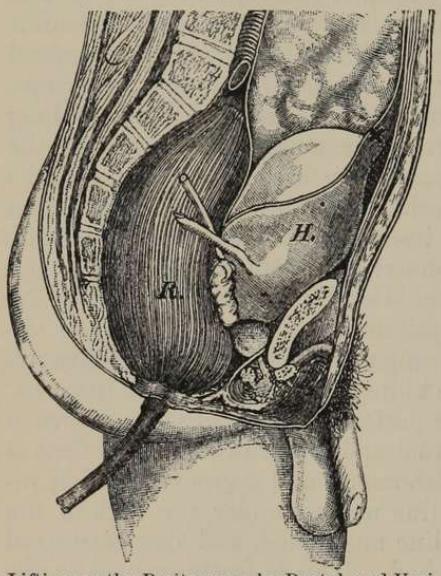
off the staff, so that it cannot be reached, it would be proper to perform at once a suprapubic lithotomy, to pass a catheter from the bladder out through the perineum, and to place a small drainage-tube in the recto-vesical space alongside of it. The accident can be avoided in the majority of cases if the plan frequently followed by Agnew in very young children with entire success be adopted—namely, to dispense with the introduction of the finger and to carry a pair of small forceps directly along the groove of the staff after the incision has been made into the bladder. When it is clearly recognized that they have grasped the stone, the staff may be withdrawn and the extraction completed. The same result can be attained by passing the finger along the concavity of the staff—*i. e.* along the roof, the more fixed portion of the urethra. In a few instances the urethra has been missed altogether and the bladder opened behind the prostate, and in others the knife has been carried on so far that the posterior wall of the bladder itself has been wounded. Both of these accidents are likely to result fatally from extravasation of urine, pelvic cellulitis, and peritonitis. Death may occur after lateral lithotomy from any of the causes which have been mentioned; from septicemia following sloughing or absorption of the wound products or of decomposing urine; or from suppurative pyelo-nephritis, especially in cases in which the kidneys are already much diseased.

Median Lithotomy.—This operation is performed by means of an incision made through the raphé between the scrotum and the anus. The patient is placed in the same position as for lateral lithotomy, and a grooved staff is introduced and held carefully in the median line well up under the arch of the pubes. An incision is then made in the line mentioned, and deepened until the membranous part of the urethra is reached. This is freely opened on the groove of the staff for the space of about three-quarters of an inch. The finger is then introduced, and carried with a boring or rotatory motion onward through the prostatic portion of the urethra to the bladder. When the stone is touched the staff is withdrawn and a pair of forceps introduced, or a director may be first passed along the groove of the staff into the bladder and the staff withdrawn, and the finger then passed along the director as a guide. This has the advantage of allowing more room for the finger and of permitting it to follow the upper wall of the urethra, which is more firmly fixed than the lower, and therefore less liable to be torn across. The parts divided in this operation are the skin, superficial fascia, sphincter ani, perineal center, the lower edge of the triangular ligament, the compressor urethræ, the membranous urethra, and the apex of the prostate. The advantages claimed for it are the slight amount of hemorrhage, as there are no vessels of any size in the line of the incision, the avoidance of the risk of wounding the ejaculatory ducts, the lessened probability of urinary infiltration from disturbance of the recto-vesical fascia, and finally the simplicity of the operation itself. It must be remembered, however, that at the anterior end of the incision the knife is necessarily in close proximity to the bulb, and at the posterior end is very near the anterior wall of the rectum.

Suprapubic Lithotomy.—Anatomical Points.—The peritoneum is attached to the bladder at its summit, extending upon the anterior surface as far as the insertion of the remains of the urachus. Posteriorly it descends between the bladder and the rectum to a lower level. It is attached firmly to the anterior surface and summit of the bladder, but very loosely to the abdominal parietes at the level of reflection of the membrane, thus enabling it to follow the various changes in the size and position of the bladder. When empty that organ is flattened, is triangular in shape, and lies against the anterior wall of the pelvis, between which and it is a quantity

of loose connective tissue containing fat. When the bladder and rectum are entirely empty the peritoneal fold on the anterior surface is a little below the upper edge of the symphysis. When the summit of the bladder is two inches above the pubes and the organ is pressed against the abdominal wall, the reflection of peritoneum is about three-quarters of an inch above the symphysis. Distention of the bladder alone will elevate the fold of peritoneum from one-half to three-quarters of an inch. Distention of the rectum alone will elevate the base of the bladder, but will have little or no effect upon the reflection of peritoneum. It provides, however, a firm basis for the fundus of the bladder, prevents the latter when dilated from extending toward the perineum, and pushes the whole organ forward against the anterior abdominal wall. Under these circumstances the same quantity of fluid which if injected into the bladder when the rectum is empty would raise the pre-vesical fold three-quarters of an inch, has been shown to increase the elevation to from one and a half to three and a half inches (Fig. 322.) The vesical veins which run from the apex of the bladder and pass under its fundus are compressed when the rectum is distended.

Fig. 322.

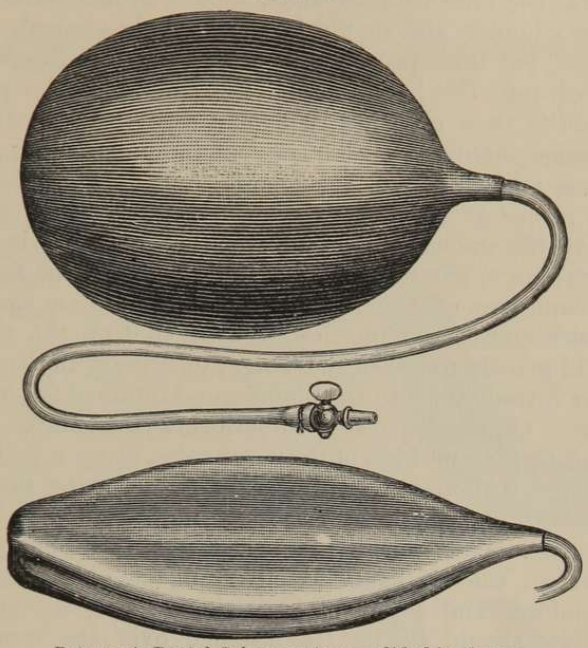


Lifting up the Peritoneum by Rectal and Vesical Distention: *H*, bladder; *R*, rectum distended by the Petersen bag; *X*, peritoneum (Rotter).

These preliminary anatomical points are of great importance in the operation, which is conducted as follows: The patient is prepared as for lateral lithotomy; an empty rectal bag (Fig. 323) is oiled, introduced into the rectum, and passed well above the sphincter. The bladder is then emptied by means of a soft catheter and washed out with a warm solution of boric acid. The rectal bag is then distended with about eight or ten ounces of fluid when the patient is an adult: larger quantities have been used, but occasionally with serious results from laceration of the mucous membrane or the peritoneum. In children, as the bladder is already an abdominal organ, the distention of the rectum can often be dispensed with altogether. The next step consists in the injection of the bladder, which can usually be sufficiently distended in an adult by the injection of ten to twelve ounces of liquid, and in a child under five years of age by the use of about three ounces. The catheter is then withdrawn and a soft india-rubber drainage-tube tied around the penis to prevent the escape of the fluid from the bladder. An incision three inches long is then made in the middle line, beginning half an inch below the upper edge of the pubes. The line between the recti or pyramidales having been found, the muscles may be separated with a few touches of the knife and the handle of the scalpel, but on no account should any forcible or vigorous tearing of the parts be employed. It is better, if the intermuscular interval is not apparent at once, to carry the incision directly through whatever muscular fibers make their appearance in the wound, adhering to the median line and deepening the incision until the transversalis fascia is reached. This is then divided, and if the edges of the wound are held asunder by retractors, a layer of loose connective tissue and fat, frequently containing large veins,

will become apparent. This lies directly over the wall of the bladder and conceals it. It may also be divided with light touches of the knife, aided occasionally by separation with the handle or the fingers, the same pre-

FIG. 323.



Petersen's Rectal Colpeurynter, modified by Guyon.

caution being observed not unnecessarily to tear or break up the connective tissue in this region, as rough manipulation may result in sloughing or in urinary infiltration after the operation. A portion of the fat may be gently pushed upward with the forefinger, and will usually carry with it the fold of peritoneum if the latter descends to this level. It is, however, not often seen during the operation. There may be at this stage profuse bleeding from the veins running in the connective tissue lying upon the front of the bladder. All bleeding should be checked by the use of hemostatic forceps, but no time need be lost in applying ligatures, as the bleeding is almost entirely venous, and will usually cease promptly when the rectal bag is emptied.

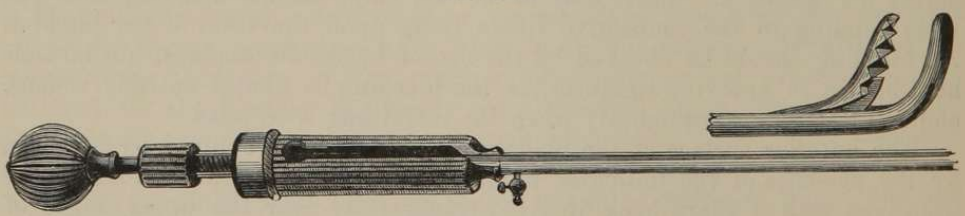
The anterior surface of the bladder having been recognized by its color, by the presence of the muscular fibers, and by its fluctuation, it should be transfixed with a sharp hook inserted transversely near the upper angle of the wound. The surgeon, holding this in the left hand or entrusting it to an assistant who fixes the bladder, opens the organ by thrusting a scalpel vertically through the wall just below the hook, and precisely in the median line, and cutting downward toward the pubes. The edges of the opening may then be seized with tenacula, or loops of silk may be passed and given to assistants to hold so as to steady the organ. The hook may then be withdrawn and the surgeon may introduce the right forefinger into the bladder. The wound should be large enough to admit easily of two fingers, which may be employed instead of lithotomy forceps, or the latter may be introduced and the stone extracted. The rectal bag is then emptied and withdrawn. The India-rubber tube encircling the penis must not be forgotten. If the bladder is healthy and uninfected, and especially if the operation has been carried out in a child or in a healthy adult, suture of the bladder may be employed. The wound is

brought within reach of the surgeon by two blunt hooks, one inserted at each of its extremities. With them it is brought forward to the surface and the margins of the incision kept steady and parallel with each other. Very fine chromicized catgut should be employed. The sutures should be interrupted, should not include the mucous membrane, should be introduced by means of a curved needle in a holder, and should be very closely applied. Many methods have been devised, but this appears to be the best (Treves). A small drainage-tube is introduced into the lower part of the wound in the parietes, and the rest of the wound is then closed. In such a case the after-treatment is conducted in the same manner as after any abdominal section.

If the case is one which does not permit of suture of the bladder, a few stitches may be placed at the two extremities of the wound in the abdominal wall, including all the tissues which have been divided. It is thought important by some surgeons to stitch the slit in the bladder to the fascial and deeper edges of the wound, two or three sutures being placed on each side, and one below at the lower end of the incision, so as to shut off the tissue behind the pubes. It is said greatly to lessen the danger of urinary infiltration. A large-sized tube also is introduced into the bladder and retained for from thirty-six to forty-eight hours. Others dispense with both these procedures, which they consider useless, and employ no form of drainage-tube, using a catheter introduced through the urethra if there is retention of urine. During the after-treatment the patient may turn upon his side from time to time so as to lessen the excoriation of the parts. The skin in the neighborhood should be protected by antiseptic ointment, the edges of the wound should be frequently lightly dusted with iodoform, and a pad of antiseptic absorbent cotton, or, better, a soft, clean sponge, should be lightly fastened over the wound itself. The patient will require constant attention to prevent troublesome excoriation, but may be allowed a considerable range of motion, and should be encouraged to sit up comparatively early.

Litholapaxy.—The operation of lithotrity, by which the stone was crushed usually at several sittings and the fragments were left for unaided evacuation

Fig. 324.

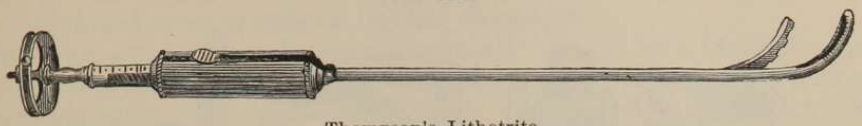


Bigelow's Lithotrite.

by the patient, has been completely supplanted by the modern operation of litholapaxy, in which the crushing and the removal of the fragments are both completed at one sitting. This, which is the greatest advance in the treatment of vesical calculus which has been made in the history of surgery, we owe to an American surgeon, Professor Bigelow of Boston, who in 1878 proposed the method and described the instruments which after long experimentation and careful study he had devised. These consist of lithotrites for crushing the stone and evacuators for removing the débris. The lithotrite is made in a variety of forms, the two most useful being those which are represented in Figs. 324, 325. The surgeon may use the kind which he prefers, but in all cases should be certain that the instrument has been made by a thoroughly

careful and reliable maker, and that it has the strength requisite for the great strain to which it is often subjected. The evacuators are also now of great

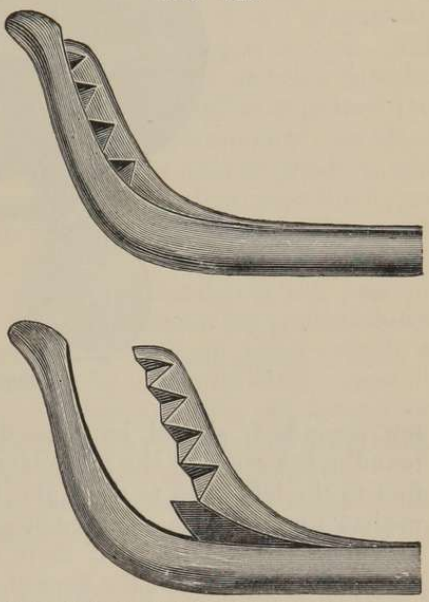
FIG. 325.



Thompson's Lithotrite.

variety. That of Dr. Bigelow is represented in Fig. 327, and in the opinion of many surgeons has not yet been improved upon. It consists of a large elastic bulb with a detachable glass bottle at its lower end, and with a stopcock at the summit for the purpose of filling the bulb, and one at its lower extremity for connection with the evacuating tube. A perforated tube which extends from the lower stopcock into the center of the bulb is so made that the area of the fenestra in its walls is greater than the area of its transverse section. Therefore, during the process of evacuation of the débris, when the bulb is compressed the current of fluid flowing back into the bladder tends to go through the small openings in the walls of the perforated tube rather than through its main channel. In this way any fragments floating in the reservoir, which have not yet settled in the glass receiver at the bottom, are arrested, and are less likely to be thrown back into the bladder. The coiled tube, figured in the cut, connects with the stopcock at the summit of the bulb, and, by dropping the sinker at the other end into a basin of warm antiseptic solution, may be used to increase the quantity of water in the bulb whenever desirable.

FIG. 326.



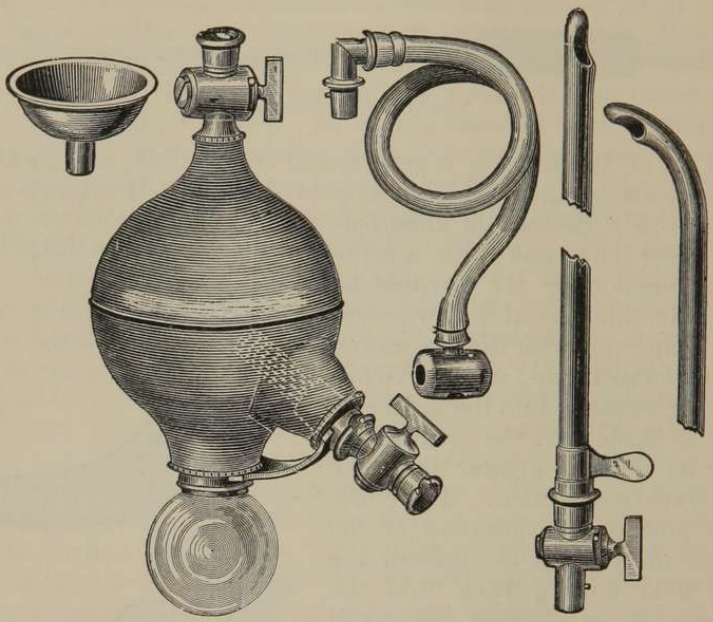
Beak of Bigelow's Lithotrite, closed and open.

The patient should be prepared as for the other operations for stone. The bladder should be emptied and washed out several times before the operation if it is infected and contains fetid urine, and in any event at the time of operation, after which about six to eight ounces of boric-acid solution should be injected and retained. The surgeon should ascertain that the urethra will admit full-sized instruments. The patient should lie upon the back with the shoulders slightly elevated and the thighs somewhat separated.

The lithotrite should be gently introduced, as in catheterism, until the beak reaches the bulbous portion of the urethra. The shaft will then be perpendicular. If it is held for a few seconds in that position, the penis at the same time being drawn upward, the blades will pass through the narrow orifice of the membranous urethra, and if then the handle be gently and slowly depressed the instrument will pass through the prostate and enter the bladder. The blades should be allowed to slide down the inclined plane of the trigone until they touch the posterior wall of the viscus. They should rest there for a few seconds until all currents in the contained fluid have subsided, and then the

male blade should be gently drawn out until a very slight resistance from its contact with the neck of the bladder is observed. After another pause of a

FIG. 327.



Bigelow's Evacuator.

few seconds it should be pressed back, and in many cases the stone will be found in the grasp of the instrument. If it is not, the blades should be rotated first to the left, then to the right, the shaft of the instrument remaining in the median line, and the same manœuver repeated. The degree of rotation may be varied if need be, or if there is a post-prostatic pouch the blades may be turned directly toward the floor of the bladder. This may be done most easily and safely by depressing the handle of the lithotrite so that the shaft is horizontal instead of directed upward. All these movements should be gentle. The rule laid down by Thompson is an excellent one: viz. that the more powerful the lithotrite—that is, the longer and larger its blades—the less ready should we be to adopt the reversed positions of the blades, and the more fluid is it desirable to have in the bladder.

The stone having been seized, the instrument is then to be partly withdrawn, so that its blades occupy the center of the cavity of the bladder; the screw is then turned, gradually at first, so that if the calculus is hard it may not fly out from between the blades. As it becomes apparent that it is firmly grasped the power is increased, and continued until the stone is felt to break, usually into several fragments. The male blade is screwed home so as to pulverize the smaller fragments, and the process of seizing and crushing is repeated until no large pieces can be felt. This should usually occupy from fifteen to thirty minutes, according to the size and hardness of the stone. The lithotrite is then withdrawn, of course with the blades well closed, and an evacuating tube introduced. For an adult, one of the caliber of 28 to 30 (French) will do in the majority of cases. It is connected with the bulb, the stopcock turned, and then gentle compression of the rubber ball made with the right hand while the evacuating tube is steadied with the left hand. Firm pressure may be made, followed by a delay of three or four seconds

after expansion of the bulb is complete (Thompson), or compression may be made more quickly and frequently and less forcibly (Bigelow).

If there is much débris in the bladder, the end of the evacuating tube should not be inserted as far as the fundus, but as the quantity diminishes it may be lowered so as to pick up the last fragments.

Sometimes the tube will become suddenly blocked by a fragment and the bulb will cease to expand. Quick, forcible pressure will generally dislodge the obstructing body. Sometimes the bladder-wall will come in contact with the eye of the tube, giving a peculiar sensation not unlike the nibbling of a fish at the end of a line, and hence called by Bigelow the "fish-bite." It indicates that the bladder is not sufficiently distended and that more fluid must be thrown in. This can be done by using the rubber tube (Fig. 327), dropping one end in a basin of warm boric-acid solution; then, after slowly compressing the bulb, the way to the bladder being open, the stopcock of the evacuating tube is closed and that communicating with the rubber tube is opened. On relaxing pressure the bulb will promptly refill from the boric solution outside. When no further pieces of stone can be heard or felt, it is well to withdraw the lithotrite, introduce a vesical sound, and make a final exploration of the bladder. If a fragment is found, a smaller lithotrite may be used to crush it, and the débris then extracted in the usual manner. Auscultation over the hypogastrium while the bulb and evacuator are in place may aid in determining the presence of a final fragment.

The only complication of the operation worthy of mention is the possible clogging of the blades of the lithotrite, so that they cannot be approximated sufficiently to permit of their safe withdrawal. In such an event (which is most unlikely to occur if the fenestrated lithotrite be used) the blades must be made to protrude in the perineum or above the pubes, and then cut down upon as in median perineal lithotomy or suprapubic lithotomy, freed, and withdrawn, the remainder of the calculus being extracted as in the above operation.

Rest in bed on the back, milk diet, warm fomentations to the epigastrium, boric acid or salol by the mouth, and moderate doses of quinine, constitute the essentials of the after-treatment.

In *children* the principles governing the selection of the form of operation for stone have lately undergone marked change. Until comparatively recent times the very low mortality of perineal lithotomy in children in the hands of skilful operators made it seem a work of supererogation to seek for a better method of operation: a safer could scarcely be found. A high rate of mortality after lithotomy was almost always due to deaths among elderly adults. Fergusson long ago said that it would be difficult to name any single operation of magnitude which was more successful on young subjects than lithotomy, quoting a series of 105 cases operated on at the Norwich Hospital, with only 3 deaths, as evidence of the correctness of his statements. Brodie said: "In boys under the age of puberty lithotomy is so simple and so generally successful that we ought to hesitate before we abandon it for any other kind of operation." These opinions were reiterated by surgical teachers almost without exception from those days until some six or seven years ago. Velpeau enumerated as the objections to lithotrity before puberty "the want of development of the sexual organs, the small diameter of the urethra, the indocility of the patients, and the extreme sensibility of the parts." In 1884, Surgeon-Major Freyer, an accomplished lithotritist and a lithotomist who had cut for stone in boys 132 times consecutively without a single death, repeated Velpeau's assertions almost in the same words, objecting to the crushing of stone in boys on account of the undeveloped condition of the genito-urinary organs,

the smallness of the bladder, the narrowness of the urethra, and the liability to laceration of the vesical and urethral mucous membrane. He added that no instruments had been invented by which litholapaxy could be performed with safety in male children.

Other objections have been advanced from time to time, mainly, however, relating to the same anatomical points and (before the introduction of litholapaxy) to the difficulty of getting rid of the fragments. As late as 1888, Keyes wrote that, on account of the limited proportions of the male urethra before puberty, the excessive sensibility of the child's bladder, and the want of docility and self-control at that time of life, lithotomy is to be preferred in male children under the age of fourteen. He made exception in favor of very small stones.

Many similar expressions could be quoted from the writings of surgeons of all degrees of experience, but they emphasize chiefly the same points, the majority of which are now, in the light of the modern improvements in lithotrity, without applicability. Anesthesia has made the "extreme sensibility" of the parts and the "indocility" of the patients of little moment. Otis has shown that in children, as in adults, the "small diameter of the urethra" may be greatly increased with entire safety; antisepsis during and after the operation has minimized the danger of laceration of the mucous membrane; instruments have been made which are at the same time small enough to permit of their introduction into the urethra and bladder of young infants, and strong enough to deal with very large and very hard calculi; Bigelow has overcome the difficulty of getting rid of the fragments; and the argument from statistics is at least neutralized by the records of Keegan and Freyer, the former having performed 59 litholapaxies in children with but 1 death; the latter, influenced by his colleague's results, having adopted the operation and performed 49 consecutive litholapaxies without a death.

In the face of these undisputed facts there is but one argument remaining which has any weight as urged against the operation of litholapaxy in children, and that is the alleged greater probability of recurrence. As regards the two great classes of operative procedures for the removal of calculus, the cutting and the crushing operations, all forms of lithotomy as compared with all forms of lithotrity, and at all ages, there can be little doubt that the statistical evidence in relation to recurrence is at present in favor of lithotomy. But it should not be accepted without reservation. Many of the tables, notably those of Sir Henry Thompson and Mr. Cadge, are based on an experience extending over many years and antedating the introduction of litholapaxy. Those tables make the proportion of recurrence after lithotrity about 1 in 7 or 1 in 8, and after lithotomy about 1 in 20; but, like so much of the statistical matter which our text-books and journals contain, they are useless or misleading at the present day. The two principal causes which lead to recurrence are: *a*, the failure to remove every portion of stone at the first operation; *b*, the new formation of stone in the kidney and its descent into the bladder. In the tables of Mr. Donald Day, based on the records of the Norwich Hospital, the first class includes two-thirds of all the cases of recurrence. But circumstances have altered. The employment of a large-sized evacuating tube, the immediate and thorough emptying of the bladder, the minute pulverization usually possible with completely fenestrated lithotrites, the increased knowledge of the great tolerance of the bladder to prolonged manipulations if they are gentle and skilful, have all combined to place the question of recurrence upon a very different level, and to make the collection of a new set of statistics absolutely necessary before venturing to draw any positive conclusions.

But if, for the sake of argument, we investigate existing statistics on this subject, we find that the great majority of cases of relapse or recurrence have taken place in patients past middle life, and especially in very old persons with enlarged prostates and feeble or atonic bladders. It will be recognized at once that these conditions do not prevail in children. The prostate is undeveloped; the bladder is almost an abdominal organ; no pouch exists at the fundus; sacculation is nearly or quite unknown; cystitis is a comparatively manageable complication; the expulsive power is proportionately greater than in the male adult, in whom a "physiological atony" is not at all infrequent. In addition to these reasons for not anticipating the formation of new calculi in children around nuclei of vesical origin, it may be reasonably expected that the conditions favoring the development of renal calculi will be more easily treated and controlled in children than in adults. Certainly among well-to-do people who can carry out a proper system of diet and medication it is fair to suppose that the lithic diathesis, of whatever variety, will be more readily combated in children, whose diet and drugs and mode of life can be rigidly ordered, than in adults with fixed and often very prejudicial habits.

For these reasons, while admitting that the question of recurrence is still *sub judice*, there is little probability that there will be enough difference between the proportions of relapses in children after lithotomies and after litholapaxies to justify any decided preference on that ground alone.

The position of litholapaxy as applied to children is moreover strengthened by a review of the history of lithotomy, which, unlike the operation with which we contrast and compare it, has undergone but little change for many years. The improvements in suprapubic lithotomy have, it is true, rendered it applicable to a much wider range of cases, and it is equally true that its most favorable results have been attained in children; but thus far the statistics of suprapubic lithotomy in children do not compare favorably with those of either litholapaxy or lateral lithotomy. This is probably due to the fact that in a large proportion of cases the operation was selected only after litholapaxy had been attempted and failed, or else was originally chosen on account of the unusual character of the calculus. It will probably always be employed in preference to lateral or median lithotomy in cases of extremely large or exceptionally hard stones; but when we remember that Freyer has removed by litholapaxy a calculus weighing 808 grains from a boy of nine, and Keegan one of 700 grains (and of uric acid) from a boy of nine and a half, it is evident that neither size nor hardness offers an insuperable bar to the latter operation.

Median lithotomy in children, although advocated by some surgeons, is objectionable on account of the great danger of wounding the bulb or the rectum, and the difficulty in obtaining space through which to pass the finger into the urethra and the bladder. It is indeed true that the passage of the finger is not absolutely necessary, although it has always been one of the time-honored rules of lithotomy not to withdraw the staff until the finger is in contact with the stone. Agnew's method (p. 847) avoids this difficulty, and Mr. Cadge recommends almost precisely the same method as both safe and efficient. It must be remembered, however, that its adoption places the surgeon in almost the same situation, in regard to the possibility of leaving débris or unnoticed stones in the bladder, that he occupies after litholapaxy. If the stone is soft and breaks down under the forceps, or if there are multiple calculi, he will be dependent on the touch and sound elicited by the vesical explorer, just as after the other operation. If, then, the introduction of the finger be dispensed with in either median or lateral lithotomy in children, these operations lose one of their alleged advantages—viz. the assurance of the absolute removal of all calculous

fragments. If it be insisted upon, it constitutes in a small proportion of cases an unavoidable source of both difficulty and danger. Sir William Fergusson, Keith, Thompson, Cadge, and many others have recorded occasional trouble with this step of the operation.

These facts and the other special dangers of lateral lithotomy in children have already been described, but one further possible contraindication should not be lost sight of. If the incision be prolonged a little too far backward, the left ejaculatory duct can hardly escape division and subsequent obliteration, and, although this may not be a serious accident in cases in which the integrity of the opposite half of the genitalia, the testicles, duct, etc., is unimpaired, yet it leaves the patient entirely dependent on that one side for fertility, if not for potency. Mr. Teevan has reported four cases of sterile husbands among lithotomized patients. Langenbeck and Sir William MacCormac have called attention to the same danger, and Keegan believes the lateral operation to be frequently followed by emasculation. Dennis quotes Dr. Charles Leale in relation to several cases coming under his own observation in which such patients grew up with shrill voices, atrophied testicles, absence of hair upon the face, etc.; in fact, with all the characteristics of eunuchs. The evidence as to this point is as yet fragmentary and inconclusive, but is of sufficient importance to deserve careful consideration.

These objections to perineal lithotomy in children are at least as weighty as any that have been urged against litholapaxy. Most recent writers, basing their opinion on the foregoing facts, express the conviction that the field of litholapaxy in children is likely to be considerably enlarged in the near future. It seems probable that the following statements will be generally accepted as correct: In every case of calculus in male children litholapaxy, on account of ease of performance, low mortality, speedy recovery, and absence of danger of emasculation, should be the operation of predilection, division of the meatus being freely resorted to if that portion of the urethra offers an obstacle to the introduction of instruments. The lithotrite and evacuating tube should be of a size which can be inserted into the bladder without much effort or overdistention, and great gentleness should be observed in passing these instruments. They should be withdrawn and reintroduced as seldom as possible, the stone being finely pulverized before the lithotrite is taken out at all. In seeking for or attempting to seize the stone, care should be taken to avoid such wide separation of the blades as would bring the male blade in frequent contact with the vesical neck. The crushing should invariably be done only after rotating the blades into the center of the bladder. Every particle of the resulting débris should be evacuated. Rest in bed, milk diet, and sterilization of the urine by boric acid or salol, given internally both before and after the operation, are valuable adjuncts. During the operation every antiseptic precaution should be observed. The exceptional cases of calculi which are both large and hard may be best treated by suprapubic lithotomy, but neither unusual size nor a moderate degree of density should of itself alone be thought positively to contraindicate litholapaxy.

Perineal lithotomy in children has now a much more limited field than heretofore, and should be employed chiefly in those cases of stones thought to be of small or medium size in which no lithotrite, however small, can be introduced with safety.

Vesical Calculus in Females.—The rarity of vesical calculus in the female is due to the shortness and dilatability of the urethra and to the comparative infrequency of vesical disease in that sex—conditions which favor the spontaneous escape of small stones descending from the kidneys, and which do not

furnish the agglutinating material in the form of vesical mucus necessary to the development of calculi from urinary sediments. The proportion of calculi in females as compared with males is about as one to twenty-two.

The causes, symptoms, and methods of diagnosis are essentially the same.

The *treatment* of stone in women is at the present time confined to three procedures:

1. If the stone is quite small, the urethra may be stretched to the required extent, first by suitable dilators, then by the little finger, and then by the forefinger. If this is done slowly, there will be but little laceration of the mucous membrane, and the incontinence that follows will be of short duration. The stone may be extracted with the finger or by means of a scoop or a pair of forceps. 2. If it be too large to extract in this manner, the dilatation of the urethra should be carried to a sufficient extent to permit of the introduction of a lithotrite: litholapaxy should then be performed in the usual manner. 3. If the stone is at once extremely large and exceptionally hard, suprapubic lithotomy should be employed, but is very rarely necessary.

The same rules are applicable to cases of stone in *female* children, although, of course, the dilatation of the urethra cannot be carried to the same extent.

Incision of the urethra and neck of the bladder should not be employed in any case, on account of the risk of permanent incontinence. *Vaginal* lithotomy, while it still has its advocates, is inferior to the methods above described.

CYSTITIS.

Inflammation of the bladder may be *acute* or *chronic*.

Acute cystitis may result from injury, as in the rough use of sounds; from the use of drugs, as cantharides; from the presence of a foreign body, as a calculus; from the extension of urethral inflammation, as in cases of stricture; from infection with micro-organisms, as with the gonococcus or the pyogenic staphylococci in specific urethritis, or with the bacillus tuberculosis; or from new growths, as epithelioma. In the milder degrees of acute cystitis the vesical mucous membrane is congested, thickened, and swollen, the epithelium detached in places, leaving raw or abraded surfaces. In the more severe forms the bladder is lined with tough, tenacious lymph; there may be ulceration and occasionally even sloughing. The submucous connective tissue, and sometimes even the entire thickness of the bladder-wall, are infiltrated with pus. Occasionally organization of the exudate covering the mucous surface takes place, and large fragments, or even casts, of the interior of the bladder are passed per urethram (membranous cystitis).

Cystitis, if long continued or of the severer grades, is very apt to spread by continuity along the ureters, and to involve the kidney, producing first a pyelitis, and then a pyelo-nephritis, not infrequently fatal.

Symptoms.—*Increased Frequency of Urination.*—This is one of the earliest symptoms, often preceding the development of actual pain by some hours. The desire to void urine occurs with increasing frequency until in bad cases it becomes almost constant. The relief afforded by passing a few drams of urine continues for but a few moments, or the urine may be passed in quantities not exceeding a few drops, and with no relief whatever to the distressing and urgent desire. *Tenesmus.*—Straining is extremely severe. The patient will lean over the vessel or urinal, quivering with the muscular effort. Often the bowels are involuntarily evacuated at the same time, and hemorrhoids are not infrequently developed as a complication. *Pain.*—The pain may be referred to the neck of the bladder, to the hypogastrium, or to

the perineum, and may radiate into the loins or down the thighs. It diminishes as the acuteness of the attack subsides. *Changes in the urine* take place soon after the development of the attack. It becomes turbid, with a heavy deposit of mucus, then scanty, then blood-tinged. Pure blood in lesser or greater quantities will often follow the expulsion of the last few drops of urine. *Constitutional Disturbance.*—This is often slight in comparison with the intensity of the local symptoms. Occasionally a marked febrile movement occurs and persists during the height of the attack.

Chronic Cystitis.—The **causes** of chronic inflammation of the bladder are all those which have been enumerated as producing acute cystitis, though the latter is not necessarily a precedent condition in every case of chronic cystitis. The latter is more apt, however, to result from a combination of mechanical and chemical causes, such as enlarged prostate, stricture, new growths, stone, or atony or paralysis of the bladder accompanied by retained or decomposing urine. Obstructive disease alone or mere loss of expulsive power may continue for a long time without causing an appreciable degree of inflammation. They produce, however, a chronic congestion of the mucous coat and degenerative changes in it and in the muscular wall of the bladder, and if subsequently, by the use of a catheter or other instrument not perfectly sterile, microbic infection occurs, the field is prepared for an obstinate and often incurable inflammatory process.

The changes in the walls of the bladder may result in atony or atrophy, with thinning of the mucous membrane, fatty degeneration of the muscular fibers almost to the point of disappearance, and great distention of the organ, or may be followed by hypertrophy of the muscular coat, the fibers forming ridges or fasciculi standing out in the interior of the bladder and separated by lozenge-shaped spaces, the organ itself being contracted, so that its cavity can contain but a few drams of fluid. Sometimes between these muscular bars pouches of mucous membrane protrude, forming distinct sacculi communicating with the interior of the bladder by narrow mouths and remaining permanent. Occasionally they contain calculi.

Symptoms.—The phenomena due to acute cystitis are present in a modified form. Urination is not so frequent; tenesmus is much less or is absent; pain is frequently very slight; and the constitutional symptoms are marked only when consecutive renal changes have occurred or when sapremia has followed absorption of the products of urinary decomposition. The urine is not apt to contain blood, but becomes loaded with a thick, tenacious mucus which is sometimes one-half its bulk, and which has given rise to the term *catarrh of the bladder* which is often used synonymously with chronic cystitis. It is almost always more or less ammoniacal, and is apt to be fetid and to contain a great excess of phosphates.

Treatment.—Removal of the causes, when possible, is of course indicated. A cystitis due to calculus or to new growths or to a retained catheter can be but little influenced by treatment until the stone or the tumor or the instrument is removed.

If the cystitis be due to the administration of cantharides or tincture of the chloride of iron or other drug, withdrawal of that article and the substitution of an alkaline diuretic will effect a prompt cure. In cases of cystitis following rough instrumentation, but in which no infection has taken place, rest in bed, restricted diet, anodynes or opiates to relieve tenesmus, and the administration of diluent and alkaline drinks will usually bring about a return to health.

When microbic infection has occurred, however, the case is apt to be much

more serious and prolonged. The treatment then will depend on the duration of the attack. In the stage of *acute* inflammation the plan above mentioned should be rigidly followed out. The diet for some days should consist almost exclusively of milk ; the patient should remain in bed with the hips elevated ; the bowels should be moved by salines and enemata ; opium by suppository should be used to control spasm and tenesmus ; an alkaline mixture may be administered with advantage. Ordinarily, the intensity of the symptoms will subside under this treatment in a few days, and sometimes recovery will then be complete.

Often, however, the condition passes into the *chronic form*, which is more intractable and obstinate. The same symptoms continue in a somewhat lessened degree. The urine becomes loaded with mucus and is voided with increased frequency, but with lessened tenesmus as compared with the acute variety of the disease. The treatment should consist at first in removal of the cause. If this is mechanical—that is, resulting from calculus, urethral stricture, prostatic hypertrophy, tumor, etc.—the treatment of the cystitis includes that of the condition which originated it. The treatment of vesical calculus, of stricture, of enlarged prostate, and of new growths of the bladder will be found elsewhere.

For a chronic cystitis which persists after the removal of a calculus or of a neoplasm, or after the dilatation of a stricture, or the careful withdrawal of residual urine in cases of atony or prostatic hypertrophy, a great variety of methods of treatment may be employed, and may be classified under (1) the administration of remedies by the mouth ; (2) the use of vesical injections or irrigations. In the former class are included the well-known balsams of copaiba and cubebs and the large class of terebinthinates, with buchu, uva ursi, triticum repens, etc. Under this head should also be included the administration of antiseptics, which, when excreted through the kidneys, sterilize the urine and prevent or retard the development in it of micro-organisms. The most useful of these are salol and boric acid in five-grain doses three or four times daily. Among the materials which will be found valuable for vesical irrigation may be included solutions of nitrate of silver, $\frac{1}{2}$ to 2 per cent., or stronger according to the sensitiveness of the patient ; peroxide of hydrogen, from 25 per cent. to full strength ; permanganate of potassium, from $\frac{1}{2}$ to 3 or 4 per cent. ; boric acid, from 2 to 10 per cent. ; creolin, from 1 to 5 per cent. ; corrosive sublimate, from 1 : 15,000 or 20,000 to 1 : 5000 ; carbolic acid, 1 : 500 ; and many others, chiefly belonging to the same class of antiseptics. It is useful to employ the weaker solutions in large quantities, and to precede their introduction by irrigation of the bladder with boiled water, or, in the case of the silver and permanganate salts, by distilled water. In cases which fail to yield to these methods of treatment, and in which frequent urination and painful tenesmus are prominent symptoms and are accompanied by gradual failure of the general strength, a perineal cystotomy followed by permanent drainage will often be required, and will usually give marked relief, and occasionally result in entire cure. It permits not only of the constant drainage which is so important in endeavoring to overcome sepsis, but also of the freer use of the irrigations above described.

TUMORS OF THE BLADDER.

The benign tumors of the bladder include the fibromata, the fibro-myxomata, and the papillomata. The latter are by far the most frequent, and indeed all vesical growths tend to assume a papillomatous character, although

there are no papillæ in the mucous membrane. It has been suggested that this occurrence may be explained by the embryonic relation of the bladder and allantois, the fœtal villi being partially dependent on the latter.

Fibromata and *fibro-myxomata* grow from the submucous coat of the bladder, are either sessile or pedunculated, and are covered by unaltered mucous membrane or by villi.

Papillomata spring from the superficial layer of the mucous membrane, and constitute red vascular masses, sometimes with long pedicles, occasionally sessile; their surface is soft, smooth, and rounded, and is often indistinguishable by touch from the healthy mucous membrane; they sometimes bleed very freely. Occasionally they undergo ulceration, and there is reason to believe that a growth originally purely papillomatous may become malignant in its later stages.

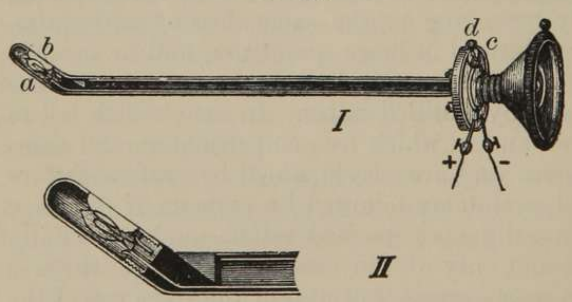
Malignant Tumors of the Bladder may be sarcomatous, but the epithelio. mata are by far the most frequent. They originate in any portion of the bladder, grow with great rapidity, and are soon followed by ulceration of the mucous surface, and often by involvement of the entire thickness of the bladder-wall. Enlargement of the pelvic glands and secondary deposits in other viscera are common.

Symptoms of Tumors of the Bladder.—The chief symptoms are vesical irritability and hemorrhage. Either may precede the other. In papillomata profuse bleeding may be the very first indication of disease. In the fibromata and carcinomata there is apt to be a period during which the symptoms are those of cystitis, but at first without marked alteration of the urine. Later hemorrhage occurs, and still later the urine becomes fetid and ammoniacal.

Diagnosis.—The recognition of new growths in their early stages is often very difficult. The most valuable diagnostic symptom is the hemorrhage, which, when free and spontaneous and recurring at intervals, the urine in the mean time remaining clear, is extremely suggestive. Free hemorrhage after gentle sounding, the symptoms of cystitis in the absence of stone or of any infective cause, severe vesical pain radiating to other regions, are all valuable aids to diagnosis.

Certainty can be reached only by the recognition of the villi of a papilloma, detached portions of a fibroma, or cell-nests and small sloughs from an epithelioma, or by the aid of the cystoscope, which is here of the greatest usefulness.

FIG. 328.



Leiter's Cystoscope: *I*, longitudinal section; *a*, metal tube; *b*, opening for light from the small electric lamp; *d*, loop of current from *c*; *II*, enlargement of extremity of tube (Tillmanns).

This instrument, as improved by Leiter, consists of a long hollow shaft of large caliber, with an obtuse angle a short distance from its extremity. At the angle is a prismatic window, so arranged that the rays of light entering it are reflected along the shaft to the eye of the surgeon, and near the end of the beak there is another window covering in a small incandescent electric lamp (Fig. 328). The tube contains magnifying lenses. Adjustable ends carry windows on the concavity or convexity of the curve, so that either the anterior surface of the bladder or the bas-fond and trigone may be conveniently observed.

In using the instrument it should be lubricated with glycerin; the bladder should be washed out and filled with a clear liquid; the current should not be turned on until the instrument is in position. If the inspection has been at all prolonged, so that the lamp may have become hot, the precaution should be taken to turn off the current a half-minute to a minute before the instrument is withdrawn, so that there may be no risk of burning the urethra.

The value of the cystoscope in the recognition of new growths is unquestioned, but is as yet confined within narrow limits. Such growths may undoubtedly be seen in many cases by its help, and their exact size and site outlined, but often an almost equally accurate diagnosis of location can be made with the vesical sound, and a far more precise knowledge of the character of the growths can be obtained by microscopic examination of fragments removed by forceps or passed spontaneously. The presence of foreign bodies unsuited for litholapaxy and requiring lithotomy has been demonstrated by the cystoscope. The determination of the side from which renal hemorrhage is taking place can also be made in some instances in this way.

Extravagant claims have been made as to the usefulness of the instrument, and are not likely to be fully realized, but it has taken an assured place in the armamentarium of genito-urinary surgeons. Its congener, the electric urethroscope, is of far less value, and has been much abused by novices and over-eager investigators, who have thus far added but little by its means to our knowledge of urethral conditions.

Treatment.—The operative treatment of tumors of the bladder should be by means of either a perineal or a suprapubic incision.

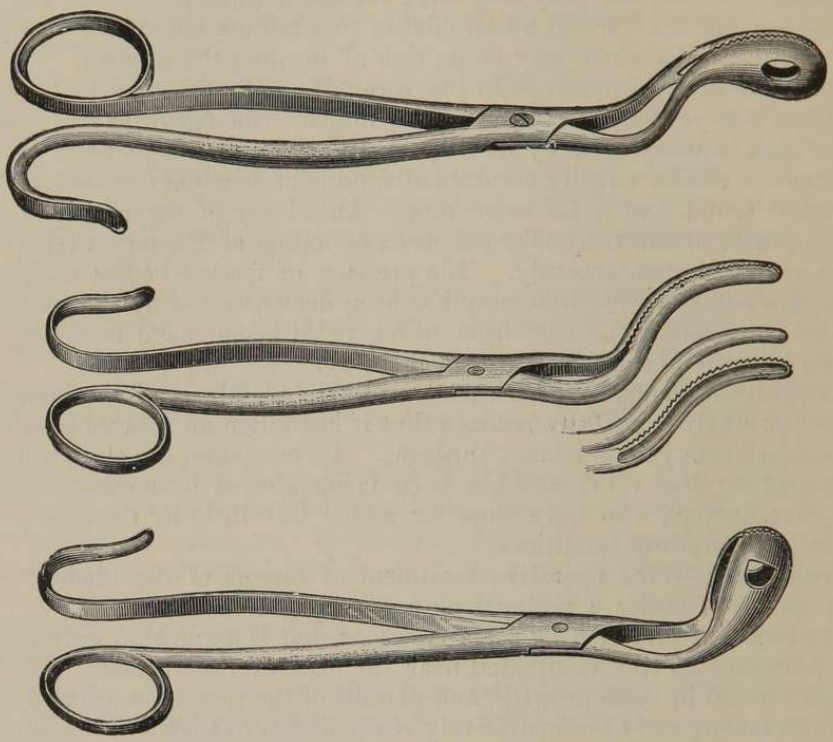
The former is preferred by some surgeons, but is applicable only to single small pedunculated tumors situated near the neck of the bladder. The latter is equally useful in these growths, and permits of the free exposure and inspection of all tumors and of comparatively ready access to them. It is the operation of preference in by far the larger number of cases.

If the perineal route is for any reason selected, the bladder is opened just as in the operation of median lithotomy. (See p. 847.) The finger of the surgeon having recognized the situation and limitations of the growth, a pair of forceps is introduced, the tumor seized, and partly bitten, partly twisted off. Too much direct traction should not be made, for fear of injuring the bladder-wall, nor should the manipulations with the forceps be carried out while much suprapubic pressure is being made, as a double fold of the bladder-wall might be thus included with the growth in the grasp of the forceps and gravely injured. The risk of this taking place is much increased if the tumor is sessile.

In the suprapubic operation the bladder is opened as in suprapubic lithotomy. The following methods of dealing with the growth may be mentioned (Treves): The growth, when exposed and carefully examined by the finger and also by inspection, may be dealt with in the same manner as like growths in more accessible parts would be treated. A small electric lamp is of considerable service. Growths with slender pedicles may be pinched or twisted off. If the pedicle be stouter, it may be grasped and fixed close to the bladder-wall by means of a pair of pressure forceps bent at a suitable angle. The neck is then grasped by a straight pair of pressure forceps at a little distance from the first pair, and is twisted off by rotating the instrument last introduced. In other instances an écraseur, carrying a cord or a fine wire, may be employed. If the growth have a broader base, it may, if it be well defined, be transfixed close to the bladder-wall by means of a rectangular needle in a handle, and be then ligatured with silk in two segments. Some of the softer and more diffused growths can be scraped away with the finger-

nail or with a curette or a sharp spoon. Others, of greater substance, can be removed piecemeal with Thompson's forceps (Fig. 329) and the resulting stump

FIG. 329.



Thompson's Vesical Forceps for removing Growths in Bladder.

then well scraped with Volkmann's spoon. This is the method which would be applied to epitheliomatous growths.

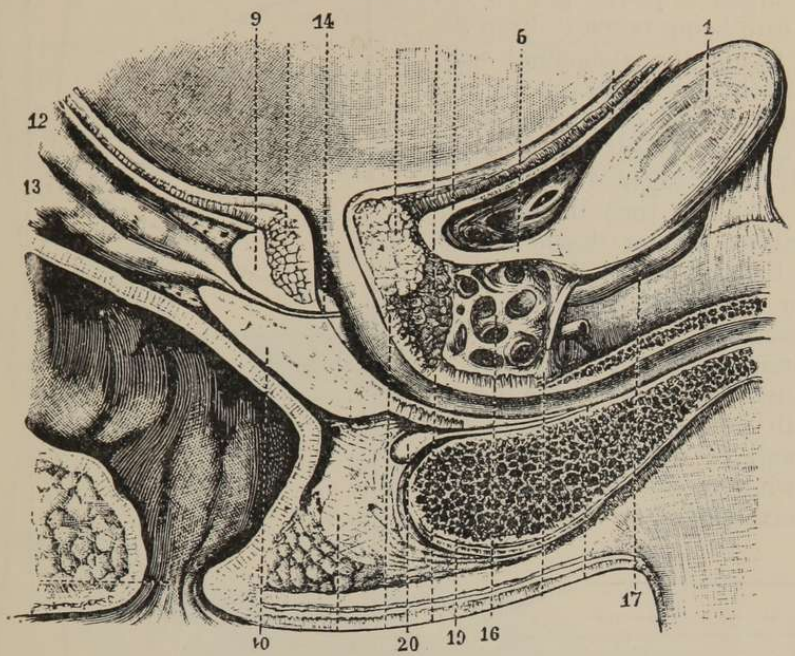
After the removal of extensive growths the bladder may be well rubbed out with a Turkey sponge, which will remove all detached or partly-detached fragments. Bleeding may be checked by the pressure of a firm piece of sponge or by injections of either cold or hot boric-acid solution. The cases must be few in which an appeal to the actual cautery is necessary. The pressure of the rectal bag causes venous engorgement, and the sooner that appliance can be dispensed with the better. Two fingers introduced into the rectum by an assistant will often bring the growth more readily into view than will the rectal bag. The after-treatment of the case is the same as is proper after suprapubic lithotomy.

PART III.—DISEASES AND INJURIES OF THE URETHRA.

The normal male urethra is about nine inches in length, and is divided into three portions. The *spongy* or *penile* portion is about seven inches long, is contained within the erectile tissue of the corpus spongiosum, and extends from the meatus to the posterior extremity of the bulb. When the penis is flaccid, it constitutes a curve the concavity of which is downward, but when the organ is raised or is erect the curve is obliterated and becomes a straight line. The *membranous* urethra is found between the two layers of the triangular ligament, about an inch below the under surface of the symphysis pubis. It is a half to three-quarters of an inch in length, and is surrounded

by the compressor urethræ muscle, which, taking its origin on each side from the upper part of the descending pubic ramus, serves to support and, when it contracts, to compress this portion of the urethra. The *prostatic* urethra runs through the prostate gland at the junction of its upper and its middle third. It is from one and a half to one and three-quarters inches in length (Fig. 330).

FIG. 330.



A Section of the Bladder and Adjacent Structures, showing relations of prostate and urethra: 1, pubes; 5, pubo-prostatic ligament; 9, middle lobe of 10, the prostate; 12, the left vas; 13, the left vesicula seminalis; 14, the common ejaculatory duct; 16, prostatic plexus receiving 17, dorsal vein of penis; 19, bulb; 20, Cowper's gland (Owen).

The urethra is narrow at the meatus, enlarges within the glans at the fossa navicularis, has a variable caliber, with normal points of constriction in the spongy portion, enlarges again in the region of the bulb, is narrow at the bulbo-membranous junction and between the layers of the ligament, and again widens as it penetrates the prostate, so that this portion of the urethra has normally the largest caliber and is the most dilatable.

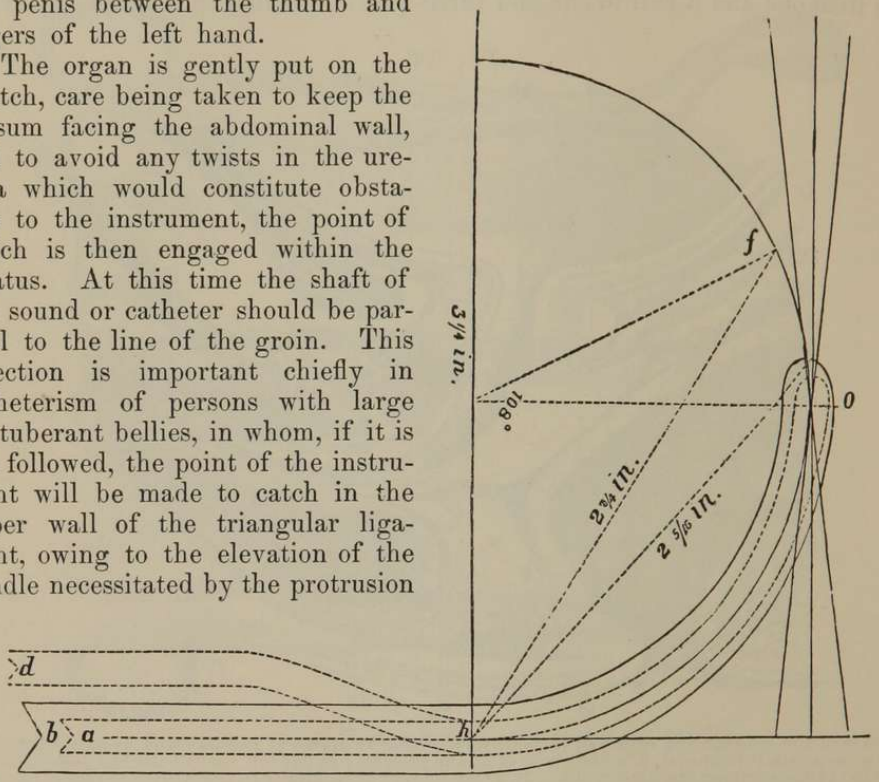
The fixed curve of the urethra—*i. e.* the curve assumed by the majority of adult urethræ—in a condition of rest is measured from just in front of the triangular ligament to the neck of the bladder. It is that of a circle three and a quarter inches in diameter, and is represented by an arc of such a circle subtended by a chord two and three-quarter inches in length (Fig. 331). This curve may be lessened somewhat by depressing the urethra by means of a finger at each side of the root of the penis: it is always lengthened in cases of hypertrophy of the prostate or when the bladder is greatly distended. It may be temporarily obliterated, as when a perfectly straight instrument is introduced into the bladder.

Catheterism.—The passage of a properly-made steel sound or silver catheter, the curve of which corresponds, as it should do, with that given above, is one of the minor operations of surgery most frequently required. For its performance the patient should, whenever possible, be placed in a recumbent position, the head and shoulders slightly elevated, the knees a little separated, the mus-

cles relaxed. The surgeon, if right-handed, stands at the left side of the patient. The sound or catheter, thoroughly sterilized, well warmed, and lubricated with some aseptic oil or ointment, is taken in the right hand, the penis between the thumb and fingers of the left hand.

The organ is gently put on the stretch, care being taken to keep the dorsum facing the abdominal wall, and to avoid any twists in the urethra which would constitute obstacles to the instrument, the point of which is then engaged within the meatus. At this time the shaft of the sound or catheter should be parallel to the line of the groin. This direction is important chiefly in catheterism of persons with large protuberant bellies, in whom, if it is not followed, the point of the instrument will be made to catch in the upper wall of the triangular ligament, owing to the elevation of the handle necessitated by the protrusion

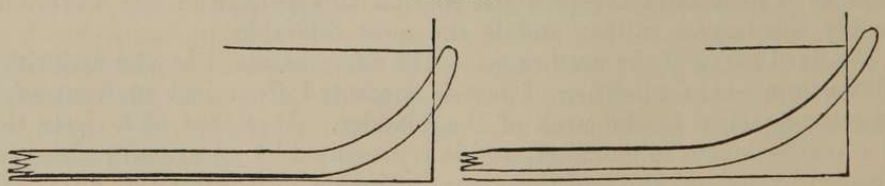
Fig. 331.



Instrument with faulty curve, *O d* (Béniqué). Correctly-curved conical instrument, *O b*. Length of natural curve of urethra, *f O h*. Length of cord of curve of sound, *h O*, $2\frac{5}{16}$ inches (Van Buren and Keyes).

of the abdomen. The handle should in any event be kept low until the tip of the instrument is about to enter the membranous urethra. The penis is

Fig. 332.

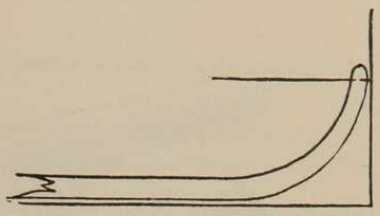


Faulty Curves (Van Buren and Keyes).

drawn up with the left hand while the instrument is gradually pushed onward, the handle being finally swept around to the median line, the shaft being kept parallel to the anterior plane of the body and nearly touching the integument. The instrument is now pressed downward toward the feet, while the left hand still steadies the penis and makes slight upward traction. After four or five inches of the shaft have disappeared within the urethra, it will be found that the downward motion of the instrument is arrested (Fig. 334). The fingers of the left hand can then be shifted to the perineum, where the curve of the instrument

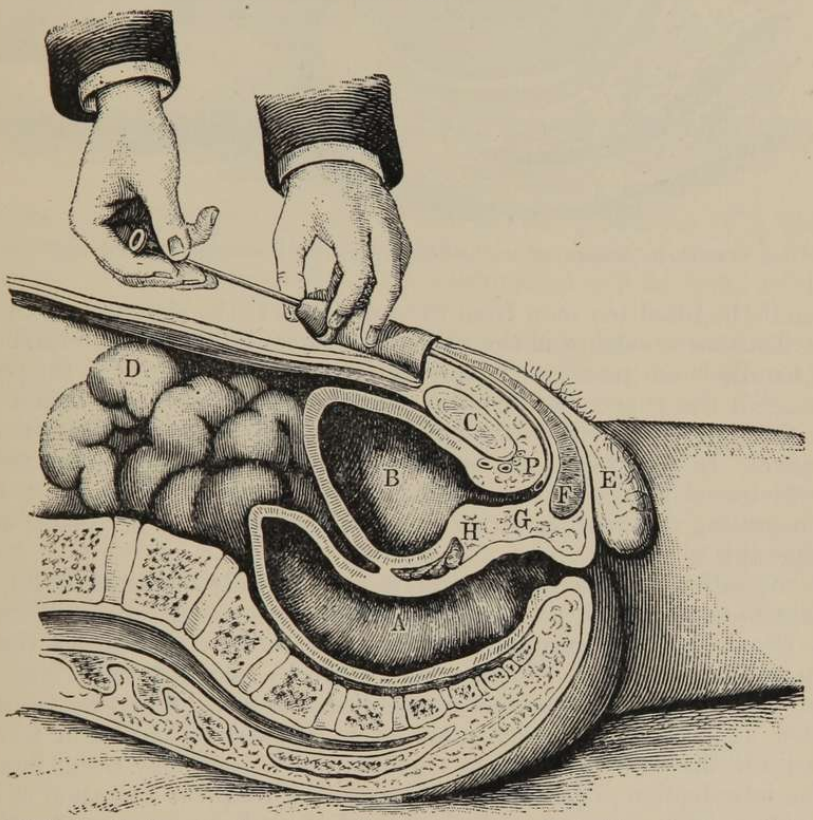
can be felt behind the scrotum. The handle may then, and not until then, be lifted from its close relation with the anterior abdominal wall and swept gently over in the median line, describing the arc of a circle, while the left hand acts as a fulcrum over which the curve of the instrument glides (Fig. 335). It often facilitates the final step in catheterism if after the shaft has reached and passed the perpendicular the handle is taken in the left hand, and the index and middle fingers of the right hand are placed one on each side of the root of the penis, making downward pressure, while the left hand, depressing the handle, carries the point of the instrument through the membranous and

FIG. 333.



Proper Curve (Van Buren and Keyes).

FIG. 334.



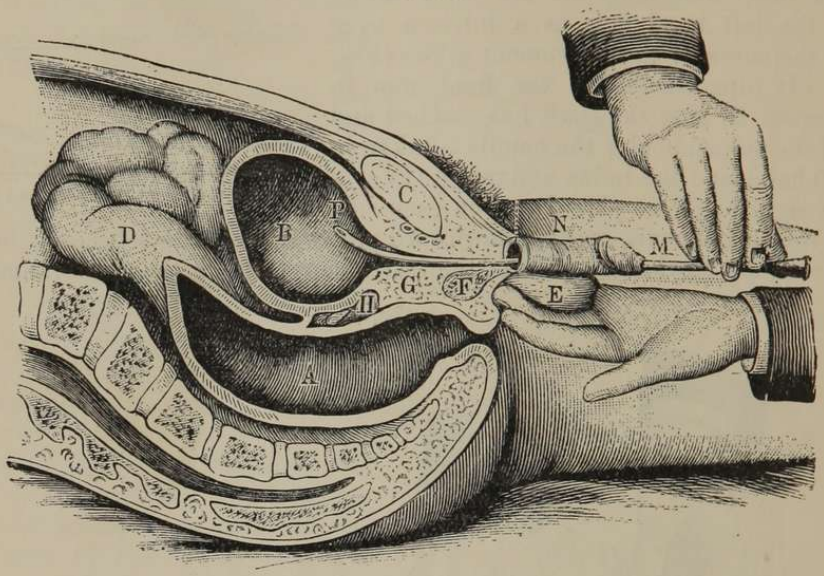
Passing a Catheter (to the membranous urethra): *A*, rectum; *B*, bladder; *C*, pubes; *D*, intestines; *E*, scrotum; *F*, bulb; *G*, prostate; *H*, neck of bladder; *P*, tip of catheter (Albert).

prostatic urethra into the bladder. Its entrance into that organ will be recognized by the free motion that can be given the tip of the instrument when the handle is rotated, and by the latter remaining exactly in the median line and pointing away from the pubes when the hold upon it is relaxed. The whole manœuver should be done with gentleness; no force whatever is necessary.

If there is spasm of the circular fibers of the urethra at any point, or, as is often the case, of the compressor urethræ at the bulbo-membranous junction, a little delay will be followed by relaxation. At this same region, where the large and movable bulbous urethra contracts as it passes through the ligament,

the onward pressure of a bougie or catheter is more often arrested on account of unskilfulness on the part of the operator than at any other point. If

FIG. 335.



Passing a Catheter into the bladder (Albert). (For references see Fig. 334.)

the handle be lifted too soon from the proximity to the abdominal wall, the tip of the instrument catches in the subpubic ligament above the urethral orifice; if the handle is not raised at the proper time or if the fingers in the perineum do not give the curve of the instrument the gentle upward pressure that it needs, the tip buries itself in the loose and movable floor of the urethra below the orifice. In either case the curve protrudes unnaturally in the perineum. The withdrawal of the instrument for an inch or two and its gentle reintroduction, raising or lowering its tip as may be required, will usually suffice to overcome this obstacle.

If the catheter is a small one and is used roughly and unskilfully, it may be made to penetrate the wall of the urethra instead of following the canal itself. Such wounds leading into the peri-urethral or submucous tissues are known as *false passages*. They are most apt to occur in the bulbous and in the prostatic regions, for obvious anatomical reasons. When recent they are attended by profuse hemorrhage, are often followed by chill and fever, and, especially if the patient's kidneys are already diseased, may result fatally.

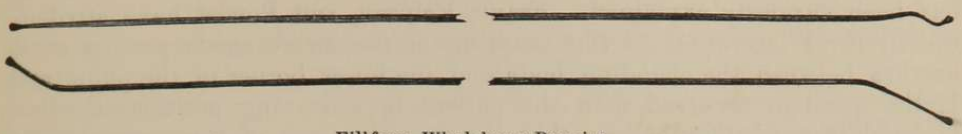
The introduction and retention of a catheter, frequent irrigation of bladder and urethra with antiseptic solutions, and the administration of salol, boric acid, and quinine are the essentials of treatment. If suppuration follows and chill and fever are recurrent or persistent, it may be necessary to drain through the perineum.

Old false passages are often sources of difficulty during catheterism. This may sometimes be overcome by inserting into the abnormal channel one or several filiform bougies, after which it often becomes easier to pass one into the bladder.

In cases of enlarged prostate a catheter with a much longer shaft and larger curve will be required, or a Mercier catheter will be found useful. In stricture a large variety of sizes and shapes may be employed. If the

contraction is small and tortuous, the most useful instruments are the whalebone filiform bougies, which may be used straight, or, better, with a slight

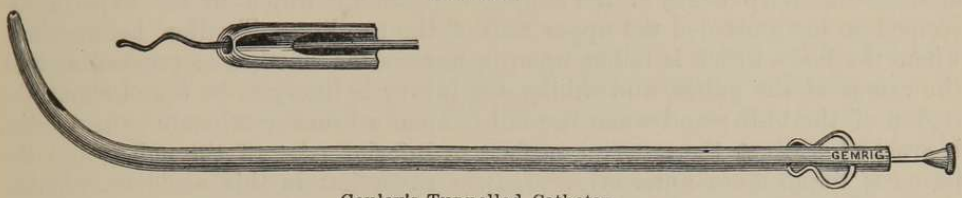
FIG. 336.



Filiform Whalebone Bougies.

angle given them near the tip (Fig. 336), as the orifice of a stricture is usually eccentric, *i. e.* not in the middle or center of the obstruction. It happens very

FIG. 337.



Gouley's Tunnelled Catheter.

rarely that one of these will not pass. The tunnelled catheter (Fig. 337) and the ordinary steel sound are indispensable instruments in the treatment of these cases. The indications for their employment will be found in the section on Strictures.

Urethral Fever, Catheter Fever, Urinary Fever, Acute and Chronic.—Following the introduction of an instrument, even when it has been done with skill and care, the patient may, after an interval varying from a few moments to several hours, have a chill, followed by a rise of temperature. In many cases this is not repeated. Warmth to the surface, a full dose of quinine, and the immediate administration of a urinary antiseptic are usually the only treatment required. The pathogenesis is not certainly determined. In this form—*acute urinary fever*—it may be that a nervous element enters to a considerable extent into the causation of the chill; but in the recurring form—*chronic urinary fever*—we have a true toxemia, always dependent on bacterial infection, and often to be avoided by thorough instrumental asepsis and proper preparation of the patient. When it does occur, the same line of treatment as for any other form of infection of the urinary tract is appropriate.

INJURIES OF THE URETHRA.

RUPTURES of the pendulous portion of the urethra are rare, and are not apt to be extensive, nor, although troublesome in regard to treatment and cure, are they usually dangerous. In most cases the rupture occurs during sexual intercourse, and has been accompanied by immediate pain and swelling, followed by ecchymotic discoloration of the entire pendulous portion of the penis and by more or less severe hemorrhage from the meatus. They usually do well under the use of evaporating lotions and rest, followed by gentle catheterization after the blood has disappeared and the swelling subsided. Ruptures affecting the deeper portions of the urethra are, however, much more serious. Excluding those which result from instrumental violence—that is, false passages—and those which result from the giving way of the

softened and distended urethra behind a stricture, which are described elsewhere, they are caused almost invariably by some form of traumatism applied to the urethra, most of the recorded examples having been the result of falls astride of hard or resistant bodies. The mechanism of rupture of the urethra has been variously explained. Franc, Velpeau, and Poncet have attributed the urethral laceration to the crushing of the membranous portion of the urethra between the offending body and the lower border of the pubic arch. If the accident occurred with the patient in a leaning position, the body directed forward, they believe that the posterior part of the spongy urethra could be crushed against the pubes, and think that when the force which produces the injury acts in the lateral direction the urethra is more probably pressed against the upper portion of the descending pubic ramus. Ollier refers lacerations of the membranous urethra to the pressure of the canal against the sharp edges of the subpubic ligament, which in his experiments seemed to have divided the upper wall of the urethra. Terillon believes that when the body which is fallen upon is narrow the urethra is crushed against the ramus of the pubes, and thinks the injury is likely to be found about the region of the bulb; and when the fall is upon a broader substance the urethra is crushed against the anterior surface or inferior edge of the pubes, and the lesion is found more anteriorly. Guyon says that in this accident, whether the cause is a fall or a blow, the mechanism is the same: the urethra and the soft parts which immediately surround it are pressed and crushed against the resisting pubic symphysis, whilst the superficial tissues, more supple and more elastic, escape or are scarcely involved. He believes, as does Terillon, that such ruptures are frequently only partial, and that they are commonly situated in the spongy portion of the urethra, an inch or less in front of the anterior layer of the triangular ligament; and in this opinion he is supported by Iversen, who has recently analyzed twenty-nine cases of this accident. Duplay thinks that in a certain proportion of cases the urethra is ruptured by a temporary dislocation of the symphysis pubis, the soft bones springing back into their proper relation after the crushing force is removed, and leaving no trace of the accident except the urethral lesion. He thinks that this ("rupture by traction") may also occur in case of fracture of the pelvis with a displacement of a portion of the pubic arch; and it is of course evident that the urethral wall could be wounded directly by a fragment of bone after such a fracture.

In attempting to diagnosticate a rupture of the urethra we must depend chiefly upon—1, the history of the accident; 2, the phenomena connected with urination, which is usually difficult or impossible; 3, the appearance of blood either at the meatus or beneath the skin or in both situations; 4, the development of a swelling due to extravasated urine. As in the majority of cases all these symptoms are present, the diagnosis in general terms of a rupture of the urethra can hardly be said to be difficult, but in exceptional cases, where one or more are absent, it may be a matter of great uncertainty. So, too, the recognition of the precise seat of the rupture may be comparatively easy if the case is an uncomplicated one, or under some circumstances may be almost impossible. The anatomical peculiarities of the part explain the usual course of urinary extravasation. (See Stricture of the Urethra.)

Treatment.—The important question of treatment in these cases may be simplified by adopting a classification similar to that employed by Guyon and Duplay, which is based upon symptoms rather than upon the anatomical seat of the injury. All cases may be divided into three classes—mild, moderate, and grave.

In mild cases—*i. e.* in those where after such an injury there is an appearance of blood at the meatus, with difficult urination or with retention, but with no evidence of extravasation and no general alarming symptoms, and in which catheterization is easy—the surgeon may be content with regular evacuation of the bladder by means of a soft instrument well greased with carbolized oil, and with prescribing absolute rest, the patient being carefully watched for the onset of fever or the appearance of local swelling.

In cases of a more severe type, in which, in addition to urethral hemorrhage and retention of urine, there are evidences of extravasation, and in which catheterism, though difficult, is possible, it is wisest to leave a full-sized catheter in the bladder, and at the same time freely to lay open the perineum and scrotal tissues or any which have been involved in the extravasation.

In cases of greater gravity, in which catheterism is impossible, careful perineal section should at once be made, the rent in the urethra sought for, and a catheter passed through it into the bladder. This is sometimes one of the most difficult procedures in operative surgery, particularly if it has been delayed until inflammatory change or local gangrene has altered the appearance and relations of the parts involved. If persevering and careful search fails to reveal the proximal end of the torn urethra, suprapubic cystotomy, for the purpose of retrograde catheterization, is justifiable for that purpose, the distal end of the torn urethra being almost always easily discoverable. Except as to the latter point, surgeons, as a rule, are agreed upon the above-described methods of treatment, and a number of them endorse the propriety of the suprapubic operation in such cases.

In cases of complete rupture the following indications exist after the introduction of the catheter: 1st, to open a large passage for the accumulating fluids; 2d, to keep up a free flow of urine; 3d, to encourage rapid union of the two ends of the urethra and the walls of the cavity formed by the extravasation into the perineum; 4th, to prevent the formation of a cicatricial stricture of the urethra. Suprapubic aspiration (Lefort, Mollière) is palliative and meets none of the indications. External urethrotomy (Guyon and others) does not provide for prompt union of the canal and does not prevent consecutive contraction. Antiseptic measures, carried out by allowing an elastic catheter to remain in the perineal wound, which is tamponed, or by suturing its borders, produce more rapid union, but are likewise followed by urethral coarctation. The stitching of the proximal end of the urethra into the wound, and catheterizing only after healthy granulations have formed, while reducing risks to the life of the patient, is followed by the same results.

Suturing of the divided ends of the urethra has now been done in a sufficient number of cases (Erasme, Guyon, White, Keyes, Barling, and others) to justify its employment whenever they can be brought together. Catgut is the preferable suture-material. The mucous membrane should not be included.

GONORRHEA (URETHRITIS).

The word gonorrhea, although etymologically inaccurate as a designation of the disease in question, is still so universally employed and so well understood that it has been retained here for the sake of convenience.

The only debatable ground in the consideration of gonorrhea at this time is the question of its specific character; that is, its invariable dependence upon a virus which is said to constitute the contagious element and to impart to the disease such distinctive or specific characters as clearly to separate it from other affections.

Recent researches seem to show a definite etiological relation between a particular microbe—the **gonococcus** (Pl. II, Fig. 2)—and gonorrhea, but, although probable and asserted by a large number of authorities, this cannot yet be considered as absolutely demonstrated. The statement that the disease has been produced by inoculation of pure cultures of the gonococcus (the only scientific and demonstrative proof of such relation) rests upon experiments which are as yet numerically insufficient to entitle it to an unhesitating acceptance, though the weight of evidence is gradually accumulating upon this side of the question. Clinically, however, we may assume that in the majority of cases of acute urethritis gonococci, the microbes of suppuration, and other bacteria will be found intermingled.

Inflammation of the male urethra may be thus either *simple*, in which infection with only pyogenic microbes has taken place, or *specific*, in which gonococci are also present.

Simple urethritis may be due to a great variety of causes. Authentic cases are recorded of well-marked urethritis following accidental or experimental exposure to leucorrheal discharges; to the pus from a healthy abscess or from a purulent bronchial catarrh; to the secretion from an endocervicitis or endometritis; to the discharge resulting from ulceration or malignant disease of the uterus; to the menstrual fluid or acrid vaginal discharges; to powerful injections; to the passage of gravel; to catheterism; and to many other undoubtedly non-specific causes. The condition thus evoked is often indistinguishable clinically from that following sexual intercourse with a person already having a similar disease, many severe and complicated cases of gonorrhea being derived from one or the other of these sources. As a rule, however, it is somewhat less severe and less protracted than the specific variety, due to infection with the gonococci, though great caution should be observed in drawing any inference as to causation from the character of a particular attack, as the variations observed in the different grades of urethritis are no greater than those which prevail among inflammations of other mucous passages, and which are due to individual idiosyncrasy or to differences in the power of the original irritant.

The facts that urethritis of either variety does not protect from subsequent attacks, that its pathology is that of any catarrhal inflammation, and that it may be reawakened or reproduced by local irritation, by indiscretion in diet, etc., afforded strong ground for the assertion that it is not a specific disease.

Late bacteriological discoveries have, however, as above stated, outweighed these arguments, though for convenience we may still differentiate the varieties of urethritis according to their clinical course, dividing them into (1) *typical* or *acute inflammatory* gonorrhea; (2) *subacute* or *catarrhal* gonorrhea; (3) *irritative* or *abortive* gonorrhea.

We may begin with a description of **acute inflammatory gonorrhea**, which is the variety most frequently encountered, particularly in those persons who are for the first time affected.

The *interval of incubation*, or the time which elapses between exposure and the development of urethral symptoms, is a variable one, extending from a few hours to twelve or fourteen days. In the great majority of cases, however, the disease appears during the first week. The patient notices a drop of milk-and-watery-like fluid at the meatus, which is slightly red and puffed or everted; a tickling sensation is often felt in this locality, and the next act of urination is attended with a feeling of warmth at the end of the canal or with actual scalding. After this the symptoms increase rapidly in number and

severity, so that within forty-eight hours, or even sooner, the disease may be described as having passed into its first or "increasing" stage, the characteristic phenomena of which, with their respective causes, are as follows:

Changes in the Meatus.—There are redness, eversion, and often erosion of the lips of the meatus; sometimes, but rarely, so much swelling as to constitute a distinct obstacle to the passage of urine, which escapes only by drops.

Ardor Urinæ.—Scalding at each act of urination, or ardor urinæ, is the symptom which gives the disease in French its popular name of "chaude-pisse." This is due partly to the distention of the inflamed and swollen mucous folds of the urethra during the passage of the stream, but chiefly to the contact of the salts of the urine with the inflamed surface.

Chordee.—Painful erection, or chordee, is present to a greater or less extent in all such cases. It may occur at any time during the twenty-four hours, but is most frequent after the patient has become warm in bed. He is awakened or kept awake by an intractable, persistent priapism, which is associated with pain felt along the under surface or often along the sides of the penis. In well-marked cases the organ is bent or curved, usually in a downward direction, more rarely upward or laterally. The corpus spongiosum, situated beneath and between the corpora cavernosa and surrounding the urethra, is more directly involved in the inflammatory process than the other portions of the penis. The urethritis extends by contiguity to the submucous connective tissue, and thence continuously to the trabeculæ of the erectile tissue of the spongy body. The lymph which is exuded in these localities blocks or fills up the intertrabecular spaces or meshes containing the intricate venous plexus which by its engorgement and distention furnishes the essential mechanical element of normal erection. When the organ becomes erect, the corpora cavernosa expand normally and fully, but the blood is unable to find its way into the partially obliterated erectile tissue of the corpus spongiosum, which remains rigid and inflexible. The pain along the sides is produced by the pressure on the nerves caused by the unnatural position, and that along the under surface by the attempted distention of the spongy body.

Frequent Urination and *Vesical Tenesmus* are other symptoms which occur about this time in many cases. They generally indicate an extension of the inflammation to the deep urethra, and are the most obvious diagnostic symptoms between *anterior* and *posterior* urethritis, the latter term signifying that the infective inflammation has spread to the region behind the compressor urethræ muscle. The same symptoms may exceptionally be due to reflex influence from a disturbance as yet localized at or near the meatus. In either event the irritability of the neck of the bladder is shown by the inability of that organ to retain more than a very small quantity of urine, the urgency of the calls to evacuate it, the difficulty in starting the stream, and the bearing-down, expulsive efforts which accompany or follow the dribbling of the last few drops.

The discharge during this period has been growing more and more profuse. At first thin and of a bluish-white hue, like city milk, it has become white, then yellow, and then greenish or streaked with blood.

There are, then, certain conditions—ardor urinæ, profuse purulent discharge, chordee, and frequent urination—which characterize the first or increasing stage of inflammatory gonorrhea.

The Complications of the First Stage.—*Balanitis.*—When the inflammation, instead of remaining within the urethra or involving only the lips of the meatus, extends over the surface of the glans penis, we have the

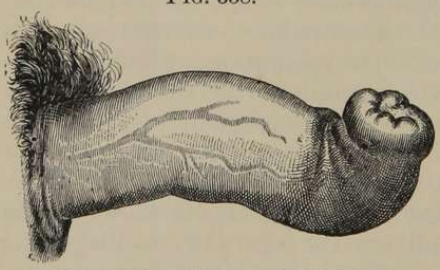
condition known as balanitis. This is usually caused by a neglect of cleanliness, but it occasionally occurs from extension of inflammatory action by continuity and in spite of the greatest care. Its symptoms are those of superficial inflammation—viz. heat, redness, burning or itching, and finally exfoliation of epithelium, leaving an eroded or sometimes a superficially ulcerated surface. Not infrequently little crops of herpetic vesicles appear, and may remain discrete until they desiccate, or may pustulate, coalesce, and leave an ulcer which is sometimes mistaken for a chancre or chancroid.

The form of the initial lesion of syphilis known as the chancrous erosion may be mistaken for a superficial balanitis. The period of incubation, the absence of urethral discharge, the abrupt limitation of the erosion, the presence at its base of "parchment" induration, the enlargement of the inguinal lymphatics, and the lack of an inflammatory element are symptoms of the former condition which should render it easily distinguishable from a solution of continuity due to balanitis.

Balano-posthitis.—An extension of the inflammation from the surface of the glans to the inner or mucous layer of the prepuce gives rise to what is known as balano-posthitis. It has no special clinical significance, except that it is almost invariably followed by, or associated with, an inability to retract the foreskin so as to uncover the glans penis. This is due to an extension of the inflammation to the loose cellular tissue uniting the two surfaces of the foreskin, which rapidly becomes œdematous, and in some cases is the seat of an effusion of plastic lymph.

Phimosis (Fig. 338).—The phimosis thus produced is an extremely objectionable complication, as it interferes with treatment, necessitates most vigilant and unremitting care as to cleanliness, and obscures the diagnosis and prognosis. If the case has not been watched from the beginning, and the patient comes under observation for the first time with a vague history and with an œdematous, swollen prepuce, from the orifice of which pus or pus and blood exude, it is not always easy to determine the exact underlying condition. An indurated chancre can generally be discovered without trouble by its hardness, and moreover is not often complicated in this manner. A soft or chancroidal sore, however, or a balanitic ulceration may not be so readily recognized. The main points of distinction may be tabulated as follows:

FIG. 338.



Phimosis from Gonorrhea (Cullerier).

Phimosis from Gonorrhea.	Phimosis with Subpreputial Chancroid.
No history of sore on glans or prepuce.	History of sore.
Swelling in foreskin at first almost entirely œdematous.	Swelling often due to plastic lymph around the ulcer.
Discharge usually purulent.	Discharge often sanguinolent.
No definite area more tender or harder than the rest.	A distinct spot usually discoverable by palpation.
Chordee often present.	Never any true chordee.
Ardor urinæ extends along the whole length of the canal.	Ardor urinæ only when the urine comes in contact with the inflamed or ulcerated foreskin.
Vesical symptoms not infrequent.	No vesical symptoms in uncomplicated cases.
Bubo very rare.	Bubo common.

Paraphimosis (Fig. 339), a condition in which the prepuce, retracted and caught behind the projecting corona glandis, cannot be brought forward, is a less frequent but more annoying and dangerous complication. The tense and rather inelastic edge of the preputial orifice constitutes the cause of the constriction, which grows tighter as swelling increases. The neighboring parts, at first œdematous, soon become infiltrated with lymph, the return of blood from the glans is interfered with, and, in extreme cases, ulceration or even sloughing of the head of the penis has occurred. The line of constriction is situated a short distance behind the glans, immediately back of which is a furrow due to the normal depression existing there, intensified by the surrounding œdema. Back of this is a swollen fold of mucous membrane, which is the part of the inner layer of the prepuce normally in contact with the posterior face and edge of the corona. Then is found a second and very deep furrow, which is the actual seat of the trouble, and behind this another prominent collar of swollen integument. Paraphimosis is attended with severe pain, which does not disappear until either the prepuce has been replaced or the constriction has been relieved by division or by ulceration. It is often productive of deformity from cicatricial contraction in those cases in which surgical interference has been delayed or ineffective. These complications—balanitis, balano-posthitis, phimosis, and paraphimosis—are by far the most frequent of those which make their appearance during this early period of the disease, and have accordingly been described in their usual clinical order. The first stage, or that in which there is a progressive increase in the severity of the symptoms, is of variable duration, but under well-directed treatment commonly terminates in from five days to a week, after which, for a short time, the condition appears to remain stationary.

Fig. 339.

Paraphimosis (Cullerier).

Symptoms and Complications of the Second or Stationary Stage.—The discharge is still profuse, and the ardor urinæ and chordee marked and in some cases agonizing. Patients will complain bitterly that their comfort during the day is interfered with by urgent calls to urinate, which they resist to the last possible moment in a vain endeavor to avoid the pain occasioned by it, and that their rest at night is disturbed by frequently recurring erections, which are no less painful, and which often will not subside until some means has been adopted for their reduction. During this period, which may be said to extend on an average from the seventh or eighth day to the end of the second week, the inflammation is gradually extending backward and may give rise to other complications.

Follicular and Peri-urethral Abscess.—Dipping down from the urethral membrane into the follicles which empty upon its surface, the inflammation of gonorrhea occludes their mouths by causing swelling of their lining membrane, and converts them into little bags or pockets of pus—follicular abscesses—which appear as small, round, tender tumors along the under surface of the urethra. They very often open internally, but now and then adhesion to the skin takes place, pointing occurs outwardly, and they discharge upon the cutaneous surface. Fortunately, they are not followed by urinary fistulæ. If the suppurative process involves the loose connective tissue around the urethra, a peri-urethral abscess is formed. This is most frequent at precisely the points which on *a priori*

grounds would have been selected—those at which gonorrhea is most persistent, the fossa navicularis and the anterior part of the membranous urethra.

Lymphangitis.—In a certain proportion of cases of gonorrhea a simple lymphangitis occurs as a result of infection with pyogenic microbes. It affects most commonly the lymphatics of the dorsum of the penis, and is almost invariably associated with neglect of cleanliness and retention of the discharge between the prepuce and the glans. This is what might be expected on anatomical grounds from the group of lymphatics involved, those directly connected with the urethra itself belonging to the deeper set, and running beneath the pubic arch to join the deep lymphatics of the pelvis and to terminate in the lumbar glands. The symptoms consist in a thickened, cord-like line of induration extending from the prepuce to the root of the penis, usually tender to the touch, easily isolated from the surrounding structures, and often traceable upon the surface by a faint red linear blush.

Gonorrheal Bubo.—Either with or without lymphangitis as a forerunner, inflammation of one of the glands of the groin may be the result of gonorrhea. The gland affected is usually one of the superficial set, lying just below Poupart's ligament, imbedded in the subcutaneous cellular tissue and above the fascia lata. A small, painful tumor makes its appearance in the groin: it is at first freely movable beneath the skin, but afterward contracts adhesions to the latter and to the surrounding parts, and becomes doughy in feel and reddish or purplish in hue. In the majority of cases, after reaching this condition, it will subside under appropriate treatment, disappearing by resolution. In others, however, suppuration ensues, the connective tissue which surrounds the glands liquefying first. Indeed, very often the glandular structure itself is not involved in the suppurative action.

Another group of complications may be mentioned as possible occurrences toward the end of the third week, some of them, however, often appearing much later. They are cowperitis, prostatitis, and cystitis.

Cowperitis.—Inflammation of one or both of Cowper's glands is a result of extension of the urethritis by continuity along their ducts, which empty into the posterior portion of the spongy urethra. The first symptom usually developed is pain in the perineum, much increased by pressure and rendering sitting or walking markedly painful. The inflammatory swelling of the glands is resisted by the two layers of the triangular ligament between which they are situated and by the deep perineal fascia, and this resistance, associated with the determination of blood to the part by gravitation, imparts, as in other inflammations where the same conditions exist, a throbbing element to the pain which renders it peculiarly distressing. Suppuration in the periglandular tissue sometimes occurs, in which case the usual signs of the formation of pus are present.

Prostatitis.—After gonorrhea has spread backward as far as the prostatic urethra, it may, and in some cases unavoidably does, involve the prostate gland in spite of the best-directed treatment. The follicles and the glandular elements of this body are primarily and chiefly affected, the muscular tissue which composes the larger portion of its mass remaining in mild cases uninvaded. The anatomical and physiological relations of the gland furnish a key to the symptoms produced by its inflammation, the earliest of which will probably be a feeling of weight and distention in the perineum and rectum. This is soon followed by frequent urination, due to the inability of the bladder completely to empty itself, the exit of the urine being interfered with by the engorged gland. The end of the act is painful. Defecation is also painful, markedly so if the feces are inspissated, and the finger inserted into the rectum feels the anterior wall pushed into the center of the bowel, hot, unnaturally firm, and

tender to the touch, while through it the outlines of the greatly enlarged prostate can be felt. As the disease progresses the pain increases, becomes throbbing, particularly when the patient is erect or in the sitting posture, radiates along the cords of the hypogastric plexus to all the neighboring regions, and is very greatly aggravated by any evacuation of the bladder or rectum. The frequency and difficulty of micturition both increase, the latter sometimes proceeding to complete retention. The disease may terminate by resolution, the most frequent way, or by suppuration. If suppuration occurs, it is usually due to the coalescence of several inflamed follicles, which, lying in proximity to one another, have broken down into a common cavity. The pus is frequently discharged into the urethra, but occasionally pointing takes place in the direction of the rectum. In either event evacuation gives great relief. In most cases the prostate is left with some fibrous thickening—a hyperplasia of its cellular tissue—which is often the groundwork for future trouble, but which should not be confounded with the hypertrophy of the same tissue and of the muscular elements which so frequently takes place in advanced life. An acute prostatitis may run into a *chronic* condition, which is very annoying and intractable. The same symptoms exist in a modified and much subdued form: the pain is replaced by a sense of weight and fulness; micturition is rather too frequent and is feeble, the last drops dribbling from the meatus; a mucoid discharge like the white of raw egg, but occasionally milky, may be squeezed from the urethra by deep pressure from behind forward, and the same discharge appears at the meatus after every evacuation of the rectum. By examination through the latter the gland is found to be somewhat enlarged and slightly tender on firm pressure.

Cystitis.—A greater or less involvement of the neck of the bladder is often a concomitant of acute prostatitis, and is indicated by increased urinary trouble and by the appearance of a drop or two of blood at the end of micturition. This prostato-cystitis, which is the form of vesical disease usually encountered in gonorrhea, may subside under treatment or may pass into a well-developed inflammation of the mucous membrane of the vesical neck. In this case (gonorrheal cystitis) there are certain well-marked symptoms, chief among which are very frequent urination, the patient not being able to retain his water for more than a few moments, and the desire to expel it becoming intense and irresistible on the slightest delay; excessive vesical tenesmus at the end of the act, which is characterized by severe burning pain instead of a sense of relief, blood and pus following the stream of urine, the latter part of which is turbid or milky. There are few constitutional symptoms, little or no fever, no rigors, and but slight deterioration of the general health unless the disease runs a protracted course. The diagnosis between prostatitis and cystitis, which are the only complications of gonorrhea likely to be confounded, may be made by attention to the following points:

Prostatitis.	Cystitis.
Perineal and rectal pain.	Possibly a little tenderness of the perineum on pressure, but no rectal pain.
Pain violent and throbbing, aggravated during defecation.	Pain burning, not especially affected by defecation.
Tenesmus not always present.	Tenesmus constant and severe; very characteristic.
Stream of urine diminished in size.	Size of stream not always affected.
Retention of urine common.	Retention of urine rare.
Urine not much changed in appearance.	Urine turbid and ropy, last drops mixed with blood.
Rectal examination shows enlargement and great tenderness of the prostate.	No prostatic enlargement or tenderness recognizable on rectal examination.

These complications belong in the majority of cases to the stationary period of gonorrhea, which extends from one to two weeks, rarely longer, and during which the acute symptoms of the first stage, the ardor urinæ, chordee, etc., remain nearly or quite unaltered.

At the termination of this stage that of subsidence begins, and in uncomplicated cases progresses rapidly until complete recovery has taken place.

Symptoms and Complications of the Third Stage, or that of Subsidence.—Urination becomes painless and less frequent; the discharge grows thinner, becomes watery and scanty, or dries up altogether; erections no longer occur with abnormal frequency, and do not give rise to curvation of the penis or to pain. If any of the complications which have been described has existed, the last vestiges of it fade away.

But until this stage is actually completed, as long as any of the symptoms of urethritis are still evident there are yet certain dangers to be avoided and serious difficulties which may present themselves.

Epididymitis.—Chief among these, in respect to frequency of occurrence, is epididymitis, or swelled testicle, which is a complication usually supervening in the fifth or sixth week of the disease, sometimes coming much earlier, and sometimes as late as the end of the second month or even in the third month. In the great majority of instances it is obviously the result of the extension of the urethral inflammation along the ejaculatory ducts and spermatic canal to the epididymis itself. The first symptom is an aching, occasionally a neuralgic, pain along the line of the groin, more frequently on the left side. If the cord be taken between the thumb and finger and rolled gently, it will be found to be tender on pressure. If the inflammation progresses and the epididymis is involved, this preliminary pain is soon followed by a feeling of weight and a dull ache in the affected testicle, which begins to increase in size and rapidly becomes of great bulk and exceedingly painful. The nauseating quality possessed by this pain is peculiar to it, and serves greatly to aggravate its unpleasantness. The scrotum becomes purplish in color.

The patient, particularly if the testicle be not supported so that its weight is withdrawn from the cord, will walk in a slightly stooping posture with the legs apart. The dragging of the heavy tumor upon the spermatic vessels prevents the free return of blood from the testicle and serves to increase the tension, and by additional pressure upon the nerves to add to the pain. Under proper treatment the acute inflammatory symptoms subside by resolution in a few days, but the enlargement disappears very gradually, a small portion of the globus minor often remaining perceptibly indurated throughout life. In a still smaller number of cases suppuration occurs in the subcutaneous cellular tissue, and sometimes involves a large portion of the scrotum. Persistent induration of the globus minor, which consists of a single tube for the passage of semen, may interfere with or entirely prevent the exercise of its function, and if both testicles have been involved sterility more or less permanent may result. There may be all the indications of virility; there is no diminution in desire nor in ability to perform the sexual act, which is accompanied by emission of fluid derived chiefly from the prostate and the seminal vesicles, and is attended by the customary amount of pleasure. In other words, the patient, though sterile by reason of the absence of spermatozoa from the fluid which he emits, is not by any means impotent. Time and suitable remedies will sometimes remove this condition, but the prognosis in this respect should be guarded.

That the left testicle is affected twice as often as the right is usually attributed to the fact that as a rule it hangs lower, and thus receives less support from the scrotum. It is more probably, however, the result of the position of

the left spermatic vein behind the sigmoid flexure, and also of its indirect communication with the vena cava through the renal vein, which it enters at a right angle, the right spermatic vein emptying into the cava at an acute angle. These causes are sufficient to produce local congestion, a powerful predisposing cause of inflammatory attacks. As a result of pressure on the efferent vessels by inflammatory products, or as a consequence of extension of the inflammatory action itself, acute hydrocele may and often does complicate epididymitis, adding to the size of the swollen organ and increasing the feeling of tension to both the patient and the surgeon. It requires no special treatment, and usually subsides when the declining stage is reached.

Subacute or Catarrhal Gonorrhea.—This occurs most commonly in persons who have had previous attacks of gonorrhea, and is an example of the tendency manifested by all mucous structures to take on inflammation upon slight provocation after having once been affected. It is particularly noticeable in the urethra for several reasons: the canal affords periodical passage to a secretion, the urine, which is especially liable, by reason of changes in its constitution, to become an actual irritant; it is exposed at times of erection to intense congestion of all its vessels,—the converse also being true, that a congested or irritated spot along the urethra predisposes to erection; gravitation, the proportionately excessive supply of blood to the region, and the absence of extra-vascular resistance, due to the loose character of the spongy tissue, all favor the persistence of any congestion left after a first attack of urethritis; the approximation of the mucous surfaces of the urethral walls during the intervals between the acts of micturition is here, as elsewhere, unfavorable to the disappearance of granular or injected areas or other traces of inflammation. For these reasons, among men who have had gonorrhea once, many have subsequent manifestations, a predisposing cause being usually present, although some additional irritant, such as contact with menstrual fluid or with a leucorrheal secretion, is generally necessary to bring on marked symptoms.

Symptoms.—A patient with this variety of urethritis will present himself, after a suspicious or an unaccustomed connection, with a free muco-purulent or purulent urethral discharge. He will complain of very little pain, possibly only of a sensation of warmth during urination. Chordee is absent or very slight, there is no vesical irritability, and complications are infrequent. The only affection for which this form of gonorrhea is likely to be mistaken is urethral chancre, the possibility of which should never be forgotten.[1] Under treatment the discharge rapidly diminishes until only a drop or two of muco-pus can be seen, and that chiefly in the mornings. This symptom is apt to linger in spite of all efforts to remove it, and is perhaps the most persistent, and by reason of its long continuance the most annoying, consequence of this form of gonorrhea. There are, however, some complications which, although they may likewise appear during an acute attack, are often associated with this catarrhal condition of the urethra, and are of considerable gravity. These are gonorrheal rheumatism, gonorrheal ophthalmia, and gonorrheal conjunctivitis.

Complications of Catarrhal Gonorrhea.—Gonorrheal Rheumatism, or urethral synovitis, or **Post-Gonorrheal Arthritis** as it has been better called, may appear at any time during the existence of a purulent discharge from the urethra. It is much more common in men than in women. It develops suddenly, and is usually accompanied by some abatement of the discharge, more rarely by its entire disappearance. The disease has been ascribed to various causes—metastasis, reflex agency, identity of gonorrhea

[1] The diagnosis between infecting chancre of the urethra and gonorrhea may be found in the chapter on Syphilis.

and syphilis, development of a pre-existing rheumatic diathesis, and, finally, a form of septicemic infection, the last hypothesis being the one now generally accepted as correct.

The *symptoms* of this complication come on rapidly, usually during the later stages of either an acute or a catarrhal gonorrhea. The patient, without any premonitory signs, or perhaps after a slight chill or "creep" and a little febrile disturbance, notices pain and swelling in an articulation, commonly the knee, ankle, wrist, or elbow, the degree of frequency being in the order of mention. Within a few hours the swelling, due to synovial exudation, increases, the joint becomes moderately red and hot and very tender, the suffering on touch or movement being great. It may remain in this condition for some time, may involve neighboring tissues, producing a general arthritis, or may in a very few cases subside rapidly. There are few if any constitutional symptoms. The disease in a certain number of cases develops only vague travelling pains in joints, bones, and muscles, and does not produce well-marked local symptoms. Ordinary rheumatism is the only disease for which this form of joint-affection is likely to be mistaken. The diagnosis should be based upon the following points, which, for convenience' sake, may be tabulated thus:

Post-Gonorrheal Arthritis or Gonorrheal Rheumatism.	Ordinary Rheumatism.
Associated with urethritis.	Not associated with urethritis.
Very infrequent in women.	Not very rare in women.
Constitutional symptoms transient and not severe.	Constitutional symptoms marked and prolonged.
Very little fever.	High fever.
No sweating.	Profuse sweating.
Urine unaltered.	Urine high-colored and loaded with urates.
Often associated with sclerotitis, bursitis, and teno-synovitis.	Not complicated with sclerotitis, bursitis, or teno-synovitis.
Cardiac lesions rare.	Cardiac lesions frequent.
Inflammation remains fixed; involves one or a few joints.	Inflammation jumps from one joint to another, involving many.
Local pains rather less than in true rheumatism.	Pains always severe.
Effused fluid is absorbed very slowly.	Effused fluid absorbed with comparative rapidity.
Tendency to hydrarthrosis after acute stage has passed.	Tendency to chronic hydrarthrosis less marked.
Great tendency to relapse during subsequent gonorrheas.	Relapses have no association with urethral conditions.
Anti-rheumatic remedies are of little value.	Anti-rheumatic remedies are evidently useful.

Gonorrheal Ophthalmia and Gonorrheal Conjunctivitis.—See *purulent conjunctivitis*, p. 1047.

Irritative or Abortive Gonorrhea.—There remains to be considered the third variety of so-called "gonorrhea," the irritative or "abortive." Not infrequently after a suspicious connection a patient will complain of a slight pain on urination and a little itching at the meatus. An examination discloses a reddening of the lips of that orifice, and a little transparent secretion coming from the anterior half-inch of the urethra. These symptoms are very similar to those of the earliest stage of an acute urethritis, and indeed are altogether indistinguishable from them—a fact of importance in deciding as to the propriety of "abortive" treatment. Instead, however, of increasing in intensity, they remain stationary for some days, and then, if not aggravated by improper treatment, subside entirely, the whole duration of the case not exceeding a week or ten days. There are no sequelæ and no complications

associated with this condition, which is simply one of mucous irritation and consequent hypersecretion.

The three varieties of urethritis which have thus been described may be contrasted as follows, it being understood that such accurate clinical differentiation does not invariably occur, but that in many cases the characteristics of the different classes are intermingled. The tabular form will be useful in enabling us to recognize at a glance the main points of difference:

Acute Inflammatory Urethritis.	Catarrhal Urethritis.	Irritative Urethritis.
Usually a first attack.	Usually a second or subsequent attack.	No relation to previous urethral disease.
Begins with a little redness, pouting, and tingling, itching, or smarting at the meatus.	The same.	The same, but to a much less degree.
Rapidly develops free discharge, ardor urinæ, chordee, and other symptoms.	Most of these symptoms, with the exception of the discharge, are absent.	All these symptoms absent; does not progress beyond this point.
Discharge thick, yellow, greenish, or bloody.	Discharge milky or watery.	Almost no discharge.
Usual complications: prostatitis, cystitis, bubo, etc.	Most common complications: rheumatism, ophthalmia.	No complications.
Treatment at first actively sedative and antiphlogistic or mildly antiseptic.	Treatment may soon be "anti-blennorrhagic:" cubebs, copaiba, etc., with injections.	No treatment necessary.

Chronic Urethral Discharges.—As a direct continuation or prolongation of the acute affections of the urethra, or as more or less remote sequelæ, a number of chronic urethral discharges are met with. These may for convenience be divided into three classes: those due to a urethral catarrh, a condition often left after the subsidence of an acute urethritis; those dependent upon a chronic gonorrhea, the inflammation having localized itself in some portion of the urethra, producing a granular or even superficially ulcerated surface; and those commonly known as **gleet**, which in almost every instance will be found associated with urethral coarctations, often of the sort known as "strictures of large caliber." Nearly all chronic discharges arising from the urethra proper will be found to fall under one or the other of these heads, and, as it is a matter of much therapeutic importance to be able to distinguish them, their chief diagnostic points may be briefly considered.

Urethral Catarrh.—In many cases of gonorrhea, for some time after the disappearance of the last drops of muco-purulent discharge there will still be found a condition of excessive secretion or of increased "urethral moisture," which will often be a source of unnecessary anxiety to the patient and the surgeon. The symptoms associated with this mucous catarrh vary from a mere feeling of wetness about the meatus to the possible production, by "stripping" the urethra, of a drop or two of clear, albuminoid liquid, slightly tenacious and resembling that resulting from a prostatorrhea, with which, indeed, it is often associated. There is no subjective symptom, except a sensation of dampness at the extremity of the penis. This is often so marked as to lead the patient to useless examinations of the organ, or to induce the belief that a free discharge exists, but is absorbed by the dressings or by the under-clothing. Treatment of any sort, as a rule, serves only to aggravate, or at least to perpetuate, this condition, which, in nineteen cases out of twenty, will subside spontaneously in a few days or weeks.

Chronic Gonorrhea.—In other cases, after all marked symptoms have

vanished there will yet remain a milky, or rather creamy, drop, which can be pressed out of the meatus whenever a few hours have elapsed after urination. This may come from any portion of the urethra, but will usually be found to proceed from the fossa navicularis or from the anterior membranous portion. By "stripping" the urethra an inch or so at a time, gradually working backward, or by proper use of a bulbous bougie, as will be described under the head of Treatment, or by means of the urethroscope, a very definite idea of the exact site of the trouble may be obtained. The meatus will be found a little reddened or swollen; there will be an undue warmth or even a slight scalding on urination; erections will be accompanied with a dull ache, and all these symptoms will be much increased by venereal, alcoholic, or other excesses, especially by prolonged and ungratified sexual excitement and by the free use of spirituous liquors. There is no interval between this condition and the last stage, or rather the preceding stage, of an acute urethritis.

Gleet.—In some cases, and especially in those in which the gonorrhea has been of long continuance or has frequently been repeated, there will occur another group of symptoms, chief among which is a "gleety" or muco-purulent discharge. In the mornings the lips of the meatus will be found glued more or less tightly together, and on separating them a drop of opalescent, whitish fluid will become apparent or may be squeezed out. The discharge may be more profuse, but cannot usually be found during the day in sufficient quantity to be made apparent at the meatus, owing to the frequent washing out of the urethra by the stream of urine. There will often be found associated with this discharge a dribbling of urine at the end of micturition, an increased frequency of the latter act, and a few vague lumbar or hypogastric pains or aches—a group of symptoms which should always suggest the existence of a stricture of large caliber.

We may now bring together the main points of difference between the various chronic urethral discharges:

Urethral Catarrh.	Chronic Gonorrhea.	Gleet.
Follows immediately on subsidence of gonorrhea.	Continuous with attack of gonorrhea, often a first one.	Usually a variable interval after subsidence of gonorrhea; generally after several attacks.
Discharge watery; thin mucus.	Discharge creamy; pus.	Discharge milky or milk-and-watery; muco-pus.
Not much affected by habits.	Greatly aggravated by excess in drink or by sexual excitement.	Increased by the same causes, but not to the same degree.
No subjective symptoms.	Warmth or scalding on urination; very slight tendency to chordee.	Dribbling after urination; frequency of urination; hypogastric and lumbar pains.
Affects no special portion of the urethra.	Lingers chiefly about the navicular fossa and the bulbo-membranous junction.	Source of the discharge always back of the coarctation.
Cause: loss of tone and dilatation of capillaries of part.	Persistence of low grade of inflammation. Circumscribed congestion with small granulations.	Submucous deposit around urethra, interfering more or less with its caliber.
Prognosis: subsides without treatment.	Requires local treatment.	If cause be not removed, almost certainly grows worse.
Expectant treatment.	Treatment by local injections.	Treatment by dilatation and injections.
With bulbous bougie urethra is found to be normal.	Point of sensitiveness, from which bougie brings pus.	Point of moderate resistance.

Prostatorrhea.—There is a form of discharge dependent upon *chronic follicular prostatitis* in which the chief diagnostic points are as follows: 1. Undue frequency of micturition, with pain felt in or near the end of the penis at the termination of the act. The prostatic nerve-plexus, supplying the vesical neck and the gland itself, becomes the cavernous plexus, and is continued to the end of the penis, terminating at the proximal side of the fossa navicularis. This nervous supply sufficiently explains the above symptom. 2. A feeling of weight or of fulness in the perineum and rectum, sometimes amounting to absolute pain, especially during the passage of hardened feces. The relations of the pelvic plexus of the sympathetic, which supplies the rectum as well as the skin of the buttocks, perineum, and external genitals, in addition to furnishing the nerves for the mucous surfaces and muscular portions of the bladder, prostate, and urethra, of course explain the occurrence of this symptom. 3. Diminution in the force of the stream, associated with dribbling toward the end of the act. The frequency of this symptom shows that in the majority of cases of this kind the inflammatory trouble does not remain localized in the mucous membrane, but extends into the prostatic ducts, and even into the substance of the gland itself. This is further shown by the fact that in the great majority of such cases the volume of the prostate, as examined through the rectum, is appreciably increased, while there is often slight tenderness upon pressure. 4. The first portion of urine passed, if collected in a glass, will be found more turbid than the second portion. This aids in diagnosticating the condition under consideration from a primary cystitis, although the symptom has not the practical value which Ultzmann has attached to it. 5. The sediment in the urine will be found to consist of prostatic epithelium, muco-pus, and a few mucous shreds. These are often associated with casts of the follicles and prostatic ducts, which are sometimes deceptively like hyaline casts of renal origin. This resemblance is most frequent in cases of chronic trouble. 6. There is often, but not invariably, associated with these conditions a certain amount of sexual excitability, frequent erection, and premature ejaculation during attempts at intercourse.

This group of symptoms is characteristic of follicular prostatitis or prostatorrhea, and is not so apt to be found in uncomplicated cases of stricture of the urethra, but the condition is frequently diagnosticated and treated as one of gleet depending upon stricture.

TREATMENT OF GONORRHEA.

In determining the proper treatment for existing gonorrhea it is necessary, in the first place, to understand clearly the character and stage of the case with which we are dealing. The classification which has been given will be found a good one for practical purposes, and nearly all cases can be assigned to one or other of the three classes—acute, subacute, or abortive.

To take them up seriatim, we may suppose that a patient belonging to the first or acute inflammatory class presents himself for treatment with the symptoms characteristic of the early stage: a red, swollen meatus, a little pain on urination, and a muco-purulent discharge. The propriety of employing in such a case the so-called "abortive" treatment at once suggests itself, but should not be seriously considered. There is a strong practical objection to the adoption of this method in the impossibility which exists of accurately distinguishing at the outset between the different varieties of urethritis; one of which, beyond question, would be greatly aggravated by this treatment. As the most ardent advocates of the abortive treatment recommend it only

at the earliest appearance of symptoms, it is evident that in many cases a slight local irritation, limited to the extremity of the urethra and likely to subside spontaneously in a few days, would be converted into a general urethritis. This treatment, then, which consists in the injection once or twice of a strong solution of nitrate of silver, or in the very frequent injection of weaker solutions of the same salt or of some astringent such as tannin, need not here be further described. The first care should be to remove as far as possible all sources of irritation, chief among which are (1) the influence of motion, friction, and gravitation in increasing the amount of blood in the part; (2) the similar effect produced by sexual stimulus; and (3) the character of the urine, which must necessarily come in contact with the irritated surface.

(1) To overcome the first, rest in the recumbent position is obviously the most important means at our command, and its power in limiting and subduing the intensity of acute urethritis can hardly be over-estimated. The patient should be told to avoid, in every possible manner, physical exertion, to ride instead of walking, to sit instead of standing, and at such times as may be convenient to lie on his back with his hips elevated. (2) The patient should carefully avoid the companionship of women of any class, as under the circumstances there is apt to be an exaltation of sexual impulse which renders even the mere proximity of females more or less provocative of erection, or at least of a very harmful hyperemia of the parts. (3) In order to render the urine as bland and innocuous as possible, rigid attention to certain dietary rules is indispensable. A skimmed-milk diet is beyond question the one best adapted to this stage of the disease. A few farinaceous articles or a little stale bread and butter may be added, but the more nearly the diet is made to consist of skimmed milk the more likely is it that the patient will escape the severe ardor urinæ and troublesome chordee of the first week or two. In most cases, however, we are compelled to be content with a modification of the ordinary regimen, and should instruct the patient to reduce his animal food to the minimum, to avoid all greasy, fried, or highly-seasoned articles, to abstain from the use of pepper, vinegar, salt, coffee, and tea. Salad dressings, asparagus, acid fruits, tomatoes, strawberries, etc., pastry of all kinds, and indeed any article of food difficult of digestion, should be strictly prohibited, as should all malt, vinous, and spirituous liquors. The patient should be expressly warned against the use of beer and champagne. Apollinaris, seltzer, and soda water are permissible drinks and may be taken in large quantities, serving then the double purpose of diluting the urine and at the same time of reducing the appetite, so as to render more easy the observance of moderation in eating. Ordinary drinking-water may be taken in the same way, to the amount of three or four quarts daily, with great advantage; and to meet the same indication, the reduction of the salts contained in the urine, it is well to prescribe some alkaline hydragogue diuretic, combining with it an arterial sedative and an anodyne directed especially to the genital functions.

Instructions should next be given as to the best method of retaining such dressings as will serve to collect and absorb the discharge. If the foreskin quite covers the glans penis, the very best dressing consists of a little morsel of absorbent cotton placed over the meatus and retained within the preputial orifice. If it nearly covers the glans, but does not extend to the meatus, a small aperture should be cut in the center of a piece of patent lint or old linen, two and a half to three inches square; this should be stretched gently with the fingers until just large enough to slip over the head of the penis and back of the corona. The ends should then be turned forward and the

foreskin brought in the same direction, when it will serve to hold the lint or linen in place. If the glans penis be entirely uncovered, it will be necessary to support the dressing in some other manner. A good plan then is to take the foot of an old stocking or a bag of old muslin made large enough to hold the organ comfortably, and pin it to the front of the underclothing. "Gonorrhea bags" of antiseptic wood wool constitute an excellent dressing.

The foregoing directions all pertain to the first visit of the patient. If the case belong to the third (irritative or abortive) class, all the symptoms will subside in a few days; if to the second (subacute or catarrhal), the discharge will become more profuse, but no marked subjective symptom will develop; if to the first (acute inflammatory), the phenomena already described will make their appearance with an intensity proportionate chiefly to the lesser or greater strictness with which the directions given have been observed. In the first case (irritative gonorrhea) no further treatment is required; in the second (catarrhal gonorrhea) we may at once begin with the use of such injections as will be hereafter described as appropriate to the declining stage of inflammatory urethritis; but if we are dealing with a case of the acute inflammatory variety, we must continue to watch for and treat the symptoms.

Treatment of Ardor Urinæ.—For the relief of the ardor urinæ and tendency to frequent urination such a diuretic mixture as that suggested above is very useful, and should be persevered in or given in larger doses and more frequently. In addition, the patient may be instructed to immerse the penis in hot water during each urination, which is often followed by extraordinary relief, probably due to the equalization of the blood-supply caused by it, the temporary distention of the superficial vessels relieving, to a certain extent, the congested and swollen mucous membrane, and thereby diminishing the resistance to the passage of the stream of urine and the friction between it and the sensitive walls of the urethra.

Treatment of Chordee.—In the treatment of chordee attention must be paid to the following points, the first of which is the most important as a prophylactic measure: Before going to bed the bowels should invariably be evacuated. The bedroom must be cool and well ventilated, the mattress hard, and the bed-clothing light. No late meals should be taken, and any tendency of the thoughts toward sexual matters should be resolutely combated. The medicinal treatment of chordee has embraced a great variety of remedies, of which none is at the present time generally recognized as of pre-eminent value. Opium in the form of suppositories, used at bedtime, is very efficacious, but not without its disadvantages, the constipation induced by it being prejudicial. It may be necessary to employ it, however, in which case the following formula may be used:

℞ Pulv. opii, gr. vj;
Pulv. camphoræ, gr. xviij;
Ol. theobromæ, q. s.
M. et ft. suppositoria No. vj.
Sig. Use one at bedtime.

Camphor may be given internally in doses of a fluidram of the tincture or in the form of the monobromide in from three- to five-grain doses. Lupulin in fifteen- to twenty-grain doses and gelsemium in the dose of three minims or more of the fluid extract, repeated every time the patient wakes with chordee, have been extremely useful. None of these remedies are, however, so certain

in their effects as is bromide of potassium. Its employment as an alkali, as an arterial sedative, and as an anaphrodisiac, is especially indicated in the early stages of gonorrhea, and should never be neglected even when the symptom of chordee is absent. When that complication exists, the dose of bromide should be increased until decided drowsiness is produced, and it should be given at intervals during the day, with a double dose, combined with ten or fifteen drops of tincture of belladonna, at bedtime, and repeated if the patient awakes during the night with chordee. Under this treatment, pushed vigorously, the patient will rarely have any erections, painful or otherwise. If, however, in spite of the free use of bromides, the employment of camphor and opium suppositories, and attention to the hygienic rules laid down, the chordee is persistent and very painful, it is well to adopt more active measures for its repression, not only to free the patient from pain, but also because each recurrence of chordee aggravates the tendency to inflammation, and, probably, increases the liability to subsequent stricture. In such cases nothing is so effectual as the free abstraction of blood from the perineum by means of leeches. From a healthy adult eight or ten ounces should be taken, and for the next day or two he should occupy a strictly recumbent position with the hips elevated.

Urethral Injections in the Early Stage.—When the surgeon has decided to begin the use of injections he should order for the patient a blunt-pointed, hard-rubber urethral syringe large enough to hold three fluidrams. At this stage the disease, although often extending a few inches backward, has reached its greatest intensity at or near the fossa navicularis, a point at which the nozzle of an ordinary syringe may act as a mechanical irritant and serve to increase or perpetuate the inflammatory action. Having procured his syringe, the patient should be taught how to use it, and, although it gives a little more trouble, it is always well personally to inspect this procedure at least once. In using the injection the patient should sit upon the edge of a hard chair, the buttocks projecting slightly over it, the feet separated, and the thighs relaxed. In this way all pressure or tension upon the perineal muscles is removed and the injected fluid finds its way backward to a sufficient depth. In those cases in which the disease is clearly localized anteriorly, or in which any injection reaching the prostatic urethra or the neck of the bladder gives rise to vesical irritability, the patient may sit upright, with a handkerchief or towel rolled up and placed just back of the scrotum, thus occluding the urethra at that point. The syringe, having been nearly or quite filled according to the depth to which it is thought necessary to throw the injection, is held between the thumb and middle finger of the right hand, the tip of the index finger resting on the end of the piston. The conical extremity of the syringe is then inserted from a quarter to a half inch within the meatus, which is held open for that purpose by the thumb and fingers of the left hand, and which is then drawn tightly around the syringe, the pressure being made laterally, so as to narrow the aperture instead of broadening it as when it is compressed in an antero-posterior direction. If this is done properly while the syringe is depressed so that the piston points toward the umbilicus and is gently forced home, every drop of the liquid, to the amount of at least two fluidrams, will be deposited within the urethra. The patient should then use the injection in this manner after each urination, and should hold the injected fluid within the urethra for two or three minutes before suffering it to escape. It may be laid down as a rule that any injection which gives rise to more pain than might be described as a very slight smarting is likely to do harm rather than good, and should be diluted or discarded.

In selecting the drugs to be used by injection and by the mouth in the

treatment of the form of urethritis we are describing—viz. recent anterior inflammatory urethritis—our description of its etiology should not be lost sight of. As this form of gonorrhea is often an instance of mixed infection, the treatment should be more or less thoroughly antiseptic.

The application of the **principle of antisepsis** to the treatment of urethritis may be made for one of two reasons and in one of two ways. The drugs employed may be given on account of their supposed action upon either the microbes of suppuration or the alleged specific microbe of gonorrhea—the gonococcus of Neisser. They may be used locally or may be administered by the mouth, although even when given in the latter way their action is largely a local one. As to the reason for their employment, in the light of modern pathology it is not necessary to believe in an invariable and essential relation between the gonococcus and gonorrhea to see a clear indication for the use of germicidal agents. The successful treatment of suppuration anywhere demands the employment of some such agent, though it must be admitted that when the pus is furnished by a mucous surface the difficulties of treatment—*i. e.* of successful antisepsis—are greater than under most other circumstances; and it must likewise be admitted that those difficulties are much increased when the suppurative process is established in a canal like the male urethra, the anatomical peculiarities of which favor so markedly microbic growth or multiplication.

While the employment of antiseptics in urethritis or a belief in their efficacy does not necessitate a corresponding belief in the gonococcus as the sole cause of gonorrhea, yet a consideration of the rationale of such treatment undoubtedly involves an inquiry into the natural history of that microbe, which is certainly present, whether as cause or as effect, in the large majority of cases of acute gonorrhea. Unfortunately, the results of culture experiments and of experiments as to the influence of germicides upon gonococci external to the body do not afford satisfactory evidence as to the effect of the same agents when applied to the same germs imbedded in the depths of an inflamed urethral mucous membrane. Bumm's investigations appear to show that at first they multiply by preference in the papillary layer, and find their way to the surface only during the latter part of the purulent and during the subsiding (or muco-purulent) stage, and Finger uses this as a theoretical argument against the early administration of either astringents or antiseptics. Enough is known, however, to enable us to state with certainty that the agents which are effectual against the microbes of suppuration are not equally destructive of the gonococci, several competent observers having noted the fact that antiseptic solutions, when applied to gonorrheal secretions outside of the body, have seemed to exert but little effect upon the gonococcus even when strong enough to destroy pus-cells and the pyogenic microbes almost immediately.

Considering topical remedies first, and excluding a large number which have little or no claim to occupy time or attention, we may divide the remainder into three classes:

1. Those which when strong enough to exert a sufficient germicidal action are locally so irritating as to be harmful or unbearable. This class includes nitrate of silver, carbolic acid, chloride of zinc, iodine, chloral, potassium permanganate, salicylic acid, and creasote, all of which have been faithfully tried in many cases and by competent surgeons, the concurrent testimony being that when used in sufficient strength to sterilize the discharges they produce an amount of irritation and swelling, ardor urinæ, chordee, and even, exceptionally, urethral ulceration, that far outweighs any advantage to be derived from their antiseptic properties.

2. Those which are such feeble antiseptic agents that they cannot be depended upon to destroy all the bacteria found in urethral discharges. Among these may be mentioned resorcin, thallin, quinine, sulphate and acetate of zinc, lanolin, sulphur waters, tannin, alum, hydro-naphthol, and cadmium sulphate. The clinical evidence and the experimental evidence coincide as to most of these drugs. Each has had its more or less enthusiastic advocates, but when given a wider trial has been found disappointing, while bacteriologists have shown that the germicidal action is either limited to a very few varieties of bacteria or is slow and uncertain.

3. The third class includes a number of agents which, while open to the same objection of too feeble or too limited antiseptic action, have the additional drawback of insolubility in ordinary media, and of occasionally becoming mechanically irritating from the formation of concretions. Among these are iodoform, calomel, bismuth subnitrate, oxide of zinc, and other insoluble powders.

It must not be supposed that this list is intended to be even approximately complete. It might be increased literally a hundred-fold; and nothing could better demonstrate the absurdity of empirical methods than the dozens of ridiculous formulæ and the hundreds of useless drugs which have from time to time been recommended for use in the various forms of urethritis. So far, however, as they are antiseptics, they would be found in one or the other of the above classes.

There are certain agents which have been purposely omitted from this classification, but which, as ordinarily employed, might with considerable propriety have been included. These are corrosive sublimate, sulpho-carbolate of zinc, boric acid, peroxide of hydrogen, and salicylate of bismuth, which in various combinations are of practical value in attempting by topical treatment to secure asepsis in an inflamed urethra. They may be used in different proportions and either singly or in combination. A useful prescription is as follows:

℞ Hydrarg. chlorid. corros.,	gr. $\frac{1}{10}$;
Zinci sulpho-carbolat.,	gr. xviij;
Boroglyceride (25 per cent.),	f ʒij;
Aquæ rosæ,	f ʒ iv.—M.

S. Use locally; dilute if painful.

To this may be added from 18 to 24 grains of the watery extract of opium if the urethra is especially irritable.

The so-called *blennorrhagics*, of which cubebs and copaiba are the chief, may be used with advantage very early in all cases except those of high inflammatory type. There can be little doubt that the beneficial action of these drugs, as well as that of their congeners, gurjun, sandal-wood, kava-kava, eucalyptus, and the various terebinthinates, is chiefly due to their antiseptic powers, which not only deprive the altered and partially sterilized urine containing them of many of its harmful properties, but cause it to exert a positively curative effect upon the suppurating mucous membrane. They may with marked benefit be combined with salol, which by its decomposition into salicylic and carbolic acid, to be excreted through the kidneys, aids powerfully in rendering the urine not only aseptic, but also antiseptic.

A useful prescription is for a capsule containing salol 5 grs.; oleoresin of cubebs, 5 grs.; Para balsam of copaiba, 10 grs.; pepsin, 1 gr.; four to six capsules daily being given. In cases where the irritation of the whole urinary tract is so great as to contraindicate the use of cubebs or copaiba the salol may

be given alone in ten-grain doses four times daily, or boric acid may be administered in some such combination as the following:

℞ Acid. boric.,
Potassii bromidi, *āā* ℈viij;
Tinct. aconiti, gtt. xvj;
Mist. potass. citrat., f℥viij.—M.
S. One tablespoonful in water every two hours.

In certain cases where these preparations disagree or seem to lose their effect it will be well to substitute sandal-wood oil in doses of ten minims four times daily. This amount may be dropped upon a lump of sugar and swallowed with a little water, or it may be given in capsules. A commercial article is sometimes sold by druggists which has not by any means the same therapeutic value as the genuine oil, being a decided irritant to both the genito-urinary and the digestive tract. It may be known by its turbidity or cloudiness, the pure oil being perfectly translucent and of a pale amber color. A little later in any case an injection containing an insoluble sediment may be substituted for the antiseptic injection given above, as, for example,

℞ Zinci acetat.,
Acid. tannic., *āā* ʒj;
Acid. boric., ʒiij;
Liq. hydrogen. peroxid., f℥vj.—M.
S. For local use.

Sometimes, especially in the first few days, no injection can be borne except an almost purely sedative one, and then the following may be tried:

℞ Acid. boric., ʒij;
Ext. opii aq., gr. xviij;
Liq. plumbi subacet. dil., f℥vj.—M.

While using the injections containing insoluble sediments the patient will often be unable accurately to estimate the character and amount of his discharge. After a time, therefore, it is well to substitute for them a watery solution of some simple astringent, preferably of sulpho-carbolate of zinc, beginning with about two grains to the ounce, and combining it, if there be any lingering sensitiveness or scalding, with morphine or dilute hydrocyanic acid, as in the following prescriptions:

℞ Morphinæ sulphat., gr. j;
Zinci sulpho-carbolat., ℈j;
Aquæ rosæ, f℥iv.—M.

℞ Zinci sulpho-carbolat., ℈j;
Acid. hydrocyanic. dil., gtt. xij;
Aquæ rosæ, f℥iv.—M.

In this, as in all other cases, if the injection proves to be painful, it should be diluted; if painless and if it does not entirely control the discharge, it should be strengthened.

Under this treatment in many instances the discharge will disappear, and

no further symptoms manifest themselves, unless, as often occurs, treatment is prematurely discontinued. The only safe rule to follow is to instruct the patient gradually to stop the use of injections and to decrease the dose of medicines, omitting first the mid-day portions, then those of the morning, and last of all those taken just before going to bed; the whole process should extend over ten days. He should also be cautioned against frequent or vigorous "stripping" of the urethra for purposes of inspection.

Irrigation with various antiseptic solutions, usually thrown in by the aid of gravity, are in much favor with some practitioners. It is probable that their systematic use in large numbers of cases would show a reduction in the average time of cure. A considerable proportion of private patients are, however, unable or unwilling to employ them at their homes.

Treatment of Persistent Urethral Discharges.—If, in spite of the injections above given, the discharge continue, recourse may be had to stronger solutions, the sensibility of the urethra being taken as an index. In this way five or six grains of zinc sulphate to the ounce will often effect a cure when weaker injections have failed. Or acetate of zinc, tannin, sulphate of copper, nitrate of silver, alum, tincture of catechu, hydrastin, and various other drugs may be employed occasionally with advantage.

Treatment of Urethral Catarrh.—If the characteristics of what we have called urethral catarrh are present, a little attention to the general health, fifteen drops of the syrup of iodide of iron after meals, fresh air and moderate exercise, a free diet, with an occasional glass of claret or burgundy at meals, will usually be sufficient, without local treatment, to terminate the case. Perseverance in the use of astringent injections and in the introduction of bougies will sometimes hasten a cure, but quite as often seems to retard it. These constitute the majority of those chronic urethral cases which are often reported by patients as having been cured by homœopathic treatment, the negative character of which leaves free play to that *vis medicatrix naturæ* which is really all that is needed.

Treatment of Chronic Gonorrhea.—In other cases, particularly when the attack is the first one, the discharge persists, creamy or yellowish in appearance, associated with a few mild subjective symptoms indicative of a localized inflammation, which proves to be easily aroused into a state of activity; a condition which it is convenient to designate as chronic gonorrhea. To determine this beyond question, a bulbous bougie, three or four sizes smaller than the normal caliber of the urethra, should be gently inserted into the bladder, the surgeon noting as it goes in the exact situation of any point of unusual sensitiveness, and looking for this or similar points during its withdrawal. He must not be misled by the normal sensitiveness of the prostatic urethra. He should look at the shoulder of the bulb, and observe whether it brings out any discharge, and, if so, notice its character. The urethroscope may occasionally be of use in these cases. If the symptoms and appearances which have been described as characteristic of chronic gonorrhea are present, it may be assumed that the sensitive spot corresponds to a small patch of granular urethritis to which it is necessary to apply appropriate remedies directly. For this purpose the patient should be ordered a prostatic syringe of hard rubber having a long curved nozzle with a bulbous tip. He should be instructed in what manner and to what depth to insert this instrument, and the surgeon should himself administer the first two injections. For this it is well to use about one-half fluidram of a 1 or 2 per cent. solution of nitrate of silver in distilled water, or, if this does not give rise to pain on the first injection, a still stronger solution. The discharge and pain may be increased for a short time after these injections, which

should then be followed by gradually strengthened solutions of sulpho-carbolate of zinc, tannin, sulphate of copper, or some other astringent carried to the exact spot in the same manner. If the discharge diminishes, but does not disappear, the same process may be repeated; and this will almost invariably result in permanent cure. It should never be forgotten that in certain cases the progress of the injection backward may be cut off by spasmodic contraction of some of the circular muscular fibers surrounding the urethra. This, occurring as soon as the first drops of the injection reach the locality, will effectually prevent the liquid from passing any farther, and thus from coming in contact with the surface which is the source of the discharge. In these cases the use of full-sized sounds is imperatively indicated, all other treatment being worse than useless.

Irrigation of the urethra with various medicated liquids has been recommended, and is a useful procedure in cases in which the foregoing treatment proves ineffectual. A moderate-sized, short, flexible rubber catheter—preferably a "Nélaton"—with large bevelled eyelets, should be inserted *nearly* into the bladder, and then connected with a syringe like the ordinary "Mattson" or "Davidson" syringe. A pint or more of the preferred solution, usually of one of the antiseptics or astringents above mentioned, may then be passed through the urethra without withdrawing the catheter, the lotion finding its way between the instrument and the walls of the urethra and making its exit at the meatus. In one or the other of these ways chronic gonorrhea is always curable.

Treatment of Gleet.—In a case of true gleet, with a history of several previous attacks of gonorrhea or one which has been very protracted, with dribbling after urination, etc., we should carefully examine the urethra with a bougie à boule, when we shall probably find the condition described as indicative of the presence of a submucous deposit or a "stricture of large caliber" or commencing stricture. The fact that in every normal urethra the bulb of the instrument will meet with some resistance as it passes under the posterior layer of the triangular ligament (White) seems worthy of reiteration, as failure to recognize it has been a frequent source of error in diagnosis and treatment. Another source of error, already referred to, is spasm of the muscular fibers occurring at some point along the urethra and imparting to the bougie the precise sensation felt in passing a stricture. The possible association of spasms of this character with strictures of large caliber situated anteriorly should not be forgotten. The treatment of gleet in the great majority of cases thus becomes that of the stricture upon which it depends. (See section on Stricture of the Urethra.)

Treatment of Complications.—**Balanitis** usually requires for its treatment only perfect cleanliness and the use of some desiccant sedative powder, such as opium ℈j, lycopodium ʒij, and acid. boric. ʒj. Three or four times daily this should be dusted on the inflamed surface, which should be previously washed and gently dried. Strips of dry lint inserted between the glans and foreskin, and changed whenever they become moist from the discharge, will often effect a cure.

Balano-posthitis, when accompanied by œdema of the prepuce, is best reduced by a lotion of lead-water and laudanum continuously applied. The dry dressing may be used with advantage after the swelling has subsided. Good in both cases follows from painting over the inflamed glans and the inner surface of the foreskin with a 30- or 40-grain solution of nitrate of silver.

Phimosis may be relieved by circumcision or by splitting open the foreskin along the dorsum, completing the operation at some later period; but

both of these procedures are undesirable if it is possible to avoid them. In nearly every case lead-water and laudanum externally, with subpreputial injections of soap and water, followed first by clean water, and then by lead-water and laudanum, will reduce the swelling, so that the glans may be uncovered.

Paraphimosis (Fig. 339), if seen at first while the preputial swelling is œdematous and not inflammatory in its character, should be immediately reduced.

The ordinary procedure, which usually suffices, consists in oiling the parts, locking the index fingers of the two hands above and behind the corona glandis, and the middle fingers below and beneath it, and gradually compressing the glans itself with the thumbs, emptying its congested vessels, and finally forcing it backward while the fingers bring forward the swollen foreskin. Or the body of the penis may be encircled with the thumb and index finger of one hand while with the other the glans is gradually compressed and pushed into the preputial orifice. It must be remembered that not only the glans but also a ring of swollen mucous membrane is to be returned through that orifice. When these means fail, or, indeed, in preference to them in many cases, the method of Mr. Eddowes has been most satisfactory. It consists in wrapping the glans and prepuce with a slip of wet lint two inches wide and extending a little in front of the glans, and then winding around the glans from before backward a piece of round elastic ligature. By the time the corona is reached the glans will be reduced in size, and it will be often possible to slip the end of a grooved director beneath the constricting band. Then, withdrawing the ligature rapidly, the shrivelled glans may be pushed backward and the prepuce drawn forward to its natural position. If the chief obstacle to reduction be the amount of œdema, it will be proper to evacuate the serum by several minute punctures with an exploring needle.

When the paraphimosis has been of longer duration and an effusion of plastic lymph is present, more permanent compression may be required, and in that case the glans and foreskin should be "strapped" with pieces of adhesive plaster. In twenty-four hours reduction usually becomes possible. If not, the dressing should be removed. If all these means fail, we may divide the constriction on the dorsum of the penis by inserting beneath the prepuce a flattened sharp-pointed bistoury and then turning its edge and cutting upward; or the stricture may be cut down upon from without inward, always remembering to look for it in the furrow which divides the mucous membrane from the integument, the first one behind the furrow of the cervix glandis.

Follicular Abscess often opens spontaneously into the urethra and requires no surgical interference. When the skin becomes thinned and discolored over such a swelling, it is well to incise it freely.

Peri-urethral Abscess should be evacuated more promptly—as soon, indeed, as suppuration is established, as a spontaneous opening in these cases may be followed by urinary extravasation. In their earliest stages these abscesses may sometimes be aborted by the use of sedative lotions, with absolute rest in bed, moderate elevation of the organ, and free purgation.

Lymphangitis rarely requires any special treatment. Evaporating and sedative lotions and rest will usually relieve any pain which may be associated with it.

Bubo may be aborted by the use of pressure or iodine, or, if these fail, may be poulticed and opened as in any case of glandular suppuration. It is never a serious affection.

Cowperitis requires rest, elevation of the buttocks, leeches to the

perineum, hot sitz-baths, poultices, and prompt evacuation if suppuration occur.

Prostatitis, Prostato-cystitis, and **Cystitis** must all be treated in very much the same manner. Upon the first development of the early symptoms—frequent urination, vesical tenesmus, etc.—the patient should be placed at absolute rest in the recumbent position, with the hips elevated upon a hair pillow; his diet for a few days should be limited to skimmed milk, of which he may take any desired quantity; an alkaline diuretic mixture should be freely administered; three-ounce enemata of hot water, or of hot starch-water containing a few drops of laudanum, should be given every two or three hours; six or eight ounces of blood may, with advantage, be taken by leeches from the perineum, which should afterward be covered with hot fomentations; and finally opium, combined with belladonna or hyoscyamus, in suppositories, should be used at bedtime and at intervals during the night if the calls to urinate are frequent. Bromide of lithium in five-grain doses every three hours, or citrate of caffeine in three-grain doses, may be added to the diuretic mixture if the urine remain scanty and high-colored.

All urethral injections should be immediately stopped, and the patient should be instructed to resist as long as possible the desire to urinate, and also the inclination to strain and bear down at the end of the act.

Retention of Urine.—If retention of urine should occur as an additional complication, place over the hypogastrium a large, mushy, hot hop poultice covered with oiled silk, and renew every two hours; give an enema of hot water and soapsuds. If the symptoms of retention and of distention of the bladder become serious, the urine should be drawn away with a Nélaton catheter, using the greatest possible tenderness in its insertion. It must be understood that the evils of the gentle introduction of a soft catheter, even as often as every six or eight hours, are less than those produced by the intense and almost continuous tenesmus. Of course, if a tight stricture is present and there is difficulty in introducing a soft instrument, other instruments must be tried, and occasionally external urethrotomy or perineal section may become necessary.

Prostatic Abscess.—When during an attack of acute prostatitis the patient suddenly has rigors, followed by increased fever and sweating, it is probable that suppuration has occurred in the gland. If the abscess opens into the urethra, as it usually does, no special treatment is necessary; if it points toward the rectum, however, or if, with unmistakable symptoms of suppuration, the abscess shows no disposition to point in either of these directions, it becomes necessary to evacuate it. An incision should be made in the median line until the pus-cavity is reached.

Chronic Prostatitis.—When prostatitis becomes chronic the treatment is difficult and prolonged. It may be summarized as follows: Removal of stricture, contracted meatus, phimosis, or other predisposing cause; restricted diet; avoidance of all liquors, except some form of light red wine; careful attention to the bowels, cold-water enemata once a day being often of great service; daily cool hip-baths of a temperature and duration governed by the sensations of the patient, and persisted in as long as they are followed by relief of subjective symptoms; counter-irritation to the perineum, preferably by iodine; normal exercise of the genital functions. Cauterization of the prostatic urethra is unquestionably useful in many cases, but should be employed only after the foregoing measures have failed. A few drops of a 30- or 40-grain solution of nitrate of silver should be deposited in the prostatic urethra, and the immediate effect, which is a more or less marked inflammatory action, watched

and controlled by rest and appropriate remedies. The operation may be repeated if no benefit result from the first application.

In the form of urethral discharge dependent upon **chronic follicular prostatitis,** which has been described (p. 881), attention to the following rules of treatment will give the most satisfactory results in a large proportion of cases: Limited diet, especially as regards nitrogenous articles of food; abstinence from sexual excitement, particularly if ungratified; great attention to the condition of the rectum, which should never be allowed to contain, even for a few hours, a mass of hardened inspissated feces. To avoid this, white wheat-gluten suppositories or weak glycerin suppositories used at bedtime are most satisfactory. A free application of a mixture of tincture of iodine and tincture of belladonna should be made to the perineum, and repeated night and morning until the skin becomes tender, resuming it at once when the tenderness passes away. This is better than the actual blisters recommended by Sir Henry Thompson and others, on account of the long-continued irritation which can be kept up in this manner. Careful attention should be paid to the condition of the urine. As a routine treatment a mixture of bromide and citrate of potassium, with small doses of aconite, belladonna, and ergot, will be found useful.

The prostate is so situated anatomically that congestions and inflammations once occurring in it are powerfully favored by the influence of gravitation. In nearly every position of the body it is at the lower extremity of a portion of the circulatory system which is peculiarly apt, in bipeds, to suffer from chronic congestion and vascular dilatation. Hemorrhoids are chiefly, if not exclusively, a disease of the human and anthropoid species, and prostatic hypertrophy, simply as a result of advancing years, is found almost exclusively in these species, and is possibly due to the same cause. In all ordinary postures the blood which has entered the prostate must make its exit against the attraction of gravitation. Whenever we find this mechanical condition in the body, we are apt to find also dilatation of the blood-vessels and hypertrophic tissue-change. To prevent this, and to restore both the vessels and the tissues to their normal size and caliber, there is no better remedy than the application of cold, especially in the form of a jet or stream of water. In the cases in question the persistent and thorough use of the *bidet* is of the greatest benefit (White). The patient should use it for ten or fifteen minutes at least twice daily, once after his usual evacuation of the bowels and once before going to bed. It is well at both these times to wash out the rectum with tepid or warm water, and to employ the cold jet directed against the perineum. The powerful contraction of all the muscular and vascular structures in the neighborhood is well shown in the effects of this treatment upon hemorrhoids, prolapsus ani, and similar conditions, and is participated in by the vessels and muscular structure of the prostate.

Epididymitis, at its onset, should be treated as follows: Put the patient to bed in the recumbent position; elevate the scrotum above the level of the thighs. Apply directly over the painful testicle a piece of patent lint soaked in the following lotion, with which it should be kept continually wet:

℞ Tinct. aconiti,
Tinct. opii, āā f℥j;
Liq. plumbi subacetat. dil.,
Aquæ, āā f℥ij.—M.

Shave the hair from the groin on the affected side, and take about six ounces

of blood, by means of leeches, along the line of the cord. Administer a half bottle of the effervescing citrate of magnesium, place the patient on restricted diet, stop all urethral treatment, give him a drop of tincture of aconite and five grains of bromide of potassium every two hours, or more frequently if there be any febrile reaction. Often this treatment at an early stage will prevent any further manifestations: the symptoms will subside, and in two or three days the patient may be permitted to walk around, keeping the testicle still enveloped in the lotion and well supported by a suspensory. When the swelling, either in spite of treatment or in its absence, has progressed to a considerable extent and the testicle presents a large solid mass, the pain having become dull and aching, and severe only upon motion or in walking, great relief may be obtained by the application of compression.

In *strapping a testicle* the scrotum should be shaved, the testicle drawn down as far as possible, and a strip of adhesive plaster about half an inch in width made to encircle its upper extremity, so as to retain it in that position in the form of a tense tumor, pear-shaped and purplish in color. This is then tightly covered in with successive strips of plaster, placed first circularly until the greatest circumference of the tumor is reached and they refuse to adapt themselves neatly to the surface, and then longitudinally so as to cover in the lower segment completely. The testicle may then be placed in a suspensory bandage, and in most cases the patient is able to go about with little or no pain. The dressing should be replaced every day or two, since it will loosen as the swelling disappears. An ointment of belladonna and iodoform may then be applied upon a piece of lint worn beneath the suspensory.

The induration of the epididymis which remains after all inflammatory action has disappeared is usually permanent and is not much affected by treatment. It may, however, diminish under the use of belladonna and mercurial ointment and the internal administration of iodine and a mercurial. In cases of double epididymitis followed by sterility it is well to pursue this method of treatment for a long period, as the re-establishment of the spermatic canal to ever so slight a degree is then, of course, a matter of great importance.

Gonorrheal Rheumatism is considered to be a peculiarly obstinate and intractable form of joint-trouble, and treatment is pronounced, by all authorities on the subject, to be in the highest degree unsatisfactory. It is due to infection with the gonococci; or, when it accompanies a simple urethritis, to infection with pyogenic bacteria, or often, doubtless, to a mixed infection. It is occasionally the local evidence of absorption of bacterial or chemical products and their presence in the fluids and tissues of the joints. For the symptoms and treatment see the section on the Arthritis of Infective Disease (p. 399).

For the treatment of **Gonorrheal Ophthalmia** and **Conjunctivitis**, see p. 1047.

GONORRHEA IN THE FEMALE.

Gonorrhea in the female is not so frequent, so limited in its situation, so protracted in its course, or so serious in its results as in the male. The anatomical arrangement of the genito-urinary organs in women permits gonorrheal inflammation to develop in the vulva, vagina, urethra, or uterus, which are involved with a frequency indicated by the order of mention. Vaginitis is, however, described by some writers as the most common of these varieties of gonorrhea. The uterus is insensitive, not prone to inflammatory action from external irritants, and in a position where such irritants, especially when de-

rived from sexual intercourse, are not retained in contact with it for any length of time. The delicate urethral mucous membrane is protected from frequent contamination by its sheltered position and its situation above the genital canal, fluids deposited in or flowing from the latter not necessarily coming in contact with it. The vulva and vagina are obviously much more exposed to irritating or traumatic agencies, any one of which, whether a purulent secretion from the male urethra, violence, inordinate masturbation, etc., is capable of exciting in these parts a severe inflammation.

Vulvitis.—*Causes.*—Vulvitis may be produced in any of the ways mentioned, may be secondary to a vaginitis, may be due to worms, to the secretions of mucous patches, to uncleanliness and the accumulation of sebaceous matter, to criminal violence, or to any traumatic or infective cause. It sometimes arises spontaneously in infants during dentition, and is said by Dupuytren, who cites cases in proof, occasionally to be epidemic in very young children. However caused, vulvitis begins with an itching sensation and a feeling of heat and burning, soon followed by tumefaction of the parts, which are bathed in a secretion at first muco-purulent, then thick, yellowish or greenish, acrid, and offensive. If the parts be inspected a day or two after the onset of the disease, the labia will be found red, abraded, and excoriated, and the nymphæ sometimes swollen so as almost completely to occlude the entrance to the vagina. The parts are sensitive to pressure and painful upon motion. The vulva is often surrounded by an area of congestion which extends beyond the vulvo-femoral folds and may be seen for some distance down the thigh. The passage of the urine across the inflamed surfaces gives rise to an intense burning, which may be mistaken for the ardor urinæ of urethritis, and is often quite as severe.

Complications.—*Bubo.*—The inguinal glands are apt to be enlarged and tender, and sometimes suppurate. Bubo is, however, also less common in the female than in the male, and when it does occur is almost always associated with a vulvitis or a urethritis.

Vulvo-vaginal Abscess.—In some cases inflammation follows the ducts of Bartholin's glands, and excites suppuration or abscess in these bodies, which are compound tubular glands, surrounded by a fibrous envelope, and situated one on each side of the entrance of the vagina. In acute cases there are heat, redness, and tenderness of the inflamed part; which signs, together with the peculiar pyriform swelling, serve to facilitate the recognition of the condition. In the early stages the swelling can most readily be recognized by putting a finger in the vagina and pressing outward toward the ramus of the ischium. The abscess will sometimes evacuate itself spontaneously through the duct of the gland or at the inner surface of the nymphæ, or the pus may work its way between the layers of the ischio-pubic fascia and escape just within the labium majus; but its cure can usually be hastened by a prompt and free incision made through the mucous membrane at the inner and lower aspect of the tumor. Suppuration in these glands has a peculiar tendency to recur, and accumulation of pus and the consequent swelling will often take place, after a first attack, without any marked symptoms of inflammation. Under these circumstances—particularly if pressure on the tumor does not cause the appearance of pus at the orifice of the duct—it is possible, in exceptional cases, to mistake the condition for a pudendal hernia, for a cyst, for a hydrocele of the round ligament, or for œdema of the cellular tissue of the labium or *vice versâ*.

The differential points in the diagnosis of vulvo-vaginal abscess from the first three mentioned affections may be contrasted as follows:

Chronic Vulvo-vaginal Abscess.	Pudendal Hernia.	Cyst of the Labium.	Hydrocele of the Round Ligament.
History of previous inflammation.	Sudden appearance.	Slow, painless growth.	No previous inflammation.
Swelling pyriform; base downward; greatest swelling inward.	Shape very similar, but greatest projection outward.	More distinctly circumscribed; sometimes pedunculated.	General, diffused swelling.
Fluctuation.	Doughy or elastic.	Elastic.	Doughy.
Irreducible.	Reducible by pressure near ramus of ischium.	Irreducible.	Partially reducible.
No impulse on coughing.	Distinct impulse.	No impulse.	No impulse.
Dull on percussion.	Resonant if an enterocele.	Dull.	Dull.
Most common in old prostitutes.	Seen at any age.	Seen at any age.	Seen oftenest in young persons.

Œdema of the vulva is usually symmetrical, and in nearly every case is either a result of pregnancy or parturition or of the presence of an abdominal tumor, or accompanies a vulvitis, and is then, of course, easily recognized by the inflammatory symptoms.

Vaginitis.—*Causes.*—Vaginitis has for its most frequent cause a purulent discharge from the male urethra. In other words, gonorrhea in the female is usually due to direct infection by the male. It may, however, result from violent or excessive copulation, from masturbation, from contusions, from inflamed hemorrhoids, or in various other ways. Females already affected with leucorrhea sometimes develop a vaginitis after protracted exertion. It may result from an extension upward of a vulvitis, although the reverse is met with quite as often. Children and young girls are especially subject to inflammation of the vagina, which is sometimes found as a complication of dentition or of the eruptive fevers, and sometimes as a sequel of the first approaches of the male. Vaginitis, which is apt to be of a leucorrheal character, sometimes occurs in the early stages of syphilis as a result of the extension of inflammation from mucous patches seated upon the vulva or of changes which take place in the os uteri. The neck of the uterus is frequently the seat of certain lesions in the secondary stages of syphilis which may be the medium of propagating inflammation to the vagina.

Symptoms and Complications.—Vaginitis following purulent infection usually begins at the lower and posterior aspect of the canal. It is at first attended with a feeling of weight and fulness, sometimes referred to the rectum, and with a dry, glazed, congested appearance of the mucous membrane. After the lapse of a few hours a mucoid discharge appears, rapidly becomes purulent, and, when the disease involves an increasing extent of surface, as it generally does, is very profuse, soiling the posterior portion of the patient's linen and trickling down her thighs and over her perineum unless absorbed by suitable dressings. The subjective symptoms, although not often as marked as in vulvitis, are occasionally very characteristic, and are due in the first place to the proximity of the bladder and rectum to the inflamed canal, and in the second to the nervous connections of the region, giving rise to certain reflex phenomena. Under the first of these classes may be enumerated vesical irritability and tenesmus, aching or throbbing pelvic or hypogastric pain, hemorrhoids, dysenteric symptoms, prolapsus uteri, etc.; under the latter, sciatic, crural, lumbar, and abdominal pains. Sometimes, when the inflammation has been very intense and the discharge has been retained, extensive

though superficial ulceration of the vagina occurs, the pus becomes mingled with blood, the pain is considerably increased, and the disease assumes a very obstinate and rebellious form.

Chronic Vaginitis.—In the chronic variety of vaginitis the presence of the discharge, thickening of the vaginal mucous membrane, and enlargement of its papillæ are almost the only symptoms met with. Now and then a case is seen in which the inflammation has become strictly localized, a small patch of strawberry-red granulations being found, analogous to those seen in the urethra in chronic gonorrhea, and on other mucous membranes, as the conjunctiva, when inflammation assumes this form.

Cases of chronic vaginitis in young persons are observed in which the vagina is hard and small, its rugæ well seen, yet evidently swollen, œdematous, and with either no secretion or covered over by an old, grayish-white accumulation of epithelial detritus.

Urethritis.—*Causes.*—Urethritis in the female is commonly classed as a venereal affection, and is unquestionably due in a majority of cases to extension of inflammation from the vulva or vagina, but it is unsafe to assume that any woman with a urethritis has necessarily acquired it by contagion and as a result of exposure to the discharge resulting from a similar inflammation in the male. It may be admitted, however, that the existence of a urethritis in a female is presumptive evidence of impure connection, particularly in those cases in which it exists independently of any vulvar or vaginal affection. When these regions are involved the question of original causation reverts to them, as their inflammations almost invariably precede the urethral trouble.

Symptoms.—The shortness of the female urethra, its downward inclination from the neck of the bladder to the meatus, and the comparatively small amount of mucous membrane involved prevent at the same time the formation of any large amount of discharge and the development of any extremely painful symptoms.

Ardor urinæ does exist in nearly all cases, and is sometimes quite marked, but is not comparable in severity to the same symptom as observed in the male. The proximity of the inflamed area to the neck of the bladder renders some degree of involvement of that viscus quite common, but, although urination may be much too frequent, the degree of tenesmus and the associated spasm and pain are less distressing than when cystitis occurs as a complication of male urethritis. In many cases the spontaneous emptying of the urethra by gravitation or its washing out by the stream of urine is so complete that to obtain evidence of the existence of a discharge it is necessary to insert a finger into the vaginal outlet and gently "strip" the urethra from behind forward, compressing it against the under surface of the pubic arch. This should be done some time after urination. Occasionally the meatus will be found red, pouting, or everted, and it is sometimes surrounded by a ring of vegetations.

Uterine Gonorrhea.—The form of uterine inflammation set up by gonorrhea is usually endocervicitis. In nearly every case in which the upper portion of the vagina is implicated in the disease the os uteri is bathed almost constantly during the height of the inflammation in an acrid, irritating pus. In many cases the irritation thus engendered, instead of limiting itself to the production of congestion, abrasions, superficial ulcerations, and other changes in the os, extends into the neck and sometimes into the body of the uterus, producing in each instance its characteristic symptoms.

In the former case there will be seen upon examination with a speculum a red, swollen, ulcerated os, from between the lips of which protrudes an albuminous, mucous, or muco-purulent discharge so viscid and coherent that it is

detached with difficulty. When the disease extends to the lining membrane or to the body of the uterus itself, when it advances through the Fallopian tube to the peritoneal cavity or to the ovaries, or when in other cases it extends from the submucous connective tissue of the vagina to that which lines the pelvis, it produces complications which are of extreme gravity.

A description of metritis, salpingitis, ovaritis, peritonitis, and pelvic cellulitis, when those affections result from gonorrhea, will be found in the chapter on the Diseases of the Female Genito-urinary Organs.

TREATMENT OF GONORRHEA IN WOMEN.

Treatment of Vulvitis.—The speedy cure of a case of vulvitis depends upon attention to the following points:

The patient should be placed at absolute rest, with the pelvis elevated: this is more important in this than in any other variety of gonorrhea in the female, gravitation and the friction produced by movement operating powerfully and prejudicially if the patient insists upon walking. Perfect cleanliness and dryness of the parts are essentials of success in treatment. The labia should be gently washed every two hours with a strong solution of bicarbonate of sodium, which will dissolve and remove all accumulated sebum and mucus, and will at the same time often prove to be, in itself, a very soothing application. In using this the labia should be gently separated with the thumb and fingers of one hand, while with the other a stream of the alkaline solution is squeezed out of a sponge held a short distance above. After this operation is completed a soft old linen rag should be held in contact with the vulva until all the fluid is absorbed, the parts should be dusted with a fine powder of starch and oxide of zinc or of opium and lycopodium, a piece of patent lint should be carefully interposed between the labia, and absolute quiet should be preserved until it is time to repeat the dressing. In certain cases the inflammation runs so high, and the swelling, pain, and discharge are so excessive, that these gentle measures do not suffice. It will then be necessary to purge, to employ prolonged, general hot-baths —not sitz-baths—to follow them with a lotion of opium and lead-water kept continually on the inflamed region, or to paint the entire vulva with a forty-grain solution of nitrate of silver. This last expedient may be adopted earlier, and rarely fails to produce a good effect. When the burning and throbbing are very great, and particularly if there is some constitutional disturbance, the abstraction of blood by leeches placed along the lines of the groins and on the perineum is clearly indicated. The diet during this period should be restricted, consisting chiefly of milk and farinaceous articles.

When it becomes apparent that a vulvo-vaginal gland is involved, timely local bleeding may arrest the inflammation, but if it fail to do so suppuration may be hastened by warm fomentations, cloths wrung out of hot water and laid over the affected labium being preferable to poultices. The incision should be made on the inner and lower aspect of the swelling, as in that manner it is possible to obtain the best drainage. In chronic, frequently-recurring abscesses of this region, instead of dissecting out the capsule of the gland, as has been recommended, or of putting in a seton, it will be sufficient to lay open the cavity by a free incision, and, after curetting, to pack the wound with iodoform gauze.

Treatment of Vaginitis.—Vaginitis requires the same general management as vulvitis, rest in bed, elevated buttocks, restricted diet, and attention to cleanliness being all valuable adjuvants to treatment. The confinement to bed is hardly so imperatively necessary as when the vulva is the seat of the

disease, and motion, through friction or in any other way, does not so greatly aggravate the symptoms. The patient should, however, be particularly cautioned against undue exercise and also against indulgence in sexual intercourse. In markedly inflammatory cases this will not be necessary, as the pain induced by attempts at intromission will be a sufficient preventive. In cases of acute vaginitis with profuse purulent discharge, tumefaction of the mucous membrane, etc., the routine treatment should be as follows:

The patient, being in bed with the buttocks resting upon a hair pillow or a folded sheet, the bowels having been opened with a saline laxative, should be instructed to wash out the vagina every two hours with an injection of a pint or two of soap and water, or, if that prove irritating, with an alkaline solution; to follow this with a pint of simple water; and to conclude with the use of a pint of some medicated solution, preferably at this stage one of acetate of lead.

The materials used as injections are various, but belong chiefly to the classes of astringents and antiseptics. In the great majority of cases it will be found best to use at first the acetate of lead; to follow this, as the pain subsides and the inflammation becomes less acute, with alum or the acetate or sulphate of zinc, or with sublimate solution 1 : 10,000 or 1 : 20,000, or with peroxide of hydrogen in combination with sulpho-carbolate of zinc; and, when under this treatment the pain has entirely disappeared and the discharge has become watery, to pack the vagina with tannin or to use suppositories according to circumstances. In prescribing vaginal injections for women it is always well to order the material in powder, telling the patient how much to dissolve in a given quantity of water. For use in a pint of water, for instance, she should employ of

Acetate of lead, one teaspoonful = three drams;
Acetate of zinc, two teaspoonfuls = three drams;
Sulphate of zinc, one teaspoonful = two drams;
Alum, one teaspoonful = two drams;
Tannin, four teaspoonfuls = two drams.

These should be diluted when it is found that they occasion pain.

The subsiding stage of a vaginitis will be best treated with vaginal suppositories, which may be used thrice daily, the supine position being observed for at least an hour after the introduction of each one. As examples of useful formulæ the following may be given:

℞ Ext. opii, gr. iij;
Acidi tannici, ʒj;
Ol. theobromæ, q. s.
M. et ft. suppositoria No. xij.

℞ Pulv. aluminis,
Cerat. plumbi subacet., āā ʒiij;
Ol. theobromæ, q. s.
M. et ft. suppositoria No. xij.

In ordering these the patient should be informed that they will stain her linen if the discharge is allowed to come in contact with it.

In some women with whom oily applications prove objectionable, or in those too poor to use suppositories, it will be well to pack the vagina with strips of patent lint into the meshes of which tannin or powdered alum has been rubbed.

Occasionally, when the vagina remains irritable and raw, bleeding easily, it will be well to apply to its surface very thoroughly a strong solution of nitrate of silver, 40 to 60 grains to the ounce of water. This is best done by inserting a cylindrical speculum, elevating its outer extremity, pouring into it two or three fluidrams of the silver solution, and then gently withdrawing it. As the walls of the vagina fall across the end of the tube they will be thoroughly bathed in the liquid.

At night in all cases of vaginitis it will be found convenient to employ little pledgets of absorbent cotton into which some medicated powder has been rubbed. The patient should keep, on a chair or table beside the bed, two or three of these little rolls, and on waking during the night should insert one as far as the finger will carry it, first, of course, withdrawing the previous one. Lead, zinc, and tannin may be used in this way, the first-named usually with the greatest advantage.

Treatment of Urethritis.—Urethritis in females, as a rule, runs its course very rapidly and requires but little attention. Injections may be used by the surgeon, their strength being carefully adapted to the sensibility of the mucous membrane, and the probability of their entering the bladder being remembered. The same principles of treatment hold good and the same solutions are useful as in urethritis in the male. Copaiba, cubebs, and sandal-wood oil may also be administered with advantage, acting as usual through the urine. No mention has been made of their employment in speaking of the treatment of other forms of gonorrhea in the female, as in them the anti-blennorrhagics are worse than useless. Occasionally it may be necessary, in chronic cases, to wipe out the urethra with a probe wrapped in cotton and dipped in a solution of from 20 to 40 grains of nitrate of silver, and in some instances the solid stick has been employed.

Treatment of Uterine Gonorrhea.—The affections of the uterus produced by gonorrhea require no distinctive or peculiar therapeutic management. Nitrate of silver for abrasions, leeches for congestion, tampons or suppositories applied through a speculum and retained in contact with the os by elevation of the hips, iodoform, iodine, and all the well-known articles of the gynecological armamentarium, are useful here as in other uterine affections; and the same remark applies to the other pelvic and abdominal troubles which may complicate or follow a vaginitis.

STRICTURE OF THE URETHRA.

To consider philosophically the treatment of urethral stricture we should first have a clear idea of the exact pathological conditions which are to be overcome. Definitions are rarely at the same time comprehensive and precise, but it is probably a close approximation to the truth to describe stricture as an abnormal lessening of the caliber or of the dilatability of the urethral canal, associated with changes in the mucous, muscular, or submucous structures constituting its walls. This definition includes the following chief varieties of stricture: (1) inflammatory; (2) spasmodic; (3) organic.

(1) The existence of **Inflammatory Stricture** has been denied by eminent authorities, who assert that without congestion of the prostate, spasm of the circular fibers, or pre-existent organic stricture no swelling of the mucous membrane alone is competent to give rise to retention of urine. While this is true, it cannot be disputed that occasionally in cases of acute anterior urethritis, with no suspicion of previous stricture and with the prostate unaffected, there is great diminution in the size of the stream of urine, manifestly from

the unnatural approximation of the swollen urethral walls. Although the condition is almost always of short duration and never goes on to retention, it is often the first step in the formation of organic stricture. The treatment is that appropriate to the form of urethritis in question.

(2) **Spasmodic Stricture** depends on a contraction of the muscular fibers surrounding the urethra, either the unstriped or the compressor urethræ, and is always due to some irritative cause, direct or reflex, often aided by such predisposing causes as the uric-acid or oxalic diathesis, sexual plethora or excess, etc. It sometimes depends upon and complicates organic stricture situated in advance of the seat of spasm. The immediate treatment consists in the use of a warm bath, the administration of morphia or atropia, preferably by the rectum or hypodermatically, the use of diluent drinks, and, of course, the removal of the exciting cause if it can be discovered. The retention of urine so common after operations upon the anus and rectum, as in cases where hemorrhoids have been tied, and occurring more rarely from reflex irritation from a greater distance, is the result of vesical inhibition rather than of urethral spasm.

(3) **Organic Stricture** is always the result of some antecedent injury or disease: in the vast majority of cases it is due to a previous urethritis, and is especially apt to follow those cases in which the urethral inflammation has reached an exceptionally high grade of intensity, or, still more, cases which have run a very protracted course. The pathological condition varies from an induration and thickening of the mucous membrane, with connective-tissue proliferation occurring in its depths, to the formation of a dense mass of cicatricial tissue occupying the submucous region and extending into the meshes of the corpus spongiosum. The strictured portion of the urethra varies greatly in extent, from a mere cord-like band, the so-called *linear stricture*, to one slightly broader, *annular stricture*, and from that to a contraction which may involve as much as two or three inches of the canal, converting it into a devious irregular channel. This has been called the *tortuous stricture*. Many classifications have been adopted, but this answers well for practical purposes.

The *situation* of a stricture also varies greatly, but there can be no doubt that the great majority are to be found in the bulbo-membranous region, which includes a space from about one inch in front of the anterior layer of the triangular ligament to the prostato-membranous junction. The next most frequent seat is in the first two and a half inches of the urethra, and the smallest number are found in the middle of the spongy urethra. These remarks apply to the forms of stricture produced by urethritis. Traumatic stricture usually affects the membranous urethra, and it is asserted that stricture produced by masturbation is to be found, as a rule, in the same region. As a matter of fact, however, strictures from this latter cause are exceedingly rare. This is shown by the comparative infrequency of strictures among adult males of any community as compared with the number who have at some period of their lives been addicted to the habit of masturbation, and still more forcibly by the history of persons in prisons, asylums, and hospitals for the insane, who have been known to practise the habit to excess over long periods, but in whom stricture is not unusually frequent.

If stricture is no more common in such patients than among their associates, it may safely be assumed that, at least as ordinarily practised, masturbation can only be productive of organic stricture with such rarity as to make it scarcely worth considering as an etiological factor. The dictum of Sir James Paget may still be said to express the view of the profession, namely, "that masturbation does neither more nor less harm than sexual intercourse prac-

tised with the same frequency in the same conditions of general health, age, and circumstance."

Strictures are further divided into *irritable*, when they are readily inflamed and bleed easily upon the touch of an instrument, and *resilient*, when they are elastic and contractile, returning with great rapidity to their former size after being dilated. They are also divided into those of *small caliber*, which may be arbitrarily assumed to include strictures which will admit only instruments less in circumference than 15 millimeters, and those of *large caliber*, or strictures which will take instruments from that size upward.

These preliminary remarks are necessary to a consideration of the proper method of treating strictures, as is also some inquiry into the functional importance of strictures of large caliber. That every urethral coarctation following urethritis must at some time have been a stricture of large caliber is self-evident, but just when such a stricture becomes an active pathological factor and is able to give rise to symptoms is an unsettled point. Indeed, it is not probable that it ever can be definitely determined in a mathematical sense. The idea that any particular fixed caliber represents the normal condition of the urethra has for a long time been abandoned, the observed variations of that canal being such that no special dimensions can be assigned to it as representing the precise dividing-line between health and disease. The old method of regarding the size of the meatus as an indication of the normal caliber of the canal behind it is also unquestionably fallacious, it having been conclusively shown that no more definite relation exists between them than between any other mucous canal and its corresponding outlet, the mouth and the œsophagus, for example, or the anus and the sigmoid flexure. That there is a certain correspondence between the size of the urethra and that of the flaccid penis is true, the caliber of the one increasing with the circumference of the other, but that this ratio is present in any absolutely unvarying manner has not yet been demonstrated. At most, the size of the penis may be said to furnish a general indication of the urethral dimensions, but one which is approximate merely. On the other hand, it has been shown that there are usually certain normal variations even in the spongy portion, and that it is often impossible with any of the means at our command to distinguish between these natural irregularities and coarctations of equal caliber due to incipient stricture.

Those surgeons who follow the teachings of Dr. Otis of New York, whose valuable work has added greatly to our knowledge of the subject in question, accept his scale of the relation of the caliber of the urethra to the circumference of the flaccid penis, any interference with which they regard as evidence of the existence of stricture. The figures which Dr. Otis gives, while they doubtless represent accurately the distensibility of the male urethra, do not by any means represent what can fairly be called its normal caliber, and fail altogether to recognize the fact that there are points of physiological narrowing, notably along the course of the pendulous urethra, where some of his disciples find the greatest number of contractions. Sir Everard Home, De Camp, Reybard, and others long ago demonstrated the variations in size and dilatability of the different portions of the urethra, and Civiale observed that in the middle of the spongy urethra there is a notable diminution of elasticity. Weir and Sands of New York confirmed by casts of the urethra these older observations, and there can now be no doubt of the existence of such physiological points of constriction or of diminished distensibility. Otis in effect assumes that the urethra should be a tube of uniform caliber, at least anterior to the triangular ligament. The ingenious instrument which he has devised, the urethrometer,

when used under the guidance of Otis's table, will detect apparent strictures in the majority of normal urethras, and should be employed only in exceptional cases.

The most valuable urethral instruments for the purpose of diagnosis are the so-called "bougies à boule." They may be made of metal, with slender stems, having small expanded ends or handles, upon which the number of the instrument may be marked, the opposite end being tipped with an acorn-shaped bulb: this should represent in millimeters the circumference of the shoulder of the bulb. More satisfactory instruments are the flexible gum bougies *à boule*. The base of the acorn-shaped bulb should join the shaft at almost a right angle, and not at the large obtuse angle often found in improperly-shaped instruments. The size selected for exploration should be determined approximately in the manner already mentioned by noting the circumference of the flaccid penis. A scale which differs from that published by Dr. Otis in giving a lower grade of numbers is as follows:

A penis 3 inches in circumference at the middle of the spongy portion indicates a urethra which should normally admit an instrument of about 26 to 28 millimeters in size; when it is $3\frac{1}{4}$ inches, the urethra should have a caliber of from 28 to 30 mm.; $3\frac{1}{2}$ inches, 30 to 32 mm.; $3\frac{3}{4}$ inches, 32 to 34 mm.; 4 inches, 34 to 36 mm.; beyond which size it is seldom necessary to go (White).

If the meatus be too small to admit of the introduction of a bulbous bougie of the required size, it should be enlarged by incision. The penis should then be grasped just behind the corona and held gently between the thumb and first finger of the left hand, the foreskin, if redundant, having been retracted The dorsum of the penis should face the abdominal wall. The bougie, well oiled, should then be passed gently into the bladder. If arrested, the point on the shaft corresponding to the meatus should be marked, the distance from that to the bulb representing the position of the anterior face of the stricture. If that instrument or a smaller size passes through, it should then, after a moment's delay, be withdrawn, and if during its outward passage any contraction is found other than at the triangular ligament (which has been shown to be normal), it is probably due to stricture, though spasm, which often relaxes after a few seconds or shifts its position in the canal as measured from the meatus, may give rise to errors in diagnosis. It cannot always be recognized with certainty.

By this smaller scale the probability of mistaking physiological narrowing for stricture is greatly diminished, and cases which present definite symptoms, such as gleety discharge, frequent urination, dribbling at the end of micturition, etc., and in which such an examination discloses a distinct contraction, may with propriety be considered as cases of organic stricture. This is not unduly conservative, but represents fairly the views of the majority of modern surgeons, including many of those who, from special study and experience, have the right to speak with authority on the subject of genito-urinary diseases.

We may now consider the **treatment** appropriate to the different varieties of organic stricture.

(1) **Strictures of Large Caliber,** that is, of more than No. 15 (French), **situated at or behind the bulbo-membranous junction.**

The stricture having been located and measured by the bulbous bougie in the manner above described, a conical steel sound a few sizes larger than the bulb which has passed the stricture should be sterilized by heat or by a carbolic lotion, or at least thoroughly polished by friction with a clean towel, and, after having been warmed to the temperature of the body and oiled with 1 : 40

carbolized oil, should be carefully introduced through the stricture. If the instrument is used with ordinary care and gentleness and has been properly sterilized, and if in passing it through the deep urethra the fingers of the left hand of the surgeon are used as a fulcrum in the perineum, and the long end of the lever is depressed with slowness, while the conical point representing the short end is made to follow accurately the subpubic curve of the urethra, the production of prostatitis, epididymitis, or urethral fever, the three most common complications of rough or clumsy instrumentation, will occur with extreme rarity. In the majority of cases these complications are due to the use of force in the introduction of the bougie (when it practically becomes a divulsor, and is very objectionable) or to a slovenly disregard of antiseptic details in the use of urethral instruments.

Sometimes a few drops of blood will follow the withdrawal of the instrument. Usually the next act of urination will be slightly painful, and often the gleety discharge which has caused the patient to seek treatment will increase for a day or two. The use of an instrument in this manner is always followed by a slight and transitory hyperemia of the region about the stricture, during which condition in many cases, particularly recent ones, appreciable softening and absorption of stricture-tissue occur. This period lasts for from three to four days, and only when it begins to subside should the instrument be reintroduced. Ordinarily, an advance of one or two numbers of the French scale may be made each time, but occasionally the same instrument must be introduced at several sittings before it can be exchanged for a larger one. This should be determined by the degree of resistance experienced during its introduction, the pain which it excites at the time and subsequently, and the presence or absence of bleeding. Personal experience soon becomes the safest guide as to the degree to which dilatation may be carried at any particular sitting. The feelings of the patient should always be consulted. When the full size has been reached (following the table given above as an approximate guide), the symptoms will usually disappear, and after this it is necessary only to carry on the dilatation at longer and longer intervals to maintain the cure. Most surgeons have no difficulty in teaching patients of average intelligence to use such an instrument for themselves, and the great majority of patients do so without the least discomfort or inconvenience. A certain proportion of cases under this plan of treatment will get entirely well, so that years afterward no trace of stricture can be discovered. Others, if the intervals between the introduction of the sound are too long, will have slight recontraction, shown possibly by a recurrent gleet; but the rule is that with ordinary care a practical cure is attained by this method in the great majority of cases. Its advantages are obvious, and have for many years held for it the first place in the estimation of those surgeons whose aim is to effect a cure, or at least to cause the disappearance of all symptoms, while they at the same time minimize the danger and inconvenience to the patient, who even in those cases in which an entire cure is not brought about remains by this method master of the situation.

In contrast to this are presented the claims of internal urethrotomy, the merits of which are somewhat extravagantly vaunted by its advocates, while its undoubted dangers are sometimes ignored. We do not by this mean the danger to life itself, although that exists in a definite percentage of cases, but rather the curvation of the penis, the excessive hemorrhage, the defective expulsive power causing dribbling after urination, etc., which not infrequently follow extensive urethrotomy.

It must be remembered that no special advantage is claimed for this opera-

tion unless it is extensive, the figures of Otis being usually adopted by the practitioners who habitually employ dilatating urethrotomy in stricture of large caliber. We are justified in saying that as applied to the class of strictures under consideration (those of the deep urethra) the operation is not believed by the profession nor by the majority of those having special experience in genito-urinary disease to be either safe or curative.

(2) **Strictures of Large Caliber occupying the Pendulous Urethra.**—In this region all the risks of cutting operations are much reduced, and, if scrupulous attention to antiseptic details be observed, need scarcely be considered. The probability of permanent cure seems also to be correspondingly increased. These statements are borne out by the experience of many independent and unprejudiced observers, and the greatest differences of opinion which exist at present as regards these strictures have reference rather to their diagnosis, the frequency of their occurrence, and their pathological importance than to their treatment. The physiological variations in the caliber of the normal spongy urethra are considerable; and this fact, taken in conjunction with the excessive estimate of what constitutes normality, serves to explain the extraordinary number of strictures found in this region and operated upon by a few practitioners.

As to the diagnosis of strictures of large caliber, even the bougie à boule may be misleading if used in the deep urethra, on account of the normal points of obstruction both to its introduction and to its withdrawal which are there met with, while the urethrameter is similarly misleading in the pendulous urethra, especially if its revelations are interpreted according to an unnecessarily large standard. In the latter region the normal variations account satisfactorily for a certain proportion of the statements of a few writers on this subject who find an extraordinary number of strictures in this region. In the deep urethra it has been necessary for them to account for their frequent discovery of strictures, even in cases without antecedent history of venereal disease, by constituting masturbation an active etiological factor. Some years ago it was demonstrated that the "deep-seated stricture usually of large caliber found at the subpubic curvature and its vicinity," and described as "an essential lesion of masturbation," was in reality the point of normal resistance to the withdrawal of bulbous bougies offered by the posterior layer of the triangular ligament (White).

The prostatic urethra being at once more movable and more dilatable than the membranous portion, the bulb slips smoothly along it until the point is reached at which this layer of fascia closely embraces the posterior part of the membranous urethra and the outer surface of the prostate. Here, for obvious reasons, it is arrested, and it is at this moment that the deceptive sensation which may be considered indicative of the existence of organic stricture is communicated to the hand. A series of observations and dissections upon the cadaver have established this view, and eliminated the possibility of the resistance being due to a spasm of the compressor urethræ muscle, which surrounds the canal at this point. Arrest of the instrument occurs as invariably after death as before. Avoiding these errors, then, and accepting the lower scale which has been given, the existence of strictures in the region under consideration may be determined in the usual way.

As to **treatment,** internal urethrotomy is to be preferred when a stricture of the pendulous urethra is of long standing, distinctly fibrous in character, or non-dilatable. Resiliency or resistance to dilatation is indeed the chief indication for a cutting operation on strictures at any portion of the urethral tract, and is far more important in determining the choice of treatment than their

caliber, but internal urethrotomy in the pendulous urethra is particularly satisfactory on account of the comparative freedom from danger which has already been mentioned. As to the probability of effecting thereby a permanent cure, while, as has been said, it is much greater here than elsewhere, such a cure can be expected in only a limited proportion of cases. It is not in accord with other pathological observations to suppose that the mere division of a dense and old contractile band of fibrous tissue will result in its absorption; and the majority of the true strictures of the spongy urethra which are cured by internal urethrotomy are those in which the division of the stricture is supplemented by the use for some time of full-sized bougies. The relief of tension afforded by the section of the stricture gives full play to "inflammatory atrophic dilatation," and in a certain proportion of cases retrograde metamorphosis and absorption take place or at least a thinning and weakening of the fibrous band, which results in its practical disappearance as a cause of obstruction. It is probable, however, on both clinical and pathological grounds, that the great majority of so-called strictures of the pendulous urethra which are cut by the extremists in urethrotomy are merely points of physiological narrowing, and the so-called "cures" are merely illustrations of the fact that by a linear incision into its long axis we can put in the normal urethra a longitudinal splice of fairly healthy tissue which has but little tendency to contract afterward, and can thus more or less permanently enlarge the urethral caliber. This fact also explains the freedom from fatal results claimed by some surgeons who find strictures and do urethrotomies in the great majority of their cases of chronic urethral discharge. As there has been no real interference with the genito-urinary functions, there has been no development of renal or vesical disease, and the urethra can be operated upon and the "splice" introduced with comparative impunity. It is difficult to see, however, how such a splice would prevent the steady contraction of a mass of old cicatricial tissue, such as occupies the wall of the canal and the peri-urethral space in strictures of some standing.

The proportion of cases in which true strictures of large caliber in the pendulous urethra require internal urethrotomy varies largely with the character of the patients among whom the surgeon practises. In hospital and dispensary services, and among the poorer classes generally, strictures quite frequently will be found to have been neglected, and almost always will be of long standing before the patient presents himself for treatment, even if they are not of small caliber. They will, therefore, require urethrotomy in a much larger percentage of cases than will be found among private patients of good social position. Among the latter perhaps not more than one in eight or ten needs such operative measures, gradual dilatation, as above described, amply sufficing in the remainder to cause the disappearance of all symptoms, and sometimes of the stricture itself when it is soft and of recent formation. Indeed, even in older cases a notable amount of absorption of the indurated band constituting the stricture can often be observed, and its diminution from day to day can be verified by the touch when the urethra is stretched over a full-sized sound.

The exact time at which a urethral coarctation becomes of definite pathological importance is, as has been said, still unsettled; but that strictures of large caliber are occasionally the cause, not only of gleet, frequent micturition, dribbling, and other urinary symptoms, but also of reflex pains and of impotence and other forms of sexual disorders, is certainly true.

The increased friction and resistance resulting from even a slight fibrous peri-urethral deposit disturb the normal relations of the bladder, and by

rendering it irritable bring on the symptom of frequent micturition. The imperfect closure of the tube, the muscular action of which at the point of deposit is materially interfered with, causes the equally imperfect expulsion of the last drops of urine and produces another characteristic symptom, dribbling at the end of micturition; the retention and decomposition of these last drops, together with the abnormal friction between the stream of urine and the urethral walls, give rise to a subacute inflammation of the mucous membrane, accompanied by a catarrhal or muco-purulent discharge, constituting the condition of gleet; by reflex irritation transmitted from the area of inflammation pains in remote organs and situations are developed, notably in the lumbar and hypogastric regions.

This relation of cause and effect has been in the main accepted as correct by the profession for many years. The differences of opinion which now exist are chiefly as to the amount of urethral contraction which is sufficient to produce noticeable effects; and here the evidence must rest upon clinical observations supported by the results of autopsies.

(3) **Strictures of the Meatus and of the Neighborhood of the Fossa Navicularis.**—In this region dilatation is peculiarly unsatisfactory. Owing to the intimate relation between the spongy tissue of the glans and the urethra, to the exceptionally rich nerve-supply to the part, and to the extreme sensibility characteristic of muco-cutaneous outlets, the stretching of the stricture by means of sounds gives rise to pain, irritation, and inflammation. For these reasons, and on account of the absolute safety of the procedure, it is better to divide all such strictures than to attempt to dilate them. But while the cutting of true strictures in the anterior urethra is good surgery, the division of every narrower point at the meatus and in the first few inches, simply because those points are (as they should be normally) of smaller caliber than other points in the canal, is routine surgery of a very unprofitable sort.

The operation of *meatotomy* is best done with a probe-pointed tenotome with the usual convex cutting edge. The incision should be made upon the floor of the urethra, and should be sufficient to remove entirely all sense of resistance upon the withdrawal of a full-sized bulbous bougie. It should be a little larger than the caliber which it is desired to establish permanently, so as to allow for subsequent contraction. Like all other operations upon the urethra, it should be done with scrupulous attention to antiseptic details. A short, straight, conical bougie, the so-called meatus sound, should be gently inserted once in twenty-four hours during the healing process. Deeper troubles, unless urgent in their character, should be ignored until healing is complete. Sometimes, but much more rarely than is generally supposed, such troubles, although previously thought to be organic, will be found to have disappeared. In those cases they have probably been due to reflex irritation, but this condition never occurs except in conjunction with a pinhole meatus or with a distinctly strictured condition of the urethra in its vicinity. The production of deep urethral spasm as a result of the so-called anterior stricture of large caliber, either at the meatus or elsewhere, is open to grave doubt.

(4) **Strictures of Small Caliber** (less than 15 French) **situated in advance of the bulbo-membranous junction.**—Strictures of this caliber in this region, unless seen very early and found to be unusually soft and dilatable, furnish the typical condition for internal urethrotomy, that in which it is attended with the minimum of danger and with the greatest prospect of effecting a permanent cure. The operation may be performed with the instrument which the surgeon happens to prefer, the essentials to success being a linear division in the roof of the urethra of every portion of strictured tissue, the

incision extending from the normal parts behind to the normal parts in front of the stricture. If the contraction is of very small caliber, a Maisonneuve urethrotome may be passed through it over a filiform guide, and a preliminary urethrotomy done, so that one of the various forms of dilating urethrotomes may be passed through it and the stricture freely divided from behind forward. A bougie à boule should then be used to demonstrate the complete division of the stricture, a large-sized gum catheter passed and tied in the bladder, and bleeding controlled, if necessary, by the application of a firm bandage. The moderate risk attending this operation is reduced to its smallest proportion by the employment of sterilized instruments; the use of urethral irrigation before, and, if necessary, after, the operation; the administration of internal remedies which tend to sterilize the urine; and attention to the various details of antisepsis as applied to genito-urinary surgery.

A few days after the operation a full-sized bougie should be gently passed, and should be used afterward, as in cases of dilatation, for some weeks. Often it will be necessary to pass it at intervals for a much longer period. In a fair proportion of cases an apparent cure follows.

(5) **Strictures of Small Caliber** (less than 15 French) **situated at or deeper than the bulbo-membranous junction.**—The diagnosis of these strictures, which are surgically most important, can be made either by means of a bulbous bougie, if it is possible to pass one through them, or by introducing a sterilized sound, well warmed and oiled, down to the anterior face of the contraction. They will usually be accompanied by gleet and marked vesical symptoms, increasing in severity with the tightness of the stricture. The choice of treatment lies between dilatation and some form of urethrotomy. Divulsion is so clumsy, so uncertain, and so dangerous as to have to-day almost no advocates, and to enter into argument against it would be therefore a waste of time.

In beginning the treatment of such a stricture as we are considering we should attempt, first, with great gentleness, to pass through it a steel sound, provided its introduction requires no force whatever. Below 8 or 10 of the French scale we should not go, as a rule, in the use of metal instruments, as in the most skilful and experienced hands there is a distinct and unavoidable danger of laceration of the inflamed and degenerated mucous membrane around the strictured region, and of the formation of a "false passage"—*i. e.* of perforation of the urethral wall. If a sound of whatever size is passed through the stricture, it should be allowed to remain for from five to ten minutes and then withdrawn. If it is the first experience with the patient, it is best to avoid further instrumentation for from twenty-four to seventy-two hours, in the mean time administering five-grain doses of salol or boric acid four times daily, with a full dose of quinine night and morning. At the next sitting it is often well to recommence with the same instrument, after which one, two, or three larger sizes may be used in succession if their introduction is easy and is not accompanied by pain or followed by bleeding. Pain and hemorrhage are unmistakable indications for lengthening the intervals and for proceeding with greater slowness in the use of larger instruments.

Once fairly established, however, the treatment by dilatation is carried on as described above, the full normal caliber being usually reached in two or three weeks. If the stricture is not resilient or irritable or traumatic in its origin, it will be found that all symptoms have disappeared, unless, perhaps, the gleet persists for a time, but this, too, will finally subside. If the stricture be a recent one, it also may undergo absorption, but in any event the occasional introduction by the patient of a steel sound will always keep the case under control.

In the case of resilient, irritable, or traumatic stricture in this region, or of stricture which for any reason, as the occurrence of rigors, is non-dilatable, external perineal urethrotomy is the operation of choice.

(6) **Strictures of the Deep Urethra permeable only to Filiform Bougies.**—In certain cases no steel sound and no ordinary soft instrument can be made to pass the stricture, but a persevering trial with filiform bougies made of whalebone will result in the passage of one into the bladder. This trial should be made persistently and patiently, and in the absence of retention of urine may be repeated on successive occasions. At the first sitting, if a filiform having been passed down to the stricture refuses to enter it, it should be withdrawn and bent to an angle of 45° by bending it across the thumb-nail from one-quarter to one-third of an inch from the end (Fig. 336). The orifice of a tight stricture is frequently not in the middle of the obstructed urethra, but is to be found at some point around its circumference; and the little manœuver above described will often enable the surgeon to enter it when with a perfectly straight filiform he cannot do so. If this does not succeed, several filiforms should be passed by the side of the first one, so as to impinge upon the irregular anterior face of the stricture at a number of points. By attempting to pass first one and then another of these, the instrument bearing the right relation to the orifice will often be found and passed into the bladder. If this fails, or if one filiform can merely be engaged in the stricture, but cannot be made to pass through it, it is proper, in the absence of retention, to tie it in place and allow it to remain *in situ* for twenty-four hours. In the great majority of cases at the end of that time it can be passed with comparative ease into the bladder. There is no objection to still longer delay or to repeated trials if no urgent symptoms be present.

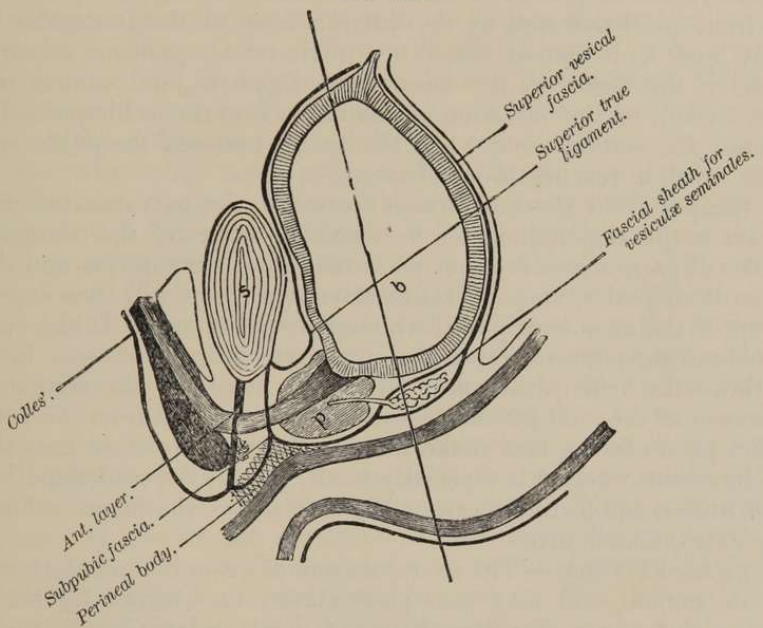
After the first instrument is introduced in such a case, four courses are open to the surgeon: (1) He may allow it to remain in place, with the certainty that in one or two days others may be slipped alongside of it, and may be used as guides for the introduction, first, of a tunnelled catheter, and later of the ordinary soft or steel bougies; (2) he may attempt to conduct a tunnelled catheter over it into the bladder at once, to be followed by gradual dilatation; (3) he may conduct over it a tunnelled and grooved staff and proceed to the performance of external perineal urethrotomy; (4) he may use it as a guide for a Maisonneuve urethrotome, and may immediately perform internal urethrotomy.

These procedures have been mentioned in the order of preference and of safety. If the stricture which is being dealt with is not of traumatic origin and is not known to be specially resilient or irritable, the first method will lead up to the adoption of gradual dilatation, with the greatest degree of comfort and absence of anxiety to both patient and surgeon. Even if there has been moderate retention, it is absolutely certain that the urine will pass with increasing freedom by the side of the filiform, and that the danger of the case, so far as retention is concerned, is at an end. If retention has been complete for a long time and is threatening, and the need for immediate relief is marked, it is well to adopt the second method and endeavor to catheterize at once. Failing in this, the third procedure should be employed in all cases of urgency and in all cases of traumatic, resilient, or irritable stricture, as well as in cases in which there is a history of frequent rigors after instrumentation. The operation is simple, is easily performed, and has a very small mortality. If the median line of the perineum be rigidly followed, hemorrhage is insignificant, and in no event is likely to be dangerous. The stricture is freely divided, and, although not frequently cured, may be left, as in a successful dilatation,

entirely under the control of the patient and the surgeon, the urethra having been restored to its full caliber. The fourth procedure should be employed only in those cases in which the patient refuses to have the external operation performed. It is attended in the best hands with a distinctly larger mortality than any of the other methods mentioned, and there is no reliable evidence that it is followed by any larger percentage of permanent cures.

(7) **Impassable Strictures of the Deep Urethra.**—If the methods of procedure which have been described are adopted, very few strictures will fall into this class, but occasionally, in spite of the most persistent efforts, no instrument can be made to enter the bladder. Sometimes the distended and chronically inflamed urethra behind such strictures will have given way and permitted the leakage of a greater or less quantity of urine into the surround-

FIG. 340.



The Fascia of the Urethra, Prostate, and Bladder: *r*, rectum; *s*, symphysis pubis; *b*, bladder; *p*, prostate (Macalister).

ing structures. In either of these events the operation of perineal section becomes imperatively necessary.

There has always been more or less confusion in the nomenclature of the perineal operation for the relief of strictures. The old "*boutonnière operation*" of Desault (of which the so-called "Cock's operation" is a modification) had for its object the establishment of an opening from the perineum into the bladder, was usually effected by opening the urethra behind the obstruction, was purely palliative, and, if it ever resulted in a cure, did it by accident, as the procedure itself did not include of necessity any division or enlargement of the strictured portion of the canal. It was an "external urethrotomy," to be sure, but it was not related either in its purpose or in its method to the other operations known by that name. Since Syme revived and popularized the operation of *external urethrotomy*—the division of a stricture upon a grooved staff passed through it into the bladder—more system has been introduced into the terms employed, but there is still much objectionable looseness. Hunter, Grainger, C. Bell, and others had, before Syme's

time, formulated the operation known as "*perineal section*," which was also an external urethrotomy, but which was then restricted to those cases in which no instrument whatever could be made to pass the stricture. The term should still be reserved for such cases, and on account of its brevity is, perhaps, preferable to its synonym, "external perineal urethrotomy without a guide."

As to the **symptoms of extravasation** which indicate the immediate performance of this operation, the urethra may be divided into four regions. In all that part from the meatus to the scrotal curve extravasation is accompanied by a swelling of the penis, greatest in the immediate neighborhood of the point of escape. In the region included between the attachment of the scrotum and the anterior part of the bulb, the course of extravasated urine is governed by the attachments of the deep layer of the superficial fascia or the fascia of Colles. Extravasation of urine occurring through a solution of continuity in the bulbous region of the urethra will first follow the space enclosed by this fascia in front and below and by the anterior layer of the triangular ligament posteriorly, and, as it cannot reach the ischio-rectal space on account of the attachment of the fascia to the base of the ligament, and cannot reach the thighs on account of the insertion of the fascia into the ischio-pubic line, it is directed into the scrotal tissues, and thence up between the pubic spine and symphysis until it reaches the abdomen.

If it escapes from the membranous urethra, the extravasated urine will be confined to the region included between the layers of the triangular ligament, and will gain access to other parts only after suppuration and sloughing have given it an outlet, and the consecutive symptoms will then depend upon the portion of the aponeurotic wall which first gives way. If the opening is situated behind the posterior layer of the triangular ligament—*i. e.* in the prostatic urethra—the urine either may follow the course of the rectum, making its appearance in the anal perineum, or, as it is separated from the pelvis only by the thin pelvic fascia, may make its way through the latter near the pubo-prostatic ligament, where it is especially weak, and may spread rapidly through the subperitoneal connective tissue. Fig. 340 shows the fasciæ influential in directing extravasated urine.

Urethral Fistulæ.—The extravasation of urine behind a stricture may be small in amount and may take place almost unobserved by the patient. At first a mere leakage of a drop or two of urine, it later causes suppuration in the peri-urethral tissues, and there results an abscess, which, if it breaks externally, causes, according to its location, a *urethro-penile*, *urethro-perineal*, or *urethro-rectal* fistula. Other causes may operate to produce these conditions, but stricture is by far the most common. The diagnosis is usually easily made by observation of the exit of urine through the abnormal channel, and by careful probing from without inward through the fistula while a steel sound is in the urethra. The *treatment* when the stricture is possible consists, first, in restoring the normal caliber of the urethra, and then curetting or laying open the fistulous tract; after which the urine should be drawn either by means of a retained catheter or by regular catheterization.

Perineal Section.—In the presence of retention or extravasation of urine in a case of stricture in which catheterization is impossible there can be no doubt as to the proper procedure. Immediate perineal section is so evidently the only operation which meets all the indications that no other can be seriously considered. The steps of the procedure are obvious and beyond dispute, except as to a few points which may be mentioned.

In all cases in which perineal section is performed for stricture impassable, but without other complications, the method of Mr. Wheelhouse of

Leeds seems to meet every indication. The passage of the staff to the stricture shows the exact site of the latter; the insertion of the threads into the divided urethra not only serves to hold it open and give an opportunity for the discovery of the proximal portion, but also fixes the anterior end and renders it easily recognizable during the operation. The least useful direction which Mr. Wheelhouse gives is that of turning the staff with the concavity of the curve upward, so as to hook it into the upper portion of the urethral wound. The instrument is sometimes in the way, has to be held by an assistant, and does not afford much help during the operation.

If persevering search fails to reveal the proximal end of the urethra in cases of traumatic stricture with practical obliteration of the canal, are suprapubic cystotomy and retrograde catheterization justifiable? This may be answered affirmatively, though such failure should be very exceptional. If the bladder contains urine, and particularly if it is distended, pressure on the hypogastrium, or bimanual pressure with the fingers of one hand on the abdomen and of the other in the rectum, will often cause a jet of urine to issue from the proximal end, and thus at once disclose its situation. Hemostasis in the whole wound by very hot water will sometimes reveal the urethra by emphasizing the difference between its color and the surrounding parts, the urethra generally being much paler. The relation to the pubes and to the lower edge of the triangular ligament should be most carefully borne in mind, the search for the torn end in ruptures or for the portion behind the stricture in those cases being frequently carried too near the pubes. The membranous urethra in the adult usually runs through the ligament about one inch below the symphysis and about three-quarters of an inch above the perineal center. All guides, however, fail occasionally in certain of these cases, and it is then that suprapubic cystotomy is warranted, as an operation with so small a mortality that the slight additional risk is far outweighed by the advantages to the patient of having even an imperfect restoration of the urethral canal.

Much difference of opinion exists as to the value of a retained catheter after perineal operations opening the urinary tract. Many authorities advise that in cases of section for stricture no instrument be employed, or that, at most, a short perineal drainage-tube be used. Others direct that it be kept in for forty-eight hours and then withdrawn. The retained catheter is, however, of great value in all operations connecting the bladder with the surface of the body, not excepting certain cases of lithotomy with purulent cystitis. If Spence's caution is observed and it is not allowed to project far into the bladder, and if it is kept clean and sweet by regular antiseptic injections, it is of the utmost advantage in aiding in the prevention of urethral fever, as has been shown by Keyes, Harrison, Diday, Shield, Davies, Hill, White, and many others. Of equal importance is regular catheterization at short intervals, begun after the removal of the catheter first introduced. A decided febrile movement after urethral operations will often disappear or reappear in accord with the employment or the neglect of the catheter. The traumatic urethritis to which the retained catheter or the frequent use of the instrument is said to give rise will almost disappear from one's practice if antiseptic irrigation is employed in such cases, and particularly if especial attention is paid to the sterilization of the urine by the internal administration of antiseptics. The sterilization of urine by boric acid or by salol is of great importance in the after-treatment of all these cases, and should never be omitted. These remedies are more effective if combined with full doses of quinine, but either of them is far more useful than quinine alone. They should be given with more freedom and more regularity in urethral and vesical operations.

The conclusions as to the treatment of organic strictures of the urethra may be summed up as follows:

1. Strictures of large caliber—that is, more than 15 French—situated at or behind the bulbo-membranous urethra are to be treated, almost without exception, by gradual dilatation.

2. Strictures of large caliber occupying the pendulous urethra are to be treated by gradual dilatation when very recent and soft, and by internal urethrotomy when of longer standing, distinctly fibrous in character, or non-dilatable. It is to be remembered that the great majority of so-called strictures of large caliber of the pendulous urethra are merely points of physiological narrowing.

3. Strictures of the meatus and of the neighborhood of the fossa navicularis should be divided upon the floor of the urethra whenever it is evident that they are real pathological conditions producing definite symptoms, and not normal points of narrowing.

4. Strictures of small caliber (less than 15 French) situated in advance of the bulbo-membranous junction, unless seen very early and found to be unusually soft and dilatable, furnish the typical condition for internal urethrotomy, which should be done preferably with a dilating urethrotome, and invariably with all possible antiseptic precautions.

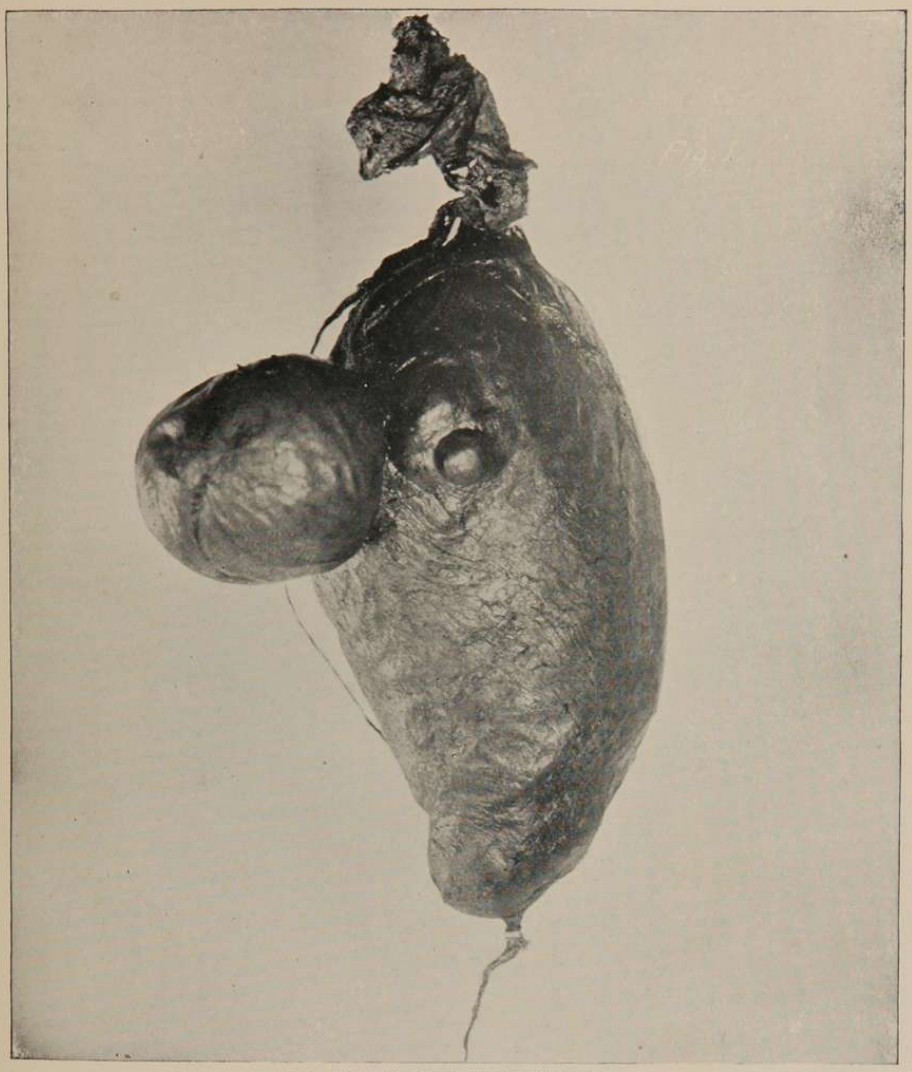
5. Strictures of small caliber (less than 15 French) situated at, or deeper than, the bulbo-membranous junction should be treated whenever possible by gradual dilatation. In a case of resilient, irritable, or traumatic stricture in this region, or of stricture which, for any reason (as the occurrence of rigors), is non-dilatable, external perineal urethrotomy is the operation of choice.

6. Strictures of the deep urethra permeable only to filiform bougies should be treated by gradual dilatation when possible, the filiform being left *in situ* for some time, and followed by the introduction of others or used as a guide for a tunnelled catheter. If the stricture be not suitable for dilatation, external perineal urethrotomy should be performed.

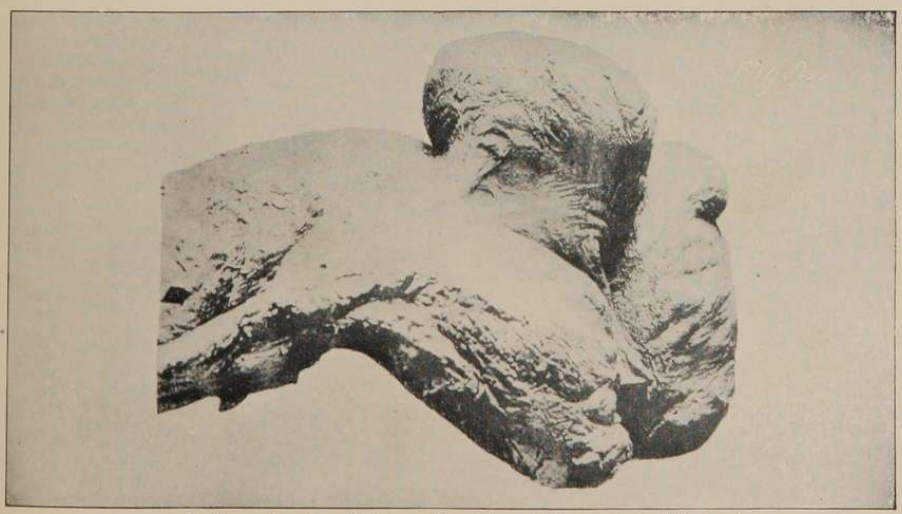
7. Impassable strictures of the deep urethra always require the performance of perineal section.

PART IV.—DISEASES OF THE PROSTATE GLAND.

Anatomy.—The prostate, which both in structure and in function is rather a muscle than a gland, is situated at the neck of the bladder and around the first inch of the urethra. It is composed chiefly of unstriped muscular fibers, the inner or circular layer of which is continuous in front with those surrounding the membranous urethra, and behind with the muscular coat of the bladder. An outer layer beneath the fibrous capsule forms a sheath for the gland, while between them the glandular structure is imbedded. This is composed of a number of follicles lined with columnar epithelium and emptying by from fifteen to twenty excretory ducts in the floor of the prostatic portion of the urethra. It is divided into two lateral lobes by a deep notch behind and by a furrow at the upper and lower surfaces. The so-called middle or third lobe is the portion which is between the two lateral lobes at the under and posterior part of the gland just beneath the neck of the bladder. The urethra usually passes through the gland at about the junction of its upper and middle thirds. The ejaculatory ducts traverse it. Its chief function is genital and ejaculatory. It contracts at the beginning of the sexual orgasm, after the semen has distended the prostatic sinus, and forces it out in jets or spurts. It is supported and held in position by the posterior layer of the triangular ligament, the deep



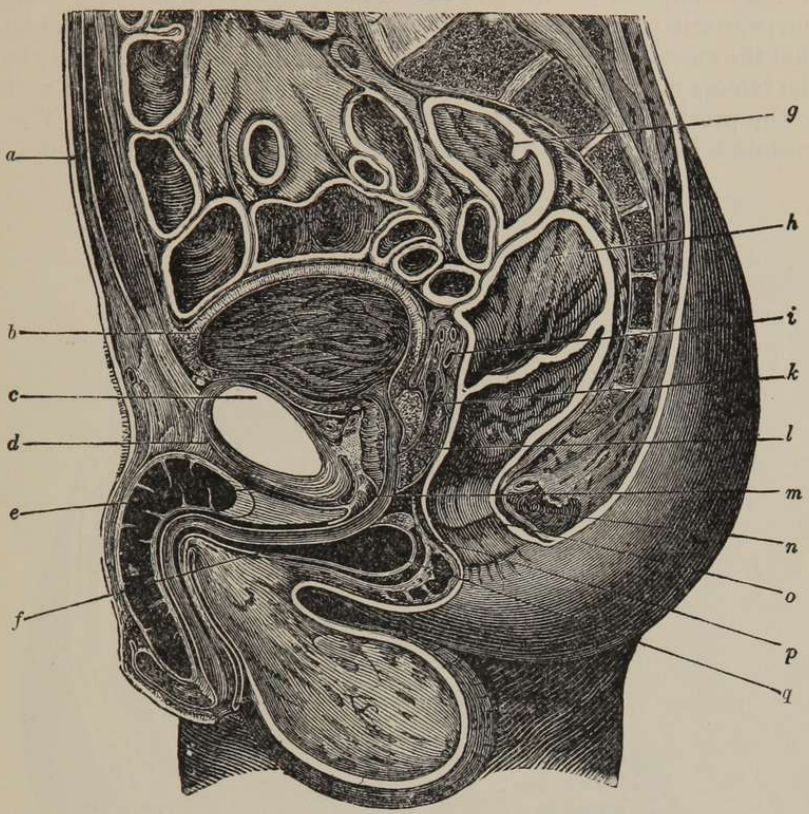
1. Diverticulum of the bladder.



2. Hypertrophy of the median lobe of the prostate (Watson).

layer of the perineal fascia, and the pubo-prostatic ligament. It is in relation with the pubes in front and the rectum behind. It is about the size of a horse-chestnut, and weighs a half-ounce (Fig. 341).

Fig. 341.



Vertical Section of a Male Pelvis: *a*, rectus abdominis muscle; *b*, bladder; *c*, symphysis pubis; *d*, suspensory ligament of penis; *e*, dorsalis penis vein; *f*, Cowper's gland; *g*, rectum; *h*, rectum; *i*, seminal vesicle; *k*, ejaculatory duct; *l*, prostate; *m*, transverse perineal muscle; *n*, external sphincter ani; *o*, internal sphincter ani; *p*, internal sphincter ani; *q*, external sphincter ani (Braune).

Wounds of the Prostate are very rare. They occur occasionally in penetrating wounds of the perineum or of the rectum, but are then usually secondary in importance to more serious injuries. The gland is of course wounded during the performance of lithotomy, but unless the incision extends beyond its capsule no evil results follow. Whenever that is opened there is great risk of pelvic cellulitis and peritonitis.

Atrophy of the Prostate has been said to occur after wasting disease, after double castration, and as a result of old age. The condition has no recognizable symptoms.

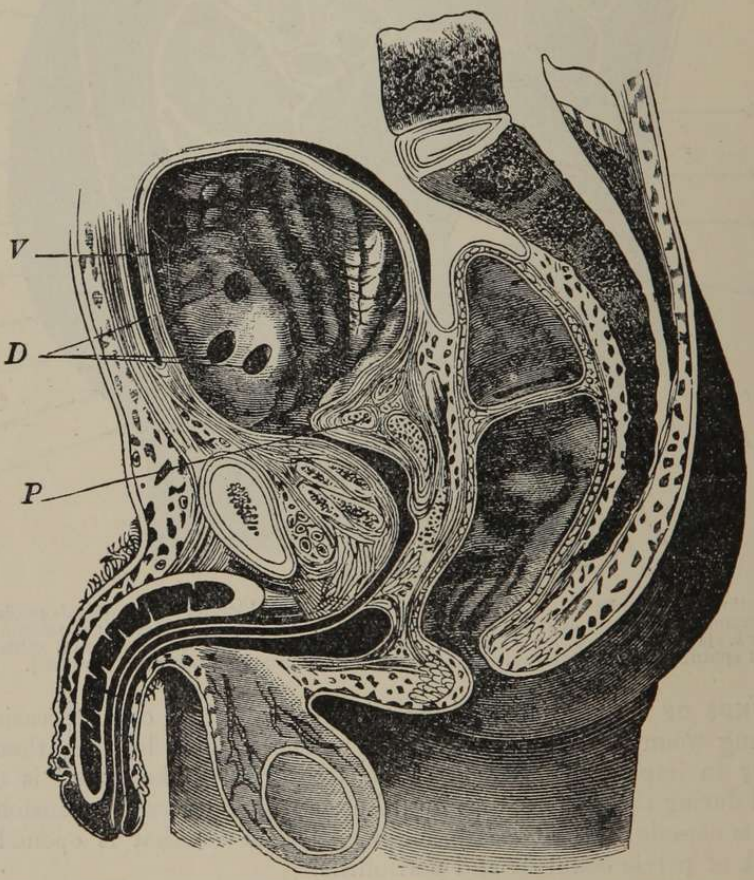
Hypertrophy of the Prostate.—In about one-third of all males who have passed middle life some enlargement of the prostate has taken place. In about one-tenth of all males over fifty-five this enlargement becomes of pathological importance.

Pathology.—The hypertrophy varies in some of its features, but as a rule consists of a general enlargement of the gland in all directions, together with the development within it of separate tumors resembling uterine fibro-myomata. The increase in size is due to overgrowth of the fibrous and muscular constituents of the organ, the glandular elements remaining almost unaffected. The

size and shape of the prostate gland itself and of the tumors it contains vary exceedingly. Either the lateral lobes or the median lobe may enlarge more than the rest of the gland (Pl. XXI, Fig. 2, and Pl. XXII); the latter may constitute a bar extending up into the bladder and blocking the orifice; the former may compress the urethra into a mere slit or chink, may elongate it so that the prostatic portion measures three or four inches, or may twist and distort it so that the most flexible instrument can only with difficulty be made to traverse it. The tumors may be no larger than a pea or may be of the size of a child's fist.

As the prostate grows certain changes in the bladder occur. The apex of the prostate is held in place by the triangular ligament. As the gland enlarges,

FIG. 342.

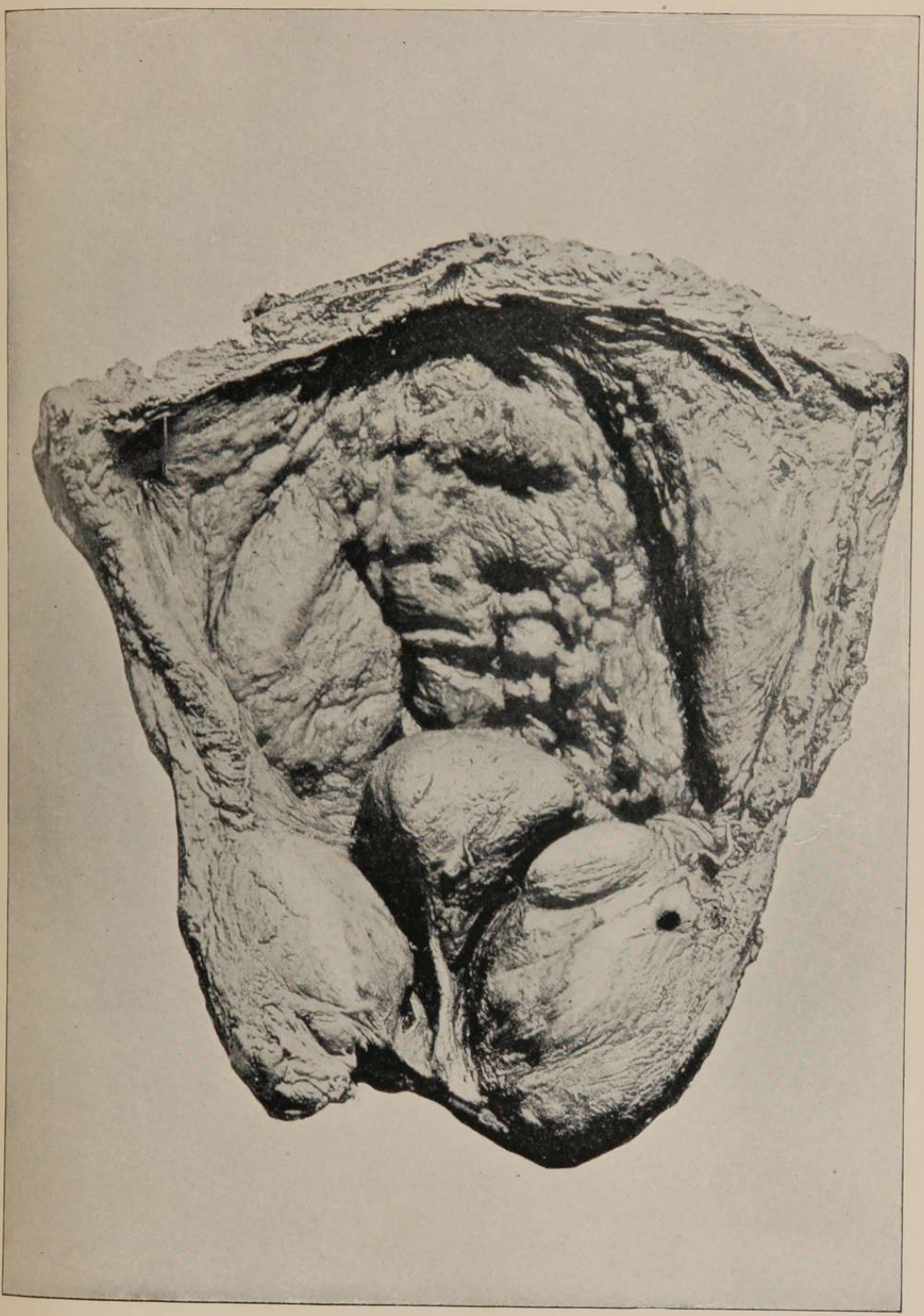


Vertical Section of Pelvis in a Case of Prostatic Hypertrophy: *P*, prostate; *D*, openings of vesical diverticula; *V*, bladder (Koenig).

therefore, it does so in a backward direction, carrying with it the neck of the bladder. If the growth is uniform, the bladder simply falls into a pouch anteriorly between the prostate and the pubes, and into another and larger one posteriorly, in front of the rectum.

If the growth is confined chiefly to the median lobe, it may act, as has been said, as a valve, and serves to obstruct the internal orifice very considerably (Pl. XXI, Fig. 2).

In cases of sudden obstruction without much antecedent irritation the bladder is apt to undergo dilatation and atony; if the obstruction is of slow development and has been accompanied, as it often is, by congestion of the vesical



Hypertrophy of the median and lateral lobes of the prostate (Watson).

neck, hypertrophy of the muscular walls takes place: they thicken, and the bladder contracts, and may become pouched or sacculated, as in the presence of any other obstructive cause.

McGill classifies the various forms of the intravesical growth—that which produces urinary symptoms—into (1) a projecting middle lobe, pedunculated or sessile; (2) an overgrowth of the middle lobe and of the two lateral lobes, forming three distinct intravesical projections (Plate XXII); (3) enlargement of the lateral lobes only; (4) a uniform collar-like projection encircling the orifice of the urethra. It is only in about 50 per cent. of cases of hypertrophied prostate that urinary troubles manifest themselves. In the others, the growth not belonging to one of the above varieties, there is but little interference with the functions of the bladder.

Symptoms.—Often the earliest symptom of prostatic disease is the increased frequency of urination, most marked at night. This may precede any enlargement appreciable through the rectum or recognizable during catheterism. It arises from the congestion of the plexus of large veins at the neck of the bladder, the return circulation through which is interfered with by the prostatic overgrowth. To this general congestion of the region of the prostate may also be attributed the unusual and occasionally unnatural sexual desires of old men. A patient with prostatic hypertrophy may not notice much increase in the frequency of micturition during the day, but at night he will be compelled to get up more and more often as the obstruction increases and as the walls of the bladder gradually become less able to overcome it. After a time a more or less considerable quantity of urine is always retained within the bladder, and the patient is able only to pass that which is in excess. This retained or "residual" urine may remain stationary in amount, but more frequently will gradually increase until in some cases, in which both the hypertrophy of the prostate and the atony of the bladder are marked, only an ounce or two can be evacuated spontaneously, although catheterism will show that the bladder contains possibly a pint or more.

From the same cause arises the characteristic enfeeblement of the stream, which, instead of being projected away from the body, will drop perpendicularly toward the feet of the patient.

These symptoms continue for an indefinite period, and in some cases, after reaching a certain intensity, fail to increase in severity, especially if by aseptic catheterism the residual urine is periodically withdrawn. In others, however, a subacute prostato-cystitis supervenes, either from infection through the urethra or by means of the catheter, and then the symptoms felt are most distressing. The desire to urinate is nearly constant, and the act is accompanied with burning pain and tenesmus: it may be followed each time by a slight hemorrhage; rest at night is interfered with; the general strength fails from the continual suffering; the urine becomes fetid, ammoniacal, and reduced in quantity; pyelo-nephritis develops; general sepsis occurs; and the patient dies uremic and comatose.

Diagnosis.—In determining the existence and the degree of prostatic enlargement a systematic course should be followed. The patient should always lie recumbent, with the knees drawn up and separated. The rectal examination may conveniently be made first. The under surface of the gland is gently palpated, the outlines recognized, the degree of projection into the rectum and the longitudinal enlargement estimated. It may be found regular, rounded, and uniformly increased in size, or it may be nodulated and uneven. It will usually be enlarged in both directions, so that the lateral borders are approximated to the pubic and ischiatic rami, and the finger fails to reach the

base or upper limit of the gland. Ordinarily it is insensitive, but occasionally there is tenderness on pressure.

After completing this examination, the patient, who should previously have urinated, is catheterized. It will be found that there is a greater or lesser amount of residual urine; that the shaft of the instrument enters the urethra to an unusual depth; and that the handle must be depressed between the thighs more than ordinarily before the point of the catheter can be made to enter the bladder. Sometimes an instrument of the usual length and curve will not reach the bladder at all; and this explains the occasional failure of attempts at catheterism for retention due to enlarged prostate.

The symptoms due to *acute prostatitis* have already been detailed, and, together with the history of urethral infection, will serve to differentiate the two conditions. The age of the patient may also serve to exclude hypertrophy.

Malignant disease may be suspected if hemorrhage is a predominant symptom and if the growth is especially irregular in shape and uniform in consistence.

Tubercle of the prostate is almost always associated with tuberculosis of some other portion of the genito-urinary tract. By collecting the urine for twenty-four hours, permitting it to settle, and carefully examining the sediment the presence of bacilli can usually be demonstrated.

Treatment.—In most cases of prostatic enlargement the best two guides to the surgeon are afforded by the degree of disturbance at night and the amount of residual urine. If the patient sleeps well, is obliged to empty the bladder only once or twice between evening and morning, and has but one or two ounces of clear residual urine, the treatment should be hygienic and general, and local interference should be avoided. Great care should be taken to avoid chilling of the surface; the diet should be light and digestible; alcohol should be used not at all or in great moderation; malt liquors and champagne should be interdicted; the bladder should be emptied at regular intervals; constipation and straining at stool should be especially avoided. If, however, the patient rises three or four or more times at night to urinate, and if the residual urine amounts to several ounces, systematic catheterism should begin at once. The evils of delay are greater than those associated with the use of the instrument. The amount of residual urine will usually increase, as will the vesical atony, the risks of renal complications are greater, and when, finally, the use of the catheter becomes imperative, there is far greater danger than if it had been begun earlier.

The frequency with which the catheter should be used is proportionate to the quantity of residual urine and the urgency of the symptoms. As a rule, where the urine does not exceed three fluidounces in amount and is not turbid or bad-smelling, the use of the instrument at bedtime will be sufficient. If, however, the urine is ammoniacal, or if it is of larger amount, or if the patient urinates with some pain and greater frequency, it may be well to catheterize two, three, or even four times daily. Experience and familiarity with the special needs of each particular case must decide this question. No drugs have the slightest effect upon the hypertrophy itself, but those which render the urine aseptic will be found valuable adjuvants in these as in nearly all other surgical diseases of the genito-urinary tract. It may be necessary to combine with them in certain cases the bromides, belladonna, or small doses of opiates, but these should always be regarded as necessary evils, to be used only in exceptional cases or in times of emergency, and to be thrown aside as soon as they can be dispensed with.

There are cases, however, in which catheterism fails to meet the indications. Either in spite of it or because of it the symptoms increase in severity, the

general condition becomes more alarming, and it is apparent that the patient will die exhausted if further relief is not given; or the same condition may arise in cases of complete retention of urine with cystitis and with extremely difficult or painful catheterism. Under these circumstances treatment may still continue to be palliative, and may consist in opening the bladder through the perineum by means of an incision like that for median lithotomy.

Harrison introduces a straight trocar and canula in the middle line of the perineum about one inch in front of the anus, and pushes it through the substance of the prostate until the bladder is tapped. A self-retaining catheter is then introduced through the canula, and the latter is withdrawn. Continuous drainage is thus secured, and the catheter may be utilized for antiseptic irrigation. In some cases this measure has been followed by permanent shrinkage of the prostate, which becomes reduced to nearly its normal dimensions. Occasionally it will seem wise to make drainage by means of a suprapubic puncture, and Hunter McGuire and others have shown that it is possible to do this by establishing a small, permanent fistulous opening running obliquely upward, and to retain considerable power over the urine. The suprapubic incision has the advantage also of permitting, better than that through the perineum, the thorough exploration of the bladder and prostate, and, if necessary, the employment of more radical methods.

Prostatectomy.—In selecting an operation for the more permanent relief of the condition it is well to remember that the severity of the symptoms in any case has no definite relation to the extent of the enlargement as felt through the rectum, but depends rather upon the presence and the extent of one or the other of the varieties of intravesical growths described on p. 915.

Such a growth having been diagnosticated, it may be approached and removed in one of three ways (Treves): 1. By perineal incision. The perineum and bladder are opened as in median lithotomy (p. 847): the projection is recognized with the fingers and enucleated with the help of a curette or seized by a pair of forceps and twisted or torn away. Watson has shown that in two-thirds of prostatic cases appropriate for radical treatment the intravesical growth lies at a distance of three inches or less from the perineum, and that therefore any one possessing an index-finger of the length of three inches may be able to attack them successfully. This, however, leaves one-third of all such cases which cannot be reached after the operation has begun—a weighty objection to this treatment. In a number of instances pedunculated growths or projecting portions of lateral lobes have been seized and removed during the performance of perineal lithotomy. But these were accidents, and in most of them the removal was incomplete so far as its effects upon the obstructive symptoms were concerned.

2. By suprapubic incision. In this operation the bladder is reached and opened just as in a suprapubic lithotomy. McGill has enumerated as follows the *special* points of technique: (1) The quantity of water thrown into the rectal bag should be smaller than usual, rarely more than from six to ten ounces. (2) Preliminary irrigation of the bladder should be continued until the fluid returns perfectly clear. (3) The quantity of fluid left in the bladder varies from ten to twenty ounces. (4) In cases where contraction of the bladder is combined with hypertrophy of the walls the operation is contraindicated. (5) A catheter left in the bladder until the latter is opened facilitates the operation. (6) The linea alba is opened by an incision directly upon the symphysis, and afterward divided upward upon a director. (7) Before beginning the removal of the prostate the bladder must be secured by passing a suture through each lip of the wound and stitching it to the wound in the abdominal

wall. A third suture between the lower angle of the vesical wound and that of the abdominal wound is thought to aid in preventing urinary extravasation into the pre-vesical space. (8) In the case of a pedunculated middle lobe the pedicle may be divided with curved scissors. A sessile middle lobe may require in addition some avulsion by forceps. The collar projection should be divided into two lateral halves by passing one blade of a pair of scissors into the urethral orifice and cutting the portion above it, repeating the procedure for the lower segment, and then enucleating with the scissors and fingers. (9) Whenever possible, enucleation with the finger should be preferred to cutting with sharp instruments, the mucous membrane over the projecting portion having first been divided with scissors. (10) Hemorrhage should be arrested by irrigation with very hot (almost scalding) water. (11) The operator should ascertain that the urethra is entirely patent at the end of the operation, by inserting the forefinger as far as the first joint into the canal. (12) A large drainage-tube should be left in the bladder for forty-eight hours. The wound should be united above the tube by a deep and a superficial row of sutures. (13) Irrigation with boric solution may be required as part of the after-treatment.

McGill has removed portions of the prostate weighing in one case seven ounces and in another two and a quarter ounces. White of Philadelphia removed in one case a mass weighing three ounces.

In any case where, after a suprapubic prostatectomy, the urethral canal is not ordinarily patent, the operation may be supplemented by median perineal urethrotomy, by means of which growths in the prostatic urethra or in the suburethral prostate can be dealt with.

The results of experience thus far seem to show that the operation of prostatectomy is justifiable in some cases of hypertrophied prostate in which catheterism is difficult or impossible or excessively painful, and in which a high grade of cystitis has developed and septicemia or uremia is imminent. The prognosis is unfavorable in proportion to the duration of the obstructive symptoms and the size of the mass which it is necessary to remove to secure patency of the urethra, and is, of course, much influenced by the condition of the kidneys.

Double Castration for Hypertrophy of the Prostate.—*White's Operation.*—In June, 1893, White, as the result of researches begun a year previously, suggested in a paper before the American Surgical Association that castration might produce atrophy of the enlarged prostate, and might thus be a valuable method of treatment. His theory had resulted from a consideration of the apparent analogy between the uterine and prostatic fibromyomata, but was further based upon a series of experiments on dogs (which showed rapid atrophy of the prostate following castration), on some physiological observations of John Hunter on the lower animals (corroborated by Griffiths), and on some scattered cases in surgical literature showing a shrinking of the prostate after castration for various causes, and strengthening the opinion previously formed. Since the publication of his paper many cases have been reported, the large majority having been extremely successful. It is too soon yet to speak with authority as to the precise limitations or the exact risks of the operation. It may be said with much confidence, however, that in a considerable proportion of all cases of enlarged prostate castration will be followed by a rapid diminution in the size of the gland, and a coincident disappearance of many—sometimes of all—the obstructive symptoms. Moreover, with the ability completely to empty itself the bladder has in a number of cases regained a healthy state of the mucosa, previously the subject of infective inflammation, and with the return of normal micturition all the symp-

toms of confirmed cystitis have disappeared. Sir Joseph Lister has noted the fact that the rapidity with which relief has followed this operation has in many of the reported cases been as remarkable as the degree of improvement itself.

Griffiths, who eighteen days after double castration examined the enlarged prostate of a patient who died of popliteal thrombosis and gangrene, has shown that changes were then taking place which were obviously preliminary to "the conversion of the prostate into a small, firm, fibrous mass containing only remnants of the tubules and but few traces of its muscular fibers." Kirby has found the beginning of these changes in the prostate of a patient castrated during an advanced stage of uremia, and who died within three days. Other reports of similar character have been published. Moullin says: "Removal of the testes is followed in a large proportion of cases, if not in all, by complete and rapid absorption of the enlarged prostate. This has now been proved conclusively." The operation thus rests now upon a firm clinical and pathological basis, and has certainly passed the theoretical stage. Experiments conducted by White with the aid of Kirby and Wood seem to show—*a*, that unilateral castration will be followed by a certain degree of prostatic atrophy on the corresponding side, but that it is not certain that this will be either prompt enough or complete enough to be curative in prostatic cases; *b*, that ligation of the cord is followed by prostatic atrophy, but usually only when the testicles have first become functionless themselves, and that this atrophy is also slow and somewhat uncertain; *c*, that ligation of the vas alone has little effect on the testicle, but causes a decrease in the size and weight of the prostate; *d*, that ligation of the nervous and vascular constituents of the cord separately influences the prostate only by first producing disorganization of the testicles, and that this result is neither prompt nor certain.

At present, therefore, double castration seems to be the operation which comes into direct comparison with the various forms of prostatectomy, and it may safely be said that it is likely in properly selected cases to have a lower mortality, is far easier of performance, requires a much shorter period of anesthesia, and when fully successful secures a return to a condition more closely resembling the normal than any of the other operations looking toward a radical cure of the hypertrophied prostate.

The operation must be regarded as still on trial so far as accurate choice of cases and precise prognosis are concerned, but the conclusions of Fenwick, after an experience of nine cases, are, with some modifications, accepted by White after a careful analysis of all reported cases, now numbering more than one hundred. They are as follows: 1. There is no doubt that shrinkage of the prostatic tissue in many of the forms of senile enlarged prostate ensues upon double castration. Further experience must, however, decide as to whether every form of prostatic growth is thus affected. 2. It is certain that escape from catheter-life after castration depends largely upon the health of the vesical muscle. The grade of the atony, therefore, should be most carefully estimated before any hopes of relief from catheterization are held out. To promise a confirmed catheter case that orchectomy will do away with the instrument may merely bring discredit on the operation and disappointment to the patient. Even after prostatectomy we are unable to promise such relief if the muscle is hopelessly atonic, and we cannot do so after castration. 3. It is possible that castration, by diminishing microbic infection from the inflamed senile prostate, will remove a constant menace to the integrity of the kidneys, for it will control the most prolific source of ascending pyelitis.

It appears that while double castration is likely to have a wide range of use-

fulness, the exact limitations of which must be determined by longer experience, it is now safe to say that it will prove of value in the following conditions:

1, in reducing bulky overgrowth of the prostate: it may be found that the small, tough, fibrous median or lateral vesical outgrowths will be better removed by suprapubic prostatectomy; 2, in controlling the distress and danger of an inflamed senile enlarged prostate; 3, in lessening the frequency or difficulty of introducing the catheter in advanced or confirmed catheter-life; 4, in avoiding the mechanical difficulty of crushing a post-prostatic or a post-trigonal stone, by levelling the base of the bladder, thus rendering the operation of litholapaxy feasible in a condition in which before it was impracticable; 5, in reducing chronic cystitis and recurrent phosphatic calculus in cases of confirmed catheter-life.

PROSTATITIS may be acute or chronic, follicular or parenchymatous.

Acute Follicular Prostatitis is usually a complication of gonorrhea, and has already been described. (See pp. 874, 891.) It may occur as a complication of stricture. The mucous membrane and the follicles which empty upon its surface are chiefly affected. If abscesses occur, they are small, are apt to be numerous, and almost invariably empty spontaneously into the urethra.

Chronic Follicular Prostatitis is often a sequel of an acute attack. It sometimes follows an attack of gonorrhea in which there has been no evidence of acute inflammation of the gland. Its symptoms, course, and treatment have been described in connection with the subject of chronic urethral discharges. (See pp. 881, 892.)

Parenchymatous Prostatitis.—In this form the inflammation affects the whole substance of the gland, after causing great disorganization. It may result from—*a*, traumatism; *b*, tubercle; or, *c*, gout. *a*. Injuries of the prostate are chiefly those inflicted during the various operations for stone or during operations upon the urethra or bladder; occasionally the use of a large instrument, especially in patients broken down in health or with a cystitis with fetid and ammoniacal urine or with pyelo-nephritis, will bring about this form of prostatitis. It is ushered in by a chill, with deep-seated perineal pain, and swelling recognized by rectal examination. It is usually suppurative in such cases, but if the symptoms are marked by the presence of vesical or renal disease, or, especially, if there is already distinct enlargement of the prostate, the character of the trouble may escape detection until it is far advanced. The pus may escape through the capsule of the gland, penetrating the recto-vesical fascia and setting up a fatal pelvic cellulitis, or it may point in the perineum or even in the groin.

Free evacuation by means of a median perineal incision is always indicated when the diagnosis is assured, and such an incision should be made for purposes of exploration when deep-seated parenchymatous suppurative prostatitis is strongly suspected. This is markedly in contrast with the follicular variety (gonorrheal prostatitis), in which operation is scarcely ever required.

b. Tubercular prostatitis is very rare as a primary affection. It occurs in the course of tubercular disease of the bladder or kidneys; occasionally, but more rarely, as a sequel of tuberculosis of the testicle. Its symptoms in the early stages are those of a high grade of chronic prostatitis or often closely resemble those of vesical calculus, hematuria after urination and pain at the end of the penis being often present. Later, the urine becomes filled with the débris of the caseating masses, and tubercle bacilli may be found if the sediment from a considerable quantity of urine be collected and examined.

The cystoscope might show the existence of ulceration at or near the neck of the bladder.

The **prognosis** is very unfavorable.

Treatment.—The general hygienic measures appropriate for tuberculosis anywhere are applicable here, but have less than their usual effect. The local use of emulsions or of suppositories of iodoform has been recommended, but the bladder and urethra will not tolerate them of sufficient strength to be of much service. The direct application to the ulcerated region of silver nitrate (from 1 to 5 per cent., or stronger if it is well borne) is sometimes of much temporary benefit. If there are no deposits elsewhere, and there is reason to believe that the prostatitis is primary, and especially if the kidneys are thought to be sound, perineal or suprapubic prostatotomy, and curetting and cauterization of the affected surfaces, would seem best to fulfil all the indications, but are rarely applicable under these limitations. They may become justifiable as palliative measures for the relief of hemorrhage, pain, and vesical tenesmus, but then a simple perineal cystotomy would probably be almost equally beneficial.

c. Gouty Prostatitis is an irritative and congestive rather than an inflammatory condition of the gland, found in men at or beyond middle life who are lithemic, who have been high livers, and who habitually indulge to excess in malt liquors or sweet sparkling wines. The uric, or sometimes the oxalic, diathesis will be found to coexist. The symptoms are those of prostato-vesical irritation. The disease never runs on to suppuration, and is rarely serious, but is very apt to recur if the original errors of diet or habits of life are resumed.

The **treatment** is that indicated by the condition of the urine. It should be largely hygienic.

Prostatic Calculi.—The prostate, like other glandular structures, is occasionally occupied by concretions consisting of inspissated secretions. These are often small and numerous at first, but later become coated with secondary phosphatic deposits, and in some cases have been agglutinated by mucous and fibrinous exudates so as to convert the whole prostate into one calculous mass. They give rise to symptoms very difficult to differentiate from those of vesical calculus. It will be observed in cases of doubt that the stone remains fixed, never changing its position with the different movements of the body, as does a stone in the bladder. It may sometimes be felt between the finger in the rectum and a sound in the urethra. If movable, the introduction of a large sound will often displace it and push it back into the bladder. When small and multiple, such calculi may often be seized by urethral forceps and extracted. White has thus removed from the prostatic sinus ten calculi weighing altogether two hundred and thirty grains. If larger and fixed, a median perineal incision is the best method for their extraction.

Malignant Disease of the Prostate.—Both carcinoma and sarcoma affect the prostate. The encephaloid variety of the former is more common. When the disease develops in a prostate already hypertrophied, the diagnosis is very difficult. Originating in a prostate previously unchanged, it may be recognized by the rapidity of the growth, the frequency and severity of the hemorrhage, the associated cachexia, etc. Extension beyond the capsule of the gland and involvement of neighboring parts, as the rectum and the vesiculæ seminales, sometimes take place, and may be discovered by digital exploration.

Treatment is of but little avail. Suprapubic or perineal cystotomy for drainage is sometimes indicated. A pedunculated growth might be twisted off through either incision, and obstructive symptoms temporarily relieved. Death usually occurs from exhaustion or from secondary deposits in other viscera.

PART V.—DISEASES OF THE TESTICLES.

Congenital Deformities.—Occasionally both testicles are entirely wanting (cryptorchidism); more commonly one is lacking (monorchidism). Supernumerary testicles have been reported, but are probably instances of detachment of the globus major from the body of the epididymis (Agnew).

Retained Testicle (undescended testicle) is much more frequent. It is usually unilateral, though occasionally both testicles fail to reach the scrotum. The organ may be arrested during its descent within the abdomen below the kidney, in the inguinal canal, or just outside of the external abdominal ring. In rare cases the testicle has been found in the perineum. If both testicles are retained, the suspicion may arise that the individual is a cryptorchid, and a microscopical examination of the fluid ejaculated during a sexual orgasm may be necessary to decide the question.

A retained testicle, especially if it is situated in the inguinal canal, is liable to inflammatory attacks and even to malignant change.

Treatment.—Various operations have been devised for placing and retaining such an organ in the scrotum, but all have been unsuccessful. If it gives rise to much trouble, and if the other testicle is present and is sound, castration is the only efficient remedy.

Inflammation of the Testicle.—Under this head are usually described both epididymitis and orchitis, which may exist either separately or conjointly.

Acute Epididymitis is usually gonorrheal in its origin, though more rarely it may follow perineal lithotomy, an injury to the perineum, lithotrity, catheterization, etc.

The **symptoms** and **treatment** have been sufficiently described in the article on Gonorrhea. (See pp. 857, 874.)

Acute Orchitis may result from the extension of an epididymitis, but this is uncommon. It is usually caused by traumatism: metastasis in mumps may give rise to a very acute orchitis.

When acutely inflamed the testicle swells rapidly, but retains its normal oval form. The pain is dull and nauseating, radiates toward the groin, hips, and loins, and is markedly lessened by support to the testicle. Acute hydrocele is not so common an accompaniment as in cases of epididymitis. The exudate, which during the acute stage occupies the connective-tissue spaces between the seminiferous tubes, may break down, and suppuration may follow in persons already in poor health and with feeble resistant powers. Infection in these cases probably occurs through the blood rather than through the urethra and vas deferens. More commonly reabsorption takes place, but the gland is apt to be left softened or atrophied and predisposed to subsequent attacks.

Bilateral orchitis may result in impotence as a result of these atrophic changes in the secreting structure of the glands themselves, while bilateral epididymitis, in consequence of its obstructive sequelæ, is far more apt to cause sterility.

Treatment.—The patient should be put to bed, the scrotum elevated, and iced lead-water and laudanum applied. If the cold is of itself a cause of suffering, hot fomentations of the same lotion will often give relief. Laxatives and febrifuges should be given, and during the height of the inflammation enough morphia hypodermatically to control the acute pain. Aconite and bromide of potassium in appropriate doses will be found of great use. Puncture of the tunica vaginalis, and even puncture or incision of the tunica albuginea, has been recommended in cases in which the tension and swelling are very great. The former is harmless, but usually needless. The latter is rarely

if ever justifiable. If the orchitis is of the rheumatic or gouty variety, the salicylates and iodide of potassium, with lithia-water and a restricted diet, are indicated.

Chronic Orchitis rarely follows an acute attack, but is more commonly the result of some constitutional infection. When it results from local causes it is characterized by a slow enlargement of the gland, with only moderate pain and with a loss of the testicular sensibility. If it continues for any length of time, atrophy of the gland is sure to result. Frequently the inflammatory exudate liquefies, the skin ulcerates, infection occurs, and the organ is riddled with sinuses or disappears almost completely.

The **treatment** should consist in careful regulation of the general health, the administration of tonics with alteratives, and the local use of equable pressure by strapping, gentle at first, firm later if it is well borne. An ointment of mercury, belladonna, and iodine, or one containing iodoform, often seems to be useful. Castration will be required if there are several suppurating foci.

Tubercular Orchitis usually occurs in patients between the ages of twenty and forty. There is often a family history of tubercular disease. The epididymis is apt to be first involved. The disease is frequently bilateral. It is insidious in its origin, giving rise to little or no pain, but beginning as a hard, irregular enlargement at the lower and posterior aspect of the gland, gradually increasing, and sometimes extending along the vas deferens. Later the whole gland is involved and undergoes caseous degeneration. The skin becomes adherent, sinuses form, and purulent infection follows. Secondary tubercular deposits in the seminal vesicles or in more remote regions are often found.

Treatment.—If the diagnosis is reasonably clear or if multiple sinuses have formed, and if the disease is unilateral, castration is clearly indicated, both to secure local health and, even more urgently, to avoid general dissemination of tubercle. If both glands are affected, however, the consequences of castration are so unpleasant that palliation and symptomatic treatment should be persevered in until there is unmistakable evidence of the complete destruction of the organ. Sinuses should be enlarged and curetted, abscesses should be opened promptly, ulcers should be treated with nitrate of silver and dressed antiseptically, and every attention should be paid to the general health and strength of the patient.

Syphilitic Orchitis (syphilitic sarcocele) also begins painlessly, but, as a rule, in the body of the gland; like tubercular orchitis, it is apt to be bilateral. It causes a dense, irregular, knotty induration, but not much increase in size. These phenomena, together with the history and the results of specific treatment, generally render its recognition easy. (For the differential diagnosis from tubercular orchitis and from carcinoma of the testis see p. 169.)

Malignant Diseases of the Testicles.—Carcinoma of the Testis usually assumes the soft or encephaloid form. It is an exception to the rule that carcinomata develop most frequently after middle age. Of 67 cases collected at random, 51 were in persons under forty, and 24 appeared before the age of thirty. The disease is usually unilateral, and begins in the form of one or more small nodules occupying the body of the gland and soon enlarging so as to involve the epididymis. The swelling is at first smooth and uniform, but as soon as the tunica albuginea breaks down it becomes irregular, with areas which are soft and fluctuating, and grows with increased rapidity. The veins of the scrotum are greatly enlarged; the skin becomes adherent and ulcerates; the growth reaches a large size and is sometimes enormous; fungous protrusions, consisting of granulations, and of sloughs of the connective tissue and even of portions of the gland, make their appearance and bleed upon the least

touch; the cord is thickened, and the inguinal and pelvic glands are involved. The general health soon fails, the patient becomes cachectic and emaciated, and death usually results in from one to two years after the first appearance of the growth.

Scirrhus of the testicle is very rare, and presents no features peculiar to the locality.

Sarcoma of the testicle is found in all its forms. Several subdivisions have been made of certain of these sarcomatous growths, and have somewhat unnecessarily complicated the study of the pathology of the testis.

The so-called *Cystic Testicle*, the "hydrated testicle" of Sir Astley Cooper, is probably almost always an early stage of sarcoma. It is of variable duration, but is often slow in its development and is attended with a gradual, painless, uniform enlargement of the whole gland, which retains its oval shape, is smooth and elastic to the touch, and often fluctuates. It may reach an immense size. It resembles hydrocele or hematocele in form and general appearance, but is heavier than the former, is more ovoidal, and is opaque. From hematocele the diagnosis may be more difficult, and sometimes it can be made in the later stages of cystic disease only by recognition of the enlarged veins over the surface of the scrotum and by the general cachexia. In the earlier stages the introduction of a trocar will in either case often be followed by bleeding, but in hematocele the blood will be in greater quantity, and will be darker and altered in appearance. In those cases in which the contents of an old hematocele have undergone partial organization, leaving areas containing fluid blood, the diagnosis may be practically impossible, but it is less important, as in both cases castration is indicated.

Enchondroma of the Testicle has been described as a benign growth, but it is probable that it is almost invariably a form of sarcomatous disease. In some cases it grows very slowly, and may then be recognized by its great weight and density, and by the absence of pain and of involvement of the skin or of neighboring tissues. Even then, however, it is extremely apt to take on malignant change, while in the more rapidly growing form it is found from the outset in combination with cystic and sarcomatous disease.

Jacobson in this connection has appropriately called attention to the close relations of cartilage to the other tissues of the connective-tissue type, and says that when it is remembered how narrow is the dividing-line between these tissues and the sarcomata, especially when, as a result of continued irritation, the former tend to recur to their embryonic form, it may well be doubted if an enchondroma of the testicle ever really deserves the term "innocent."

Sarcoma proper may be of the *round-celled* variety, in which case it is met with in an unmixed form, grows rapidly, reaches a large size, and is soon followed by secondary deposits having all the characteristics of extreme malignancy. *Spindle-celled* sarcomata are more frequently associated with other structures of the connective-tissue group—viz. cartilaginous, myxomatous, and adipose tissue—run a slower course, and are more difficult of recognition, but sooner or later develop the usual phenomena of this form of malignant growth.

Diagnosis of Malignant Disease of the Testis.—In their early stages both carcinomata and sarcomata are liable to be mistaken for enlargements due to chronic orchitis, as at this time they both have an oval shape, a smooth surface, and are somewhat indurated. Later, as the growths soften, and especially when, as is often the case, there is fluid in the tunica vaginalis, they may simulate an old hydrocele with a thickened, opaque tunic or a hematocele with thickened walls. The following points may be enumerated as of chief diagnostic value (Jacobson): (1) continuously progressing solid enlarge-

ment without inflammation; (2) unequal resistance of the swelling at different parts; (3) entire absence of translucency; (4) tendency to become adherent; (5) increasing aches or painfulness; (6) enlargement of the cord and, *a fortiori*, of the lumbar glands. In doubtful cases additional information should be at once sought for by an antiseptic tapping or exploratory incision. The latter is preferable, as it gives more certain information, and is the best treatment in those hematoceles which are liable to be mistaken for malignant disease. Puncture of a malignant growth usually gives vent to blood-stained fluid which is not large in amount, or to sero-mucous fluid which is not blood-stained. On puncture of a hematocele there usually escapes either grumous altered blood or fluid blood, which flows for some time, producing a distinct alteration in the size of the swelling.

Castration.—The most recent review of the results of operation in malignant disease of the testicles is that of Butlin. In 99 cases collected by him there were 4 deaths from causes directly connected with the operation. Many of the patients were lost sight of, but there were 5 cases of sarcoma well at the end of from twenty months to two years, and 2 cases of carcinomata without recurrence at the end of forty-two months and one hundred and eight months respectively. Mr. Butlin's conclusions as to this important subject are that castration for malignant disease is an operation which may be performed with very small danger to life. The operation, whether for sarcoma or for carcinoma, cannot be said to be attended with large success, so far as complete cure of the patient is concerned, but there is a great lack of information on this subject. There is, however, evidence that it may be attended with permanent success, and there is still further evidence that the operation may be an excellent palliative measure even if it fails in its primary object, cure. There is comparatively little likelihood of recurrence *in situ* unless the cord is thickened or the scrotum adherent at the time of the castration. There is no prospect of success for operations for recurrent disease unless the recurrence is in the scrotum. Castration may be performed for malignant disease of both testes, if not with a reasonable prospect of permanent cure, yet certainly with hope of temporary relief, and also with the hope of temporary relief in cases of malignant disease in children.

The operation is performed as follows: The hair of the pubes, scrotum, and perineum having been shaved and these regions repeatedly washed and disinfected, and the possible presence of hernia in the scrotum or in the canal being kept in mind, the skin of the scrotum should be steadied by the thumb and fingers of the left hand of the operator while an incision is made from a point just below the external abdominal ring to the bottom of the scrotum. This is gradually deepened, layer by layer, the tunic being recognized, when it is reached, by its immobility. The testis and tumor may sometimes be removed with the tunic by simply shelling out the mass from the scrotal tissues with the fingers, aided here and there by touches of the knife. Usually, however, it will be necessary to lay open the tunic either for purposes of diagnosis, to lessen the bulk of the swelling, or because the tunic itself has contracted inflammatory adhesions to the surrounding parts or has become incorporated with them during the progress of the disease. After the tumor is freed from all attachments except that to the cord, traction is made upon it so as to elongate the latter, which is then isolated by the finger. It may then be secured by a clamp, divided below it, and the vessels secured separately, or it may be encircled with a stout chromicized catgut ligature or a fine strong silk thread, and then divided, the ends of the catgut or silk being cut short and the cord allowed to retract into the canal after inspection of

the cut surface has shown that there is no hemorrhage. A small drainage-tube may be carried up to the stump of the cord and left in place for a day or two. All hemorrhage, even oozing from minute vessels, should be arrested by ligature before the wound is closed. Otherwise very troublesome bleeding may occur. During suturing the inversion of the edges of the wound by the dartos should be guarded against. The scrotum should be moderately elevated and well supported by the antiseptic dressing. Special care should be exercised to prevent infection from urine or feces.

Sterility, or incapacity to fecundate the female, may depend on some defect in the spermatic fluid, such as absence or enfeeblement of the spermatozoa. This may result permanently from disease, as any of the forms of orchitis, atrophy of the testicles, neoplasms, etc., or temporarily from sexual excess or the general feebleness following an exhausting illness. It may also be caused by the various forms of impotence, with the accompanying inability to deposit the semen within the vagina, or it may result from obstruction of the excretory ducts of the testicle, as in double epididymitis, tumor of the seminal vesicles or prostate, stricture of the urethra, etc. The diagnosis can best be made by microscopical examination of recently-ejaculated semen. If live spermatozoa are found and if the individual has no form of impotence, sterility may be excluded.

Impotence, or inability properly to perform the sexual act, may arise from absence of the penis, malformation or diminutive size of that organ, or disease or injury producing changes in portions of the erectile tissue and preventing their participation in the act of erection, thus leaving part of the penis flaccid. Various diseases and injuries of the cerebro-spinal axis, and especially of the lumbar cord, are accompanied or followed by loss of potency. Urethral stricture, especially when deep-seated and associated with hyperesthesia of the prostatic region, often causes a certain degree of impotence by inducing premature ejaculation, in many cases the erection subsiding before an entrance can be effected. Oxaluria is not infrequently a cause of very persistent and complete impotence, which, however, disappears rapidly under appropriate diet and drugs. The treatment of all these forms should be directed to the removal of the underlying condition.

Pseudo-impotence is a form of sexual disability which has its origin in the imagination or in the fear of the patient. It is very common among young men who have been unaccustomed to sexual indulgence and who have failed at their first attempt, owing to nervousness, want of confidence, or possibly a genuine distaste for the female. This sometimes happens during the early period of married life, and gives rise to intense anxiety and distress on the part of the husband. As a rule, all that is needed is a few words of advice and encouragement, with the injunction to refrain from repeated attempts while mentally perturbed. A placebo may be given, and these measures with time will always work a cure.

Varicocele.—The veins of the spermatic cord may be divided into two sets, an anterior, running with the spermatic artery and called the pampiniform plexus, and a posterior, smaller set accompanying the deferential artery and surrounding the vas deferens. The veins in the left cord are said to be always larger than those of the right (Spencer). The arteries of the cord are the spermatic, lying in front of the vas, the deferential, which runs with it, and the cremasteric, which is more superficial.

Varicocele is usually an enlargement of the veins of the pampiniform plexus only, but occasionally all the veins of the cord are involved. The

testicle on the affected side is apt to be smaller and softer than its fellow, and the dartos structure is usually flabby and relaxed.

The condition occurs chiefly in young unmarried adults, and so rarely develops before puberty or after middle age that it is evident that it has some relation to the sexual function, being apparently favored by a lack of its normal exercise. The mechanical conditions of the spermatic veins, their great length, their tortuous course, and the absence of support from firm underlying or surrounding muscles, are said to predispose to varicocele; but if these were very important factors it would be much more common on the right side than it is. Sir Astley Cooper, Agnew, Marshall (who examined 30,000 recruits), and others state that they have never seen a well-marked case on the right side. The entry of the left spermatic vein into the corresponding renal vein at a right angle instead of at the acute angle at which the right spermatic vein joins the vena cava, its passage behind the sigmoid flexure, and its greater length, have all been regarded as explaining the great preponderance of left-sided varicocele, and probably all share in bringing it about.

Exciting causes are found in whatever determines an increased amount of blood to the testicles, as heavy lifting, straining during defecation or urination, excessive sexual indulgence, etc.

Symptoms.—The disease is easily recognized. The scrotum on the affected side is filled with a tortuous mass of veins, giving a peculiar worm-like feel to the touch. Their convolutions are often visible through the skin. The scrotum is elongated and dusky or purplish in color. There is not much pain, but occasionally a dull ache extending along the cord and into the loins is experienced. Patients with varicocele are apt to be depressed and melancholy. They are often the subjects of pseudo-impotence, and if they have once failed in an attempt at sexual intercourse, if they have masturbated when younger, and especially if in addition there is a noticeable diminution in the size of the testicle on the affected side, they become sexual hypochondriacs of the most pronounced type. Occasionally, but rarely, genuine atrophy of the testes results from the interference with the circulation produced by the enlarged veins, but, as the other gland is usually normal, neither impotence nor sterility is threatened.

The disease can scarcely be mistaken for any other condition, and the directions often given for its diagnosis from scrotal hernia or congenital hydrocele seem unnecessary.

Treatment.—The palliation of a case of varicocele may be attempted by means of cold douches, regulation of the bowels, avoidance of all exciting causes, the use of a firm, well-fitting suspensory bandage, etc., but little or no effect upon the already existing enlargement need be expected.

The radical cure may be indicated either by actual pain and disability, by progressive atrophy of the testicle, or by the mental condition of the patient.

One of two methods may be selected:

(1) The scrotum and the enlarged veins are taken between the thumb and fingers of the left hand. The vas deferens, having been recognized by its hard and cord-like feel, is allowed to slip to the posterior part of the scrotum. A long hare-lip pin is then passed beneath the veins from one side of the scrotum to the other and about an inch below the ring. A second is passed half an inch or an inch farther down. A needle with an eye at the point and carrying a double ligature of fine aseptic silk is then inserted at the point of entrance of the pin, carried between the skin and the veins, and made to emerge by the side of the pin at its point of exit. The loop is then seized and the

needle withdrawn. The loop having been slipped under the point of the pin, the ligature is tied at the other end, the knot being allowed to slip under the skin, but the ends left long, so that when the pin is withdrawn in five or six days the loop of thread may follow. The procedure is repeated with the lower pin. This plan, though not now preferred by most surgeons, has given many hundreds of excellent results, and if carried out with proper antiseptic precautions is altogether without danger.

(2) Excision of the affected veins, with shortening of the scrotum on that side, is, however, the operation which is most satisfactory. The usual preliminary shaving and cleansing of the region should be done, after which, while an assistant makes the tissue tense by drawing the testicles and scrotum downward, an incision about two inches in length is made over the most prominent part of the varicocele. The veins are exposed, but are not separated from the fascia surrounding them and holding them together. The vas with its venous plexus is recognized and avoided. An aneurysm needle threaded with catgut is then passed under the veins at the upper end of the

FIG. 343.

Hydrocele (original).

incision and again at the lower end. The ligatures are tied, and in each instance left with one long end. The intermediate portion of the veins is then cut out with the scissors, and the stumps are brought into apposition and held by tying the ligature ends together. This raises the testis to a higher level and results in shortening the scrotum on that side. The results have been excellent in large numbers of cases.

HYDROCELE.—Hydrocele is a condition in which there is an abnormal quantity of fluid in the cavity of the tunica vaginalis testis (Fig. 343). It occurs with about equal frequency on both sides, and is usually unilateral. The acute form of hydrocele accompanies some varieties of orchitis and many cases of epididymitis, and occasionally follows traumatism. Sometimes the cavity of the tunic is divided into two portions by the adhesion of its walls, in which case the hydrocele is said to be bilocular. The causes of hydrocele, exclusive of traumatism, are not often very easily traced. It has been attributed to violent muscular efforts, to straining, etc., and is certainly favored by relaxation of the scrotum due to long-continued high temperature. Hydrocele is therefore more frequent in tropical climates than elsewhere.

The fluid of a hydrocele is almost identical in composition with the serum

of the blood. In the majority of cases it is transparent and of a straw or amber color. Occasionally, especially in traumatic hydroceles and in those which are secondary to disease of the tunic, the fluid is dark-colored and opaque, owing to the presence of the coloring matter of the blood-corpuscles which it contains. In old cases the tunic is often much thickened, and this thickening may of itself render the hydrocele incapable of transmitting light.

In *encysted* hydrocele the fluid is contained in the sac between the epididymis and the tunic or between the tunica vaginalis and the tunica albuginea. In *congenital* hydrocele the continuity between the cavity of the tunica vaginalis and that of the peritoneum still exists, so that the serum from the abdomen is free to pass downward along the track of the cord, and thus produces a hydrocele. *Infantile* hydrocele may be of either of the above varieties.

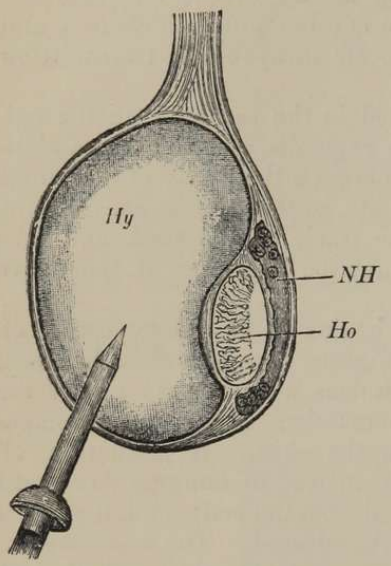
Symptoms.—The swelling in hydrocele begins at the lower portion of the scrotum, and is slow in developing: it is slightly pyriform, smooth, tense, and fluctuating; it is elastic on pressure, which does not alter the size of the swelling; it fluctuates distinctly, is dull on percussion, and is not accompanied by pain, redness, or other alteration in the skin. A peculiarity of hydrocele worthy of attention is that the tumor, instead of hanging downward between the thighs, as in hernia, projects forward from the body, and, if pressed back, springs again to its original position when released. The most characteristic symptom of hydrocele is its translucency. This should be elicited by examining the patient in a dark room while a candle is held close to one side of the scrotum, which is made tense by the hand of the surgeon, the other being placed in contact with the anterior margin of the swelling, so as to intercept the rays of light. In ordinary hydroceles the translucency is easily recognized. In those which contain an opaque or bloody fluid it cannot, of course, be found, and the use of an aspirating needle may be required to establish the diagnosis. The test by transmitted light should always be employed in cases of supposed hydrocele, to exclude the possibility of a coexistent hernia and to fix the position of the testis, which will generally be found posteriorly just below the middle of the scrotum. Attention to the features of the condition which have just been described will usually render the diagnosis easy, but in rare instances it is possible to be mistaken, as in cases of irreducible omental hernia with œdema of the scrotum and the subjacent tissues.

Treatment.—The treatment of hydrocele may be palliative or radical. Palliative treatment consists in occasional tappings when the tunic becomes fully distended. The patient should lie upon his back in a semi-recumbent position; the skin of the scrotum should be thoroughly disinfected and made tense by the left hand of the surgeon, who with the other plunges a small trocar into the anterior part of the sac in a direction upward and inward, avoiding any large superficial vein which may be apparent. The depth to which the trocar is plunged should be limited by keeping the thumb or finger-nail in contact with the canula at the distance of an inch and a half or two inches from the point of the instrument (Fig. 344). By observing this precaution and by inserting the trocar in the proper direction all danger of wounding the testicle is easily avoided, especially if its position has been previously and accurately determined by the light test. The sac having been emptied, the canula is withdrawn, and the little opening immediately closed by a pledget of bichloride cotton held in place by iodoform and collodion.

The *radical treatment* of hydrocele may be either by injection or by

operation. In the former case the fluid is withdrawn as above described. After the sac is emptied a quantity of the undiluted officinal tincture of iodine proportionate to the size of the sac, and varying from one to five or six drams, is thrown through the canula into the sac and allowed to remain there. To prevent the escape of any portion of the iodine, it is well to withdraw the syringe and canula together. The liquid is diffused over the entire surface of the membrane by lifting and gently rubbing the scrotum. The canula puncture is closed with cotton and collodion, the scrotum is elevated, and if it becomes very swollen and sensitive is covered with dilute lead-water and laudanum. In the course of twenty-four or thirty-six hours the swelling will have reached its original size or even passed beyond it. After this it begins to subside, and at the end of three or four weeks will, in successful cases, have disappeared entirely. The cause of failure in this simple operation is usually a neglect to use a sufficient quantity of iodine, or a failure to empty the sac of the hydrocele, so that the iodine which is injected is at once diluted by the remaining fluid and does not set up an adequate degree of inflammatory action. Sometimes, too, even when these precautions have been observed, a considerable quantity of the iodine already injected is lost at the moment of taking the syringe out of the canula. The great majority of all cases of uncomplicated hydrocele are curable by this method when properly performed, but if the tunica vaginalis be much thickened, injection however performed, must fail, owing to the impossibility of absolute collapse of the sac.

FIG. 344.



Tapping a Hydrocele; testicle in usual position: *Hy*, cavity of hydrocele; *NH*, epididymis; *Ho*, testicle (Tillmanns).

In congenital hydrocele in adults the method of injection may be dangerous on account of the communication of the sac with the peritoneal cavity. It would probably be better always to employ one of the methods yet to be described. Carbolic acid may be used in place of iodine, and is preferred by some surgeons. From five to ten drops of the pure acid, liquefied with the least possible amount of water, are injected, or a dram of the 5 per cent. solution in glycerin of the crystallized acid may be used.

Treatment by Incision.—By this method a vertical incision from one and a half to two inches in length is made through the disinfected tissues of the scrotum and along the anterior and lower portion of the swelling, and into the tunica vaginalis. The margins of the tunic are then stitched to the edges of the skin-wound by a few catgut sutures, and a large drainage-tube is introduced into the sac. The wound is dressed antiseptically and is washed out daily. The drainage is shortened at intervals, and the sutures may be removed before the end of the first week. Instead of using a tube, the cavity of the hydrocele may be packed with iodoform gauze.

Excision of the parietal layer of the tunic has been re-introduced by Von Bergmann, and consists in dissecting it out from the tissues of the scrotum and cutting off portions, leaving sufficient to serve as a normal covering for the testicle. A drainage-tube is inserted and the edges of the external wound are sutured. This method is more severe than those just described,

but may be required in cases of inveterate hydrocele in which all other methods fail.

Indications for the selection of one or the other of the other two methods are as follows: In the great majority of simple cases in which no previous operation has been tried the absence of a cutting operation or of an open wound, the fact that no anesthetic is required, and the comparatively short convalescence, together with the extremely favorable results, render the treatment by iodine injection the method of choice.

The antiseptic incision should be selected (*a*) in cases of previous failure with iodine; (*b*) where the sac is very large or has very thick walls; (*c*) where, on account of ill-health or premature age, the risk of inflammation after iodine injection is especially to be dreaded; (*d*) in cases of congenital hydrocele, when a careful incision with antiseptic precautions will be safer than any other method if the pressure of a truss for the obliteration of the peritoneal communication cannot be persevered in; (*e*) where the surgeon is desirous of exploring the sac of the tunica vaginalis, as in cases where enlargement of the testis of a doubtful nature coexists with hydrocele, and does not yield to ordinary treatment; (*f*) where two hydroceles coexist—*e. g.* vaginal and encysted hydroceles; (*g*) in some cases of hydrocele complicated with hernia—*e. g.* where the bowel is irreducible, and where, especially in unhealthy patients, there is a risk of the inflammation set up by the iodine extending to the hernial sac (Jacobson).

Hematocele.—Hematocele is a collection of blood in the tunica vaginalis. It is usually due to injury, but may be the result of disease affecting the inner surface of the membrane. It sometimes follows violent straining efforts, and now and then is a sequel of the treatment of hydrocele by tapping. It constitutes an ovoidal or globular tumor, with its largest circumference below, nonfluctuating, opaque, heavy, quite solid, and resistant to pressure. If these symptoms are all present, the diagnosis is usually easy. In old cases the thickening of the tissues is so great, and the density of the contents of the tunic is such, that the swelling resembles a solid tumor, and its true character can sometimes be recognized only by means of an exploratory incision.

Treatment.—In acute traumatic cases the scrotum should be elevated and wrapped in iced lead-water and laudanum. After the swelling has become stationary or has begun to subside, absorption of the blood may be favored by gentle and uniform compression, either by means of a narrow elastic bandage or by strapping with adhesive plaster. If, in spite of these means, a hematocele is very large, is increasing in size, and is accompanied by heat, pain, and œdema of the scrotum, it is well to make a longitudinal incision into the sac, evacuate its contents, irrigate the cavity, pack it with iodoform gauze, and dress it antiseptically. If at this time disease of the testicle itself is discovered, or if there is a marked amount of inflammatory change in the tunic, accompanied by great pain and irritation, castration, with removal of the sac, is the most satisfactory treatment.

DISEASES OF THE SPERMATIC CORD.

The cord is subject to a variety of *growths*, the most common of which, however, are the *lipomata*. These may be single or multiple. They are usually harmless and require no surgical treatment. Primary malignant growths of the cord are exceedingly rare, although malignant disease is often found to be secondary to similar disease of the testicle.

Diffused Hydrocele of the Cord.—The most important pathological

conditions of the spermatic cord are found in the various forms of hydrocele. As the testicle descends from the loins to the scrotum it carries with it a double layer of peritoneum, and this makes a serous sac extending from the internal ring of the abdomen to the scrotum, one layer lying in contact with the cord and the tunica albuginea, and the other with the inner surface of the cremaster muscle and the scrotum. The space between that portion of these two layers which surrounds the testicle constitutes the tunica vaginalis testis. Usually, above the external ring the space between the two layers is obliterated and they invest the cord as a single membrane. If they remain separate between the internal and external rings, and if serum accumulates between them, an elongated swelling forms, extending from a little distance above the testicle to the internal ring, cylindrical while the patient is lying down, but becoming pyriform when he is standing up. The swelling is soft and fluctuates: it may be made to appear below the external ring by pressure over the course of the canal, and will disappear when that pressure is removed. It is occasionally translucent by transmitted light. It is most likely to be mistaken for an irreducible omental hernia, as when it is tense there is a very perceptible impulse on coughing, and as the sac of such a hernia may contain a fluid which resembles that of hydrocele. It may be treated by iodine injection or by the introduction of the seton.

A similar condition, in which the two layers of the tunic investing the cord have remained open at one or more places and are blended together at others, gives rise to ENCYSTED HYDROCELE OF THE CORD, which is somewhat different in shape from the form just described, but otherwise has the same characteristics. Very rarely, the funicular process of the peritoneum contracts and becomes adherent to the cord at the external ring, but remains open above, communicating with the general peritoneal cavity. If this upper opening is large, it is possible to have a hernia and a hydrocele coexistent, but usually the funicular process adheres to the cord with sufficient closeness at the internal ring to permit only of the entrance and exit of fluid. When the patient stands erect the symptoms of this form of hydrocele are those of diffused hydrocele of the cord, but when he assumes the recumbent posture the tumor disappears, on account of its reducibility; and, as it often has a distinct impulse on coughing, this swelling is likely to be mistaken for hernia. It, however, disappears more slowly than the latter affection and without the characteristic gurgle, is slower in reappearing, and is often translucent. It should be treated by the application of a truss, which, especially in young persons, will often be followed by the closure of the peritoneal prolongation at the internal ring.

In congenital hydrocele in *children*, and, indeed, in all forms of hydrocele in infants, the treatment by the use of the seton is extremely satisfactory. The sac is punctured by a sharp tenotome, and a needle threaded with aseptic silk is passed along the blade of the instrument and brought out through the skin of the scrotum. The silk is loosely tied; the contents of the sac drain away by the side of the thread, which soon sets up sufficient adhesive inflammation to obliterate the cavity of the sac; it should be removed in two or three days, and should be covered in during its retention by an antiseptic dressing.

DISEASES OF THE SCROTUM.

Œdema of the scrotum deserves mention, as it is sometimes mistaken for hydrocele. It may follow any acute inflammation of the parts or any traumatism, but is oftener produced by the conditions which cause œdema of the lower extremities, such as cardiac and renal diseases. It is an almost invariable

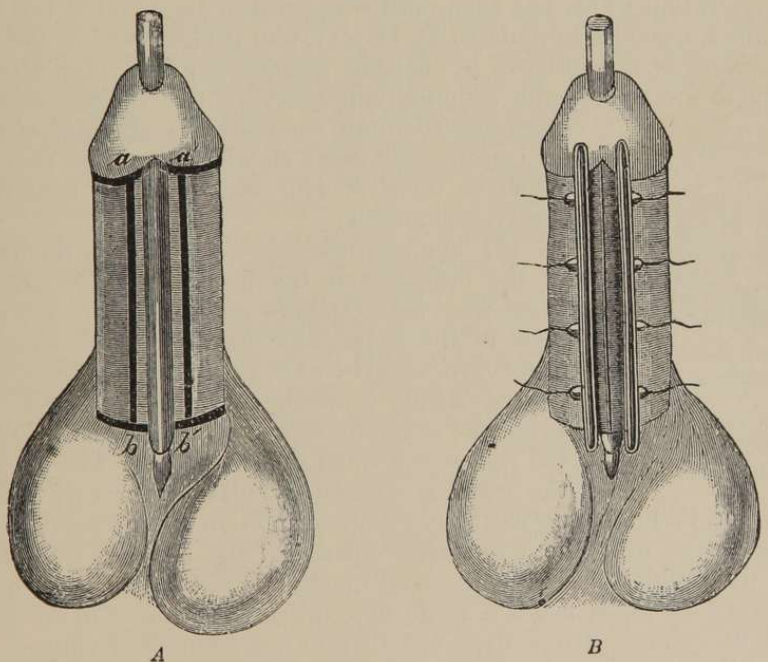
symptom of extravasation of urine superficial to Colles' fascia, in which case it soon extends to the subcutaneous tissue of the penis and prepuce, and often to that of the abdomen. It may usually be easily recognized by the pitting on pressure, the semi-transparent, glazed, and shining appearance of the skin, the disappearance of the normal scrotal folds, the doughy feel, and the uniform character of the swelling, which is almost always bilateral.

No special treatment is necessary except in cases where it arises from retained pus or urine, or where the tension is so great that the vitality of the skin is threatened. Under these circumstances free incisions extending well into the subcutaneous tissues should be employed.

Elephantiasis of the Scrotum is a disease which is accompanied by an enormous hypertrophy of the subcutaneous connective tissue, due probably to a chronic inflammatory condition of the lymph-vessels, which, in its turn, may be produced by the presence in the blood of the filaria sanguinis hominis. (See p. 461.)

Epithelioma of the Scrotum, known as chimney-sweep's cancer, is a disease which has the characteristics of epithelioma elsewhere, beginning as a little warty growth, usually at the lower part of the scrotum, often covered with a peculiar crust, ulcerating, and gradually extending until all the superficial tissues are involved. Later, the inguinal glands are infected, and the patient dies as in other forms of carcinoma. It is exceedingly rare in this country, and its comparative frequency at one time in Great Britain was supposed to be due to the soft coal which was so commonly used there, the soot or particles

Fig. 345.



Duplay's Operation for Hypospadias (Duplay and Reclus).

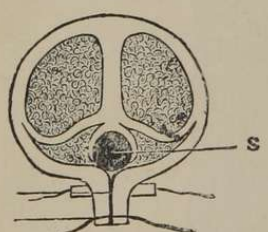
of which, accumulating in the flexures of the scrotum of an uncleanly person, were thought to give rise to persistent irritation, which later determined the cancerous growth. The treatment is by early and thorough excision.

PART VI.—DISEASES AND INJURIES OF THE PENIS.

HYPOSPADIAS.—This is a congenital deficiency in the lower wall of the urethra, which may terminate at the perineo-scrotal junction or at any point anterior to it. The varieties of hypospadias are described in accordance with the degree of arrest of development which has occurred. If this has been extreme, the anterior orifice of the urethra may even lie in the perineum, the two halves of the scrotum remaining ununited, and often consisting of two separate pouches, which are empty when the testicles have failed to descend, and which therefore resemble strongly the external genitalia of the female. In these cases the penis is atrophied and is closely applied to the fissure in the scrotum. In the *peno-scrotal* variety the opening is at the junction of the anterior fold of the scrotum with the inferior surface of the penis, and the latter is apt to be somewhat better developed, although still strongly curved downward, owing to its being much shorter on its inferior than on its upper surface. In the *penile* variety of hypospadias the urethral opening may be at any point on the lower surface of the penis between the peno-scrotal junction and the corona glandis. In the so-called *balanic* hypospadias the opening of the urethra is situated on the under surface of the glans; the frænum is absent. There is often a little groove at the anterior extremity of the glans which resembles the normal meatus, but which usually ends in a blind pouch. When this disease is situated far back, the patient is usually sterile, though not necessarily impotent if the organ is well developed. Often, however, it is so rudimentary or so markedly curved upon itself that intercourse is impossible. The glandular forms of hypospadias are of no physiological importance.

The operation which has been most successful in the relief of this condition is that which has been formulated by Duplay, and is performed in three stages: (1) The penis is straightened by incising transversely the ridge which unites the glans to the hypospadic opening, and carrying this incision as deep as is necessary to obtain complete straightening of the penis. A considerable delay should follow this step, often as much as three or four months if the incurvation has been considerable.

FIG. 346.



Transverse Section of the Penis after Operation: *S*, the new urethra (Duplay and Reclus).

(2) The next step should consist in the restoration of the meatus and the formation of a new urethral canal from the extremity of the glans to the neighborhood of the hypospadic opening, which should be left untouched to give exit to the urine. The meatus is formed simply by freshening the two lips or by deepening the latter by means of incision, and then uniting the lips over a small gum catheter. The remainder of the canal is formed by making on each side of the penis and on its lower surface a longitudinal incision extending from the base of the glans to near the hypospadic opening (Fig. 345, *A*, *ab*, *a'b'*). The internal lip of this incision is dissected up slightly, while the external is dissected freely, so as to make a large flap, taken from the skin of the lateral parts of the penis. These flaps are then united by quilled sutures of silver wire or silk, perforated shot being employed to fasten them, or the wire or silk may be passed through small perforated leaden plates or tubes (Fig. 345, *B*). These flaps are united over the catheter, which will thus have a cutaneous covering at its upper and lateral aspect and a linear granulating surface beneath it (Fig. 346). Duplay asserts that no contraction of the canal results from the cicatrix thus formed.

(3) The third stage consists in the freshening of the fistulous opening which is left, and the union of its edges over the retained catheter by means of the same form of suture.

In the second stage several operations may be required to secure a complete urethra. The statistics of the Hospital of the University of Pennsylvania show that on the average three or four operations, extending over six to eight months, are necessary.

EPISPADIAS is an absence of the upper wall of the urethra, and is much rarer than hypospadias. It is often associated with exstrophy of the bladder. It may be extensive, in which case the opening of the urethra is close to the pubes, or there may be a congenital absence of the pubic symphysis. An operation similar to that just described is employed for its cure, but is often more troublesome and less successful than that used for hypospadias.

WOUNDS OF THE PENIS are of no special importance unless they involve the urethra or extend deeply into the spongy or cavernous bodies. They should be treated on the general principles which apply to the treatment of all wounds, but will require in addition, in the majority of cases, the introduction and retention of a metal catheter in order to give a point of support for sutures or dressings. Hemorrhage is sometimes very obstinate.

When the urethra has been divided, immediate sutures, extending to the submucous tissue, and a retained catheter should be employed.

FRACTURE OF THE PENIS has been known to occur during coition, and consists in laceration of the corpora cavernosa, followed by extensive extravasation of blood into the erectile tissue. It has also occurred from injury inflicted accidentally or maliciously, but always when the organ was in a state of firm erection. Hemorrhage must be arrested as soon as possible by enveloping the penis in cold cloths and tightly bandaging it. If the distention from the escape of blood into the spongy tissue is so great as to imperil the vitality of the tissues or of the organ, one or more incisions should be made for the escape of blood. An annoying sequel of the accident is the tendency to lateral or upward or downward curvature during erection. This is sometimes so marked as greatly to interfere with coitus, and even to render the patient permanently impotent.

PHIMOSIS is a condition in which the prepuce is unnaturally elongated, and at the same time its orifice is contracted so that it is difficult or impossible to uncover the glans. It is generally congenital, although occasionally acquired as the result of masturbation at a very early age. It is of more than local importance, as in the young it keeps up a continual irritation which often leads to masturbation or to vesical irritability. It frequently interferes with the full growth and development of the organ. The balanitis and balanoposthitis to which it gives rise are sometimes followed by grave nervous symptoms—chorea, epilepsy, and other diseases of a similar character. It also favors greatly the contraction of venereal disease.

The operation of circumcision is indicated in every case in which the above condition exists. No child is too young for its performance, and most adults with hypertrophied foreskins with small orifices would be benefited by the operation. In preparing for its performance the two layers of the prepuce should be carefully washed with soap and water, and disinfected and rendered aseptic in the usual manner. The prepuce is then drawn forward, so that it can be grasped in front of the anterior extremity of the glans by a pair of forceps the blades of which are long enough to extend on either side beyond its edges. These may be self-retaining or may be entrusted to an assistant. The operator then seizes the projecting portion of the prepuce and removes it by means of a

sharp bistoury, cutting along the anterior edge of the forceps. These being removed, it will be found that while the skin retracts to or behind the corona the glans is still covered by the hood-like mucous membrane. This should now be divided in the median line up to the dorsum of the glans near the corona, and then should be trimmed off at a distance of a sixteenth to an eighth of an inch from the point of reflection, following the curve of the coronal edge, and either going through the frænum or leaving it untouched, according to the amount of hypertrophy present at that point. It should be remembered that the chief cause of the not infrequent failure of young operators permanently to uncover the glans penis by this operation is their neglect to cut this fold sufficiently short. When it is left long enough to come forward in front of the meatus, it brings with it the elastic and extensile skin: the cicatrix forms in that position, and the phimosis for which the operation was performed recurs. By leaving the strip of mucous membrane no broader than an eighth of an inch this accident may always be prevented. If the frenal artery is cut during the operation, it should be ligated with fine catgut. Torsion is not always reliable. The edges of the skin and mucous membrane should be brought into apposition by a few interrupted sutures, and the line of incision dressed with some unirritating antiseptic. Some operators prefer an entirely dry dressing, and Palmer of Louisville describes as follows a method by which he has had admirable results: After stitching, a piece of dry aseptic gauze, four inches long and half an inch wide, covered with iodoform and boric acid and spread on a clean towel, is laid under the frænum, brought up around the cut, right and left, to the dorsum, and trimmed with scissors. Over this a strip of absorbent cotton three-quarters of an inch wide, then a Maltese cross of dry gauze, with a central hole for the meatus, and then a similar cross of rubber tissue, are applied, and the whole bandaged snugly in place. A waist-belt, a jock-strap, and a bunch of cotton to cover the glans, well dusted with boric acid, complete a dressing that permits the subject to go to work at once at any ordinary vocation. If the patient will retract the dressing on urinating and use a little absorbent cotton to receive the final drops, this original dressing may be left on five days. When the stitches are removed the parts should be dusted with boric acid, a loose pledget of cotton wrapped around them, and the patient discharged.

Occasionally, owing to oozing of blood, it may be found necessary to make additional pressure. In such a case an extra one-inch roller may be applied over the dressing, to be removed some hours later without disturbing the dressing proper.

Inflammation of the Penis is usually the result of extension either from a severe infective urethritis or from a phagedenic chancre or chancroid.

Gangrene of the Penis is almost always the result either of mechanical obstruction, as where, either for mischief or for purposes of sexual excitement, foreign bodies have been tied around the organ, or of phagedena. It occasionally follows unrelieved cases of paraphimosis.

Epithelioma of the penis and of the foreskin has the usual characteristics of this disease elsewhere. It is favored by the presence of a long or contracted prepuce and by accumulations of smegma, by concretions or calculi, or by any other source of local irritation. If it is confined to the foreskin and is recognized early, circumcision is sufficient treatment. But if, as is more commonly the case, it has already extended to the glans, nothing short of amputation of the penis will be of any value, and it is better in these cases to sacrifice the larger portion of the organ.

The operation is a simple one: the hemorrhage may be controlled by the

grasp of the thumb and finger of an assistant close to the pubes or by surrounding the root of the organ with a narrow rubber cord; and a circular stroke of the knife at a point well behind the uppermost limit of the disease is sufficient for the removal of the organ. The vessels may be tied separately; the mucous membrane can be brought forward and stitched to the skin, or, if the operation is modified and the corpus spongiosum containing the urethra is left somewhat longer than the rest of the stump—the better plan—the urethra may be slit up with scissors, and the lower wall attached by a suture to the skin of the under surface of the penis, while the cut edges of the upper wall are sutured to the corpora cavernosa. The retained catheter will be required: an antiseptic dressing, preferably of iodoform, should be applied around it, and if there occurs any moistening of the parts with urine, they should be irrigated and dusted afresh with iodoform daily. The method of section by the écraseur is not to be recommended.

Amputation of the entire penis is sometimes required for malignant disease. The operation is as follows (Treves): The patient having been placed in the lithotomy position, the skin of the scrotum is incised along the whole length of the raphé. With the finger and the handle of the scalpel the halves of the scrotum are then separated down to the corpus spongiosum. A full-sized metal catheter is now passed as far as the triangular ligament, and the knife is inserted transversely between the corpora cavernosa and the corpus spongiosum. The catheter having been withdrawn, the urethra is cut across. The deep end of the urethra is then detached from the penis back to the triangular ligament. An incision is next made round the root of the penis continuous with that in the median line; the suspensory ligament is divided, and the penis separated except at the attachment of the crura. The knife is now laid aside, and with a stout periosteal elevator or rugine each crus is detached from the pubic arch. This step of the operation involves some time, on account of the very firm union of the parts to be separated. Four arteries—the two arteries of the corpora cavernosa and the two dorsal arteries—require ligature. The corpus spongiosum is slit up for about half an inch, and the edges of the cut are stitched to the back part of the incision in the scrotum. The scrotal incision is closed by sutures, and a drainage-tube is so placed in the deep part of the wound that its ends can be brought out in front and behind. No catheter is retained in the urethra.

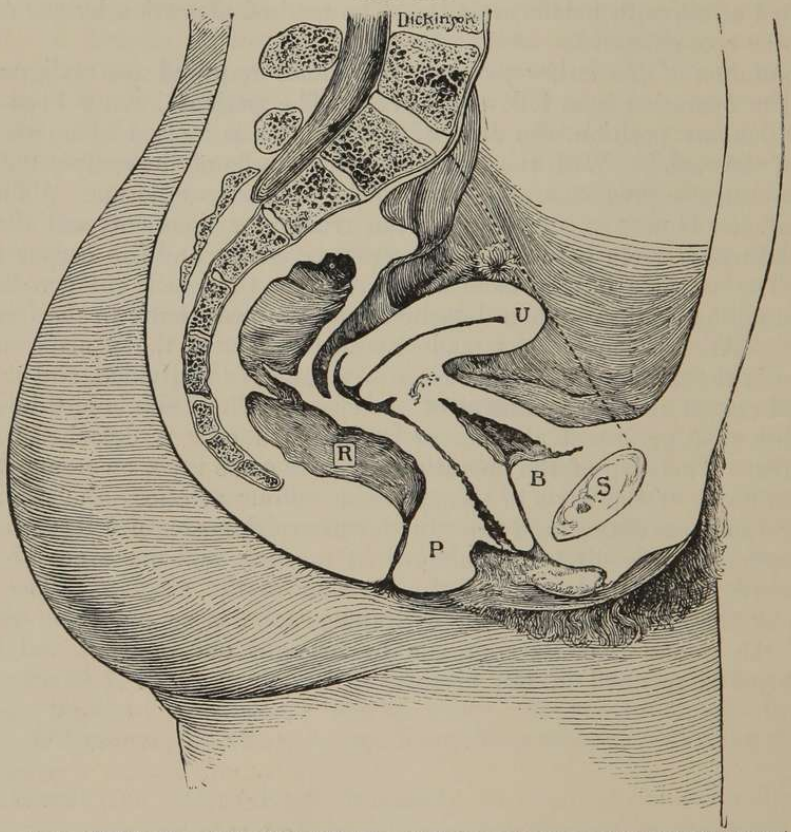
CHAPTER VIII.

SURGERY OF THE FEMALE GENERATIVE ORGANS.

Anatomical Memoranda.—Certain anatomical data are important to be borne in mind by the surgeon in the investigation and operative treatment of the generative organs of the female.

The peritoneum which invests the uterus descends in front only far enough to cover the upper three-fourths of its surface (Fig. 347). Being reflected

FIG. 347.



Diagrammatic Sagittal Section of the Female Pelvis: U, uterus; R, rectum; S, symphysis; P, perineal body; B is beneath bladder. This is the position of the uterus when the bladder is almost empty (Skene).

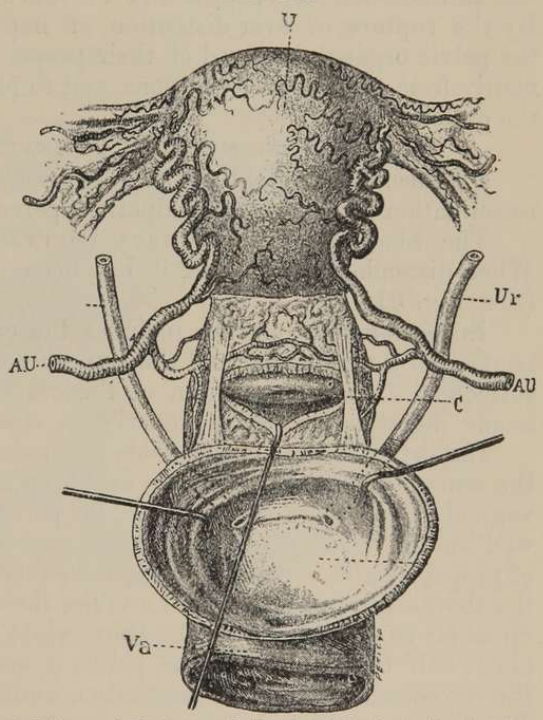
thence upon the posterior wall of the bladder, usually at about the level of the os uteri internum, the lower segment of the uterus, anteriorly, is left in close relation to the base of the bladder, being separated from it only by a thin layer of loose connective tissue. Along the posterior surface of the uterus the peritoneum descends somewhat below the level of the vaginal insertion before it is reflected backward upon the rectum. The layers of the peritoneum which extend laterally from the uterus to the sides of the pelvis, constituting the broad ligaments, enfold the Fallopian tubes, the ovaries, the parovarium, and the round ligaments, together with the cellular tissue, lymphatics, nerves, and some muscular fiber. When tension is made upon the round ligaments from without so as to draw them out through the internal abdominal ring, as in

operations to shorten them, their closely-attached peritoneal covering is drawn out with them to some extent, and requires to be carefully detached and reflected in order to make possible the extraction of the required amount of the ligament.

The ovaries project upon the posterior surface of the broad ligaments, and the fimbriated extremities of the tubes droop posteriorly toward the ovaries. To this anatomical relation is due the fact that in inflammatory affections of the ovaries and tubes these organs tend to sink into and become adherent in the posterior cul-de-sac, where they must be sought by the finger of the surgeon for the purpose of enucleation. The two layers of the broad ligaments are loosely joined by connective tissue. They are easily separated to an indefinite extent by hemorrhagic or inflammatory effusions or by the development of new growths. The ovarian artery courses along the upper border of the outer part of the broad ligament. If traction is made upon the ovary so as to make tense and prominent the part of the ligament extending from the ovary to the lateral pelvic wall, the artery may be easily identified, and preliminary ligation or compression of it may be readily done.

The uterine artery, leaving the lateral pelvic wall at a point just above the ischial spine, reaches the vaginal wall at the level of the os externum, and thence runs upward toward the uterus (Fig. 348). Opposite the junction of the vagina and uterus it gives off a good-sized branch, which with its fellow of the opposite side encircles the cervix. Thence it runs tortuously up the side of the uterus between the folds of the broad ligament, giving off frequent branches to the uterus, and finally inosculates with the ovarian artery above. Preliminary ligature of this artery may be readily done from the vagina by pulling the cervix down toward the vulva, and then passing a ligature by means of a well-curved needle introduced deeply at the side of the cervix through the lateral vaginal pouch. The needle, having described a curve through the tissues, is brought out a short distance behind its point of entrance. The ligature which is thus introduced will have passed around the artery, and when firmly drawn and tied will have closed it. The uterine artery may also be tied from above within the pelvis, when the pelvic organs have been exposed by abdominal section, by drawing the uterus to the side opposite to that upon which the ligature is to be applied, and then carrying a curved needle, armed with a ligature, through the attachment of the broad ligament to the uterus, so as just to engage the substance of the uterus; then, having penetrated both layers of the broad ligament, it should be carried back, per-

FIG. 348.



Relations of Ureters and Uterine Arteries to the Cervix *U*, uteru; *C*, cervix; *Va*, vagina; *Ur*, ureter; *A U*, uterine arteries (Pozzi).

forating the ligament again at a point about three-eighths of an inch to the outside of the first perforation. The artery will be embraced by this loop, which may then be tied.

The ureters in their course toward the base of the bladder approach laterally to within about half an inch of the uterus at the level of the os internum. They preserve about this distance from the cervix as they pass onward to the bladder, the opening of the ureter into the bladder being about half an inch anterior to the cervico-vaginal junction (Fig. 348). The lower outlet of the pelvis is closed in by a diaphragm of muscular and fascial tissue, the fibers of which, having their origin from the lateral bony points, blend in the middle line, where they converge to the outlets of the rectum and the vagina. By the integrity and tonicity of the various parts of this complex diaphragm the pelvic viscera are held in place. Additional support is received from the peritoneal reflections that envelop the pelvic viscera, and from the fibrous strands and connective-tissue substance that bind them together.

By the extensibility, the contractility, and the mobility of its different supports the widely-varying degrees of distention and of contraction which the functions of the pelvic organs normally require are made possible. This peculiarity of structure makes it possible for the uterus to be drawn down to the vaginal outlet for examination and for operative attack, and facilitates the introduction of specula and of the finger for purposes of exploration. By the rupture or over-distention of important portions of this diaphragm the pelvic organs, deprived of their proper support, tend to sink down permanently from their proper positions and to protrude in varying degrees through the outlets below.

METHODS OF INVESTIGATION.

Diagnostic investigations of the generative organs of the female include examination by inspection, palpation, percussion, and exploratory puncture.

The bladder should always be evacuated, preferably by a catheter. When distended with urine, it has been mistaken for an abdominal tumor. (See Fig. 314.)

Inspection.—Inspection includes the careful observation of the hypogastrium and the pudenda, and the exposure of the cavity of the vagina and the surface of the vaginal portion of the cervix uteri by proper specula. Microscopic investigations may properly be classed as methods of inspection.

Inspection of the hypogastrium requires the supine position; of the pudenda, the same posture with the knees drawn up and the thighs abducted. For intravaginal inspection a retractor for the perineum is required; for instance, the well-known retractor of Sims. The patient, having been placed upon a table of proper height, is made to lie upon her left side, the left arm behind the back, the thorax fully prone upon the table, the right knee fully flexed and brought up as far as possible under the body, while the left knee and leg are carried up about half the distance. The pelvis is now brought to the edge of the table, the retractor inserted into the vagina, and the perineum strongly drawn back. The vagina is distended by the air which is thus admitted, and by properly varying the depth to which the retractor is inserted and the direction in which traction is made, together with elevation of the right labium and natis by the hand of an assistant, the entire vagina and the vaginal portion of the cervix uteri may be brought into view. Inspection may be still further facilitated by elevating the anterior wall of the vagina by a suitable rod or speculum and by drawing down the uterus with a tenaculum.

Palpation.—By the touch may be ascertained the rigidity of overlying parts; the sensitiveness of the organs; their position, size, shape, and den-

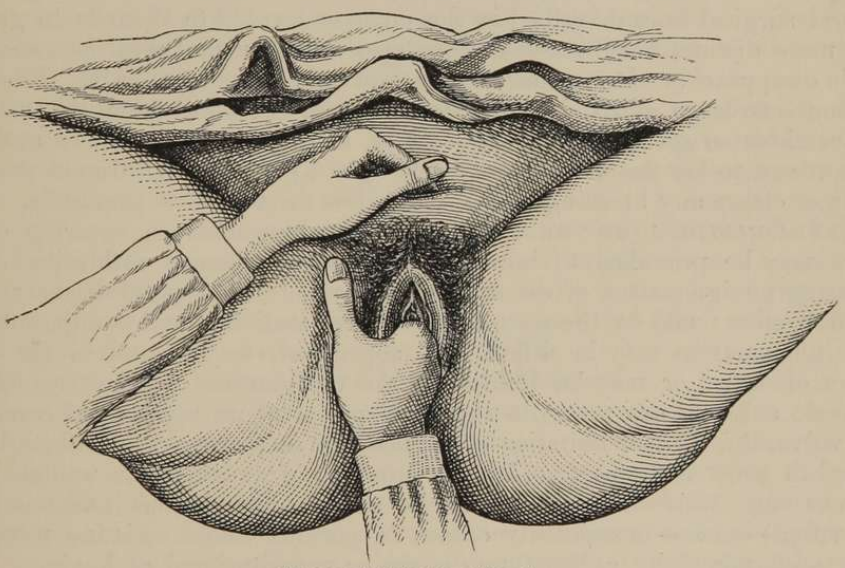
sity; their mobility and their relations to other organs; the presence of adhesions, infiltrations, exudations, and tumors; the character and extent of tumors and other abnormal masses.

For the purpose of palpation that position should be secured which will relax as much as possible the muscular and fascial coverings that hide the parts to be palpated. As a rule, the supine position, with the knees drawn up on a firm table of proper height, is the most favorable. Great differences exist in the completeness with which palpation may be done upon different individuals, owing to the varying degrees of rigidity and sensitiveness of tissues and of accumulations of adipose tissue. The more relaxed and thin the tissues, the more facile the palpation. The induction of relaxation by complete anesthesia is often requisite to make satisfactory palpation possible.

Large pelvic tumors are readily detected and much valuable information about them is to be gained by simple hypogastric palpation. Their size, their mobility, whether solid or fluid, their shape, the readiness with which the abdominal wall can be made to glide over them, may be ascertained with considerable accuracy. The vaginal touch in such cases may supplement the hypogastric, and is especially valuable in determining the relations of the tumor to the uterus and the character of the deeper portion of the tumor.

Palpation of the ovaries, tubes, and uterus should always be done by the combination of hypogastric pressure with the vaginal or rectal touch—*bimanual*

FIG. 349.



Bimanual Palpation (Pozzi).

palpation. The external hand should be placed above over the normal site of the organ to be examined, and deep, firm pressure should be exerted in the direction of the tip of the vaginal or rectal finger, so as to push the organ down toward it and prevent its escape. The finger which is in the vagina should at the same time press upward into the pelvis as far as possible. In this way in favorable cases the organ can be balanced between the two forces and its examination satisfactorily effected (Fig. 349). Rectal examination may be made more complete and satisfactory by simultaneously drawing down the uterus toward the vulva by a tenaculum in the hands of an assistant. The uterine sound is available as a means of ascertaining the depth and direc-

tion of the uterine canal. It is practically a lengthened finger, and its use is one form of palpation. It is rarely needed.

Percussion.—The relative dulness or resonance over the hypogastric region gives valuable information as to the presence and location of inflated intestine and of solid or fluid tumors. It is chiefly valuable in distinguishing ascitic fluid from cysts.

Exploratory Puncture.—Information as to the composition of an obscure swelling deep in the pelvis may be obtained by the use of a small trocar and aspirating syringe. Its results cannot always be considered as certain, for a swelling may be fluid at one part and solid at another, and the exploring trocar may not reach the fluid part, and so conclusions based upon the results of its insertion may be erroneous. Danger of wounding other organs or vessels or of introducing or disseminating infection attends its use, so that it should rarely be resorted to, especially as the information sought to be gained by it can generally be obtained by other means. Whenever it is resorted to it should be with the most careful antiseptic precautions.

SURGERY OF THE VULVA.

Injuries of the Vulva are likely to be attended with special symptoms from the rupture of some branch of the rich venous plexus with which it is supplied. Penetrating wounds may occasion copious hemorrhage; contusions may produce extensive infiltrations of blood. These are to be treated on the general surgical lines described in the chapter devoted to Wounds in general. The more distinct blood-masses, *hæmatoma vulvæ* or *pudendal hematocele*, as a rule disappear in time under simple rest and gentle pressure. When the effusion is so large as to cause decided pressure effects, or when the distended tissues threaten spontaneously to give way, it is better, with proper antiseptic precautions, to lay the whole mass freely open by the knife, turn out the clots, ligate or clamp any bleeding points, and allow the wound to granulate.

Inflammations of the Vulva.—The muco-cutaneous covering of the vulva may be provoked to inflammation by the presence within its folds of irritating foreign matter, of decomposing secretions, or of acrid discharges; by undue friction; and by the extension of inflammation of parts adjacent to it. The inflammation may be diffuse and superficial, may extend to the deeper layers of tissue, or may be limited to the muciparous or sebaceous follicles. Diabetic subjects are prone to the development of an aggravated eczema of the vulva, due to the irritation of fermenting saccharine urine which is permitted to moisten the parts. By the infection of abrasions or wounds phlegmonous suppurative inflammation may develop. Gangrenous inflammation of the vulva—*noma*—occasionally occurs in persons whose resisting power has been undermined by exhausting disease or constitutional cachexiæ. It has most frequently occurred in badly-nourished children as a sequel to one of the eruptive diseases. The ulcerations and eruptions (mucous patches) seated upon the vulva, due to venereal infection, have been treated in the chapter devoted to Syphilis.

Symptoms.—The parts are tender and congested, and more or less tumefied and covered with muco-purulent secretion. Raw patches due to exfoliation of epithelium may be present. Pruritus is apt to be a source of complaint. In the follicular variety minute red papular elevations may stud the surface of the part. These are the congested orifices of the affected follicles, and give exit to an altered and increased mucous or sebaceous secretion. Inflammation of the gland of Bartholin will declare itself by the appearance

of a painful tense oval swelling low down upon the inner aspect of the vulva at the entrance of the vagina. In the phlegmonous forms of vulvitis increased local swelling and pain and more marked constitutional reaction are present. Suppuration and gangrene are indicated by their usual signs.

Treatment.—The milder forms of vulvitis need little more than rest, the removal of the exciting cause, and cleanliness. The parts may be irrigated with a warm solution of borax or boric acid, and the labia kept separated by a fold of soft absorbent fabric, as absorbent gauze, saturated with oxide-of-zinc cream, the latter being simply enough oxide of zinc stirred up in water to form a creamy fluid, which may be extemporaneously prepared as often as needed. Solutions of permanganate of potassium, sulphate of zinc, alum, nitrate of silver, and other mildly antiseptic and astringent substances may also be used to advantage for purposes of irrigation. When the inflammation is more acute and painful, warm fomentations of lead and opium (liq. plumbi subacetat., ℥ij ; tinct. opii, f℥j ; aquæ, Oij) are to be used until the acute symptoms subside. Deep suppuration requires treatment by early incision, as in other parts of the body. Gangrene should be attacked locally by the free use of the actual cautery or of the knife, followed by a saturated solution of chloride of zinc, so as to destroy the local infective poison, with subsequent continuous antisepsis of the parts by iodoform tampons, while every possible means to stimulate the general strength of the patient should be employed.

Pruritus.—The annoying itching which attends the various forms of vulvitis may require special treatment for its relief while the measures required for the cure of the conditions that cause it are being carried on. The vulvar surfaces must be protected as far as possible from the contact of all irritating discharge. The antiseptic washes used for the relief of the vulvitis may suffice for this. Keeping the vulva well smeared with a bland ointment, as ungt. zinci oxidi, will give relief. The use of a solution of corrosive sublimate in emulsion of bitter almonds (1 : 500) will give the combined antiseptic and antipruritic effects of the mercurial and of hydrocyanic acid. It may be employed twice daily. In diabetic cases the fermentation of the urine may be kept in check by the free use of a 3 per cent. solution of hyposulphite of soda or of chloral. In senile pruritus pudendi, in which there is atrophy of the nerve-terminals, rather than inflammatory irritation, peppermint-water will sometimes afford relief—five drops of oil of peppermint shaken up thoroughly in a pint of hot water to which a teaspoonful of borax has been added. The parts should be bathed freely with this lotion. An 8 per cent. solution of cocaïne pencilled over the parts will also sometimes afford relief. In inveterate cases that have resisted other treatment relief may possibly be obtained by pencilling the entire affected surface with a mixture containing equal parts of carbolic acid and tincture of iodine. A superficial eschar is produced, with permanent change in the sensitiveness of the nerve-endings. Certain cases resist all treatment and require the constant use of opiates to relieve the suffering which the affection entails.

Tuberculosis Vulvæ.—The labia are occasionally the seat of local tubercular infection. The disease in its advanced ulcerative stages has been termed *lupus vulvæ*, and by the French *esthiomène*. The local infection first manifests itself by the formation of superficial tubercles, which coalesce. The moisture and warmth of the parts favor early necrosis. The resulting ulcer gradually extends peripherally, surrounded by a zone of infiltrated infected tissue. The edges of the ulcer are thin, purple, and undermined, and its base is irregular and eroded, secreting a scanty, thin, puriform discharge. Cicatrization is frequently present at one part while the ulcer is extending at other points. The extent of the infiltration and the destruction of tissue may vary greatly:

in some instances the inflammatory and tubercular infiltration of the parts is sufficient to occasion great increase in their volume; in others, a predominating ulcerative action, involving especially the skin and adjacent connective tissue, may produce extensive dissections about the vagina, bladder, and rectum. Erosion of blood-vessels may provoke repeated hemorrhages. The affection is most frequent in the young, and is likely to be accompanied with tuberculosis of other portions of the body. Recurrence after apparent healing is frequent.

Diagnosis.—The affection is to be distinguished from epithelioma and from syphilitic ulceration: differentiation is not always easy, but may usually be made by attention to the following points: 1. The age of the patient: the tubercular ulcer is most common in early life, epithelioma in later life. 2. The history: antecedent syphilis; tuberculosis in other parts of the body. 3. The appearance of the ulcer: the epithelioma exudes a more abundant fetid secretion; its surface is mammillated, its edges are heaped up, and its base is more extensively and deeply infiltrated. The syphilitic ulcer is crateriform, with sharply-cut edges, in marked contradistinction to the flat, superficial, eroded tubercular ulcer with its undermined edges. 4. The effects of treatment: antisyphilitic treatment causes speedy improvement in the syphilitic ulcer; is without benefit in the other forms. 5. Bacteriological tests: the detection of the bacilli of tuberculosis by adequate tests suffices to establish the diagnosis.

Treatment.—Constitutionally, measures calculated to improve the general health which are of proved value in dealing with tuberculosis in any part of the body are to be vigorously resorted to. Locally, thorough curetting of the base and borders of the ulcer should be done, scraping away all the somewhat soft and degenerated tissue which may be present, and which will readily yield to the curette. The remaining surfaces should then be cauterized with the thermocautery or with a saturated solution of chloride of zinc. Tampons of iodoform gauze or dressings of Peruvian balsam should be used in the after-treatment till full cicatrization is accomplished.

Tumors of the Vulva.—The labia may become the seat of any of the growths, benign or malignant, to which similar tissue in other parts of the body is subject. Out of 10,290 neoplasms in females recently analyzed by W. R. Williams, 420 had their initial seat in the external genitals, including the vagina. Of these, 158 were epitheliomata; 3 were sarcomata; 17 were fibromata; 1 was a lipoma; 167 were non-venereal papillomata, of which 148 were urethral caruncles; and 74 were cystomata.

Papillomatous Growths sometimes display much luxuriance, which is favored by the warmth, moisture, and friction of the parts. They should be excised if pedunculated; destroyed by caustic if broadly sessile. Small vascular papillomata at the entrance of the urethra—**urethral caruncles**—are common. They appear as bright-red, fleshy growths of small size, and are often the source of much annoyance from smarting during urination and from bleeding. They may be destroyed by cauterization or by excision, great care being given to the absolute arrest of the bleeding.

Malignant Disease of the Vulva tends to rapid extension and early involvement of the adjacent lymphatic glands. Excision to be of any avail must be done early and with care to excise a wide area of the apparently uninvolved tissues.

Dermoid and Sebaceous Cysts are met with, but the most common cystic tumor of the vulva is a **retention-cyst of the glands of Bartholin,** which presents itself as an ovoid, tense, elastic, painless tumor low down at the vulvo-vaginal junction. It may demand no treatment, but if its size becomes

inconvenient it should be dissected out. If it becomes inflamed, it should be freely laid open and its sac dissected out.

LYMPHŒDEMA, or ELEPHANTIASIS, occurs in the vulva next in frequency to elephantiasis of the leg and foot. Extirpation with the knife is the only remedy of any value.

The veins of the vulva may undergo great VARICOSE ENLARGEMENT. This may arise spontaneously, or may be due to the pressure of a pregnant uterus or of a pelvic tumor upon the venous trunks into which the vulvar veins empty, or to their occlusion. In the latter cases rest in the recumbent posture and gentle support by a properly adjusted compress is the most that can be done by way of palliation. In other cases ligation and excision of the varicose vessels are required.

ADHERENT LABIA.—Adhesion of the opposite surfaces of the labia minora is not uncommon in infants as the result of slight vulvitis from defective cleanliness. The adhesions are usually not very firm, and give way to traction. If necessary, the knife may be used to accomplish their separation. The parts should be kept separated by a suitable compress until the abraded surfaces of the labia become healed.

More dense and extensive adhesions of the labia in later life may result from ulcerative inflammation of these parts and their blending together in the subsequent cicatrization. Such adhesions require the knife.

SURGERY OF THE PERINEUM.

RUPTURE OF THE PERINEUM may be occasioned by accidental traumatism, but is commonly the result of over-distention of the perineal body during childbirth. Every degree of laceration may result from this latter cause, from slight tears of the fourchette to extensive rents involving the sphincter ani and a portion of the recto-vaginal septum. If the rent does not involve the sphincter ani, it is termed an *incomplete rupture;* if the sphincter is involved, the rupture is said to be *complete.* In other and not infrequent instances subcutaneous rupture of the muscular tissue and fasciæ of the perineum takes place, producing relaxation of the pelvic floor and loss of perineal support, although the skin and mucous surfaces remain intact. Such injuries may be termed *concealed ruptures.*

The chief disabilities determined by tears of the perineum depend upon the greater or less loss of the muscular support to the pelvic viscera which results. The injury, as a whole, is a combination in varying amounts of separation, paresis, and atrophy, the effects of over-distention and bruising as well as of laceration, so that often the apparent tear gives little clue to the extent of the real loss of support.

The **symptoms** are, first, a sense of weakness and of dragging down of the pelvic organs from the sagging down of the pelvic floor and the resulting undue stretching of the remaining supports; and, secondly, actual prolapse in varying degree of the vagina, bringing with it the anterior wall of the rectum, *rectocele,* and the base of the bladder, *cystocele,* and ultimately the uterus, *procidentia uteri.* These conditions of relaxation and prolapse are often greatly aggravated by the imprudence of patients in leaving their beds within a few days after delivery, before full involution of the uterus has taken place and before the overstretched and semi-paralyzed tissues of the pelvic floor have had time to regain their tone. Rupture of the sphincter ani adds to the above symptoms those of incontinence of feces and of flatus.

Treatment.—Immediate suture of a perineal rent for the purpose of secur-

ing primary union if possible should always be done. These tears are lacerated and infected wounds, and are to be managed in accordance with the general principles governing the treatment of such wounds. Special care should be taken so to place the sutures that perfect coaptation of the muscular elements of the perineum shall be secured. A strip of iodoform or oxide-of-zinc gauze should be laid in the vagina, protruding from the vulva, to act as a drain for the vagina, preventing accumulation of the lochia within it, and an abundant absorbent compress should cover the perineum and vulva, and be changed as often as saturated. The bowels should be kept loose, and the bladder relieved by catheter during the first week. The sutures should remain *in situ* for ten days, but should be removed at any time if evidences of deep suppuration demand the abandonment of the attempt at primary union. The usual ten days' recumbency observed after childbirth should be prolonged to at least twenty-one.

Perineoplasty.—Plastic operations for restoration of the perineal body are required when primary suture has failed or been omitted. They should not be undertaken until from six to twelve months after the original injury, and a time should be chosen when both the local and the constitutional conditions of the patient are good. In the complete variety relaxation of the contracted sphincter should first be secured by distending it twice daily for a week or more before the operation by inserting a finger into the anus and pressing the parts firmly back toward the coccyx for five minutes at a time.

As an essential preliminary in all cases the bowels should have been thoroughly cleaned out by a course of laxatives, and the rectum finally washed out by copious enemata before the operation. An hour before the operation a suppository containing a grain of opium should be placed in the rectum. The vagina and the vulva should have been subjected to repeated boro-salicylic or hydro-naphthol douches for some days, and the parts about the field of operation should be shaved and well scrubbed immediately before beginning the operation.

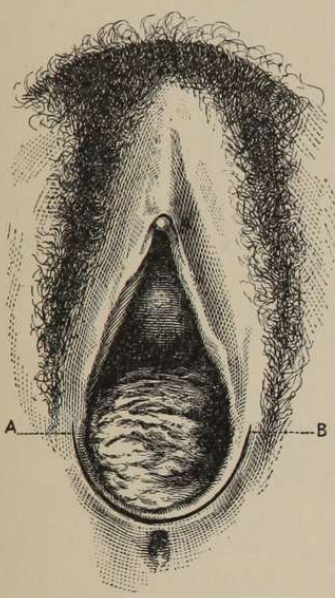
The instruments required are few and simple, including a sharp bistoury, scissors curved on the flat, two pairs of mouse-toothed forceps and one of dissecting forceps, a dozen hemostatic forceps, a needle forceps, two or more large full-curved needles, preferably Hagedorn's pattern, as many small curved needles, and a pair of suitable retractors for holding back the labia. Silk thread, sterilized by boiling or steam shortly before using, is to be preferred for sutures—a coarser thread for the deep sutures, a finer one for superficial. Catgut is to be used for ligatures, and occasionally will be best for sutures. The patient should be put in the lithotomy position, with the pelvis elevated on a hard pillow. Should operations upon the cervix uteri or upon the anterior vaginal wall be required, they may be done at the same sitting before beginning with the perineum.

The operative procedures will vary according as the laceration is of the incomplete or the complete variety. The concealed variety are to be made into the incomplete by transfixion with the bistoury and incision as the first step of the operation. Much scope to the ingenuity and judgment of the surgeon will be given in the effort to meet the varying conditions of different cases, while he keeps in view the primary indication of bringing together and securing the reunion of the divided and separated *muscular* elements of the perineum. These have retracted on each side toward the pubic rami, and a careful inspection of the parts when the labia are held asunder will usually discover some lateral depresssion in the borders of the cicatrized laceration indicating the site of these muscular stumps. A more marked dimpling on each side of

the anus shows plainly the sites of the retracted ends of the sphincter ani when the laceration is a complete one. Whatever incisions are made must be planned so as fully to denude these points, and the sutures must be placed so as to bring and hold them in apposition till reunion has occurred. This may usually be best done in the following manner:

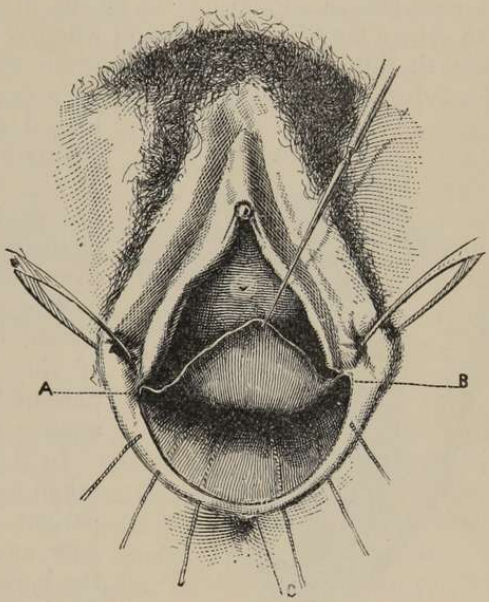
I. **Incomplete Laceration.**—The labia being held apart, the surgeon, having noted the beginning of the cicatricial tissue on each side at the base of the nymphæ, makes an incision through the skin along the outer edge of the cicatrix, from one to the other of these points (Fig. 350). The vaginal end of this incision is now seized at its middle by a pair of forceps, which retains its hold upon it until the close of the operation, lifting it up and holding it out of the way as the work progresses. With the scissors the surgeon

Fig. 350.



Line of Incision in Perineoplasty (Pozzi).

Fig. 351.



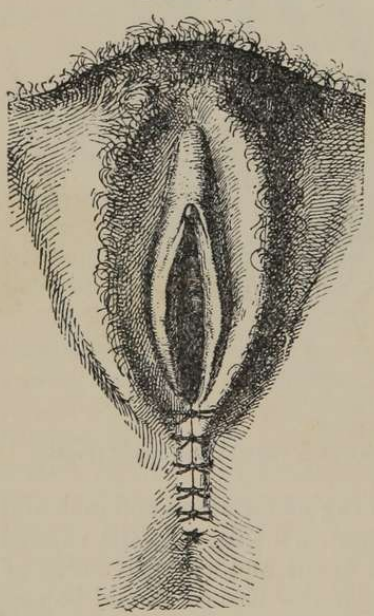
Perineoplasty, the Vaginal Flap raised (Pozzi).

now works his way in between the rectum and the vagina for about and inch and a half below and well into the base of the labia on each side. As the vaginal flap is raised up without removing any tissue, a broad and extensive area of denudation is formed (Fig. 351). The splitting of the tissues should be carried deeply into the lateral sulci, so as to expose the retracted muscular stumps. At this point there is likely to be free bleeding, for the control of which pressure forceps, hot-water tampons, ligatures, and the after-pressure of the deep sutures will suffice. Caution will often be required in the course of the dissection to avoid opening into the rectum, but care to keep the dissection along the plane of the loose submucous tissue between the vagina and rectum will prevent such an accident.

Bleeding having been arrested, the sutures are to be placed. The deep sutures are first in order. Beginning at the lower angle of the denudation, a large strong needle, armed with a strong coarse thread, is introduced close to the margin of the incision, passed outward deeply into the tissues, and made to sweep around so as to emerge in the center of the wound in its depth between the vagina and the rectum, care being exercised not to penetrate into the rectum.

Having been brought out at this point, it is again inserted at the same point and passed on through the tissues of the opposite side, being thrust in deeply at the side, so as to grasp an abundant thickness of tissue in its loop, emerging through the skin close to the border of the incision at a point opposite to where it was introduced on the other side. A second, third, and possibly a fourth similar suture are then introduced in like manner, proceeding from below upward, until sufficient have been placed evenly and firmly to close the wound. While these sutures are being introduced, the tissues in the lateral sulci, which naturally tend to retract, should be seized with the mouse-toothed forceps and drawn strongly into the wound, so that the sutures shall obtain a deep grasp upon them. The sutures are now tied seriatim, having been drawn sufficiently tight to bring the parts into coaptation. If they have been introduced in the way described, the deeper parts will be fully and easily brought from each side into contact, and a firm, competent perineal body will be restored. The ends of each suture should be cut off an inch or two from the knot, in order that the suture may be easily found when it is desired to remove it later, for, as a rule, the knot itself will have become somewhat imbedded in the skin. After the tying of the deep sutures, as many points of superficial sutures may be placed as may seem to be required fully to coaptate the superficial portions of the edges of the wound. The fold at the entrance to the vagina made by the lifting of the center of the flap, if too redundant, may be retrenched to any degree and the edges sutured (Fig. 352).

Fig. 352.



Perineoplasty, condition after Suturing (Pozzi).

The sutures having been applied, the parts should be well dredged with powdered oxide of zinc. Increased comfort will be given the patient by the pressure of a soft absorbent pad against the perineum, but it is not essential.

In the after-treatment especial care is to be taken to guard the wound from the urine. The patient should turn over upon her face to urinate, and the parts should be well douched with the boro-salicylic solution after each urination. If the patient is unable to urinate in this way, a catheter must be used, with every precaution to avoid infection of the bladder and consequent cystitis. The sutures should remain in place for at least ten days. If they are not causing much irritation, they should be left in some days longer. The patient should be kept in the reclining position for three weeks, and not allowed upon her feet until four weeks have elapsed.

II. **Complete Laceration.**—If the rent extends up into the recto-vaginal septum for any distance, it is best to secure its repair down to the level of the sphincter as a separate operation, reserving the repair of the latter and of the perineum until a later period.

The operation upon the recto-vaginal rent is to be conducted as follows: The edges and apex of the rent should first be split by a bistoury to the depth of about three-eighths of an inch. Two rows of sutures are required, rectal and vaginal. Beginning within the rectum at the apex of the rent, fine silk sutures, at intervals of about three-sixteenths of an inch, are introduced with a small well-curved needle, so that each shall come out at the bot-

tom of the split that has been made, thus embracing only the rectal half of the denudation. These should then be tied in the order in which they were introduced. A similar series of sutures, preferably of catgut, should now be inserted along the vaginal line of the wound, each being tied as it is inserted. In this way a broad surface of apposition is secured. In the after-treatment a loose movement of the bowels should be secured daily and the ordinary attention to cleanliness of the parts should be maintained. Further operation may be delayed until after a period of at least six weeks, when the procedures are the same as are now to be described for the ordinary complete laceration.

The first steps are the same as those that have been described for repair of the incomplete form. Then the lateral incisions are to be prolonged backward along the side of the anus sufficiently far fully to expose the retracted stumps of the sphincter ani. A first set of sutures must now be introduced to bring together the denuded fibers of the sphincter. The location of the stump of the muscle on each side having been identified, the needle should be passed through it so as to grasp its substance: the deepest suture should be placed first, being entered well back by the side of the anus and directed forward toward the perineum, emerging in the middle line, there to be reintroduced and carried back on the other side in the reverse direction till it shall emerge on the other side of the anus at a point symmetrical with that where it originally entered. Three such sutures should be introduced. The remaining sutures, for the perineum proper, should be introduced as in the incomplete variety. The parts are now brought into apposition and the sutures tied in the order of their introduction. The dressings and the after-treatment are the same as above described.

Not a few surgeons prefer, however, to remedy the entire defect at a single operation.

SURGERY OF THE VAGINA.

Malformations of the Vagina may be congenital or acquired. The former are vices of development, the latter the results of sloughing, adhesion, and cicatricial contraction. A median longitudinal septum occasionally divides the canal more or less completely into two, owing to the imperfect coalescence of the ducts of Müller of the embryo. The hymen may be imperforate. The vagina may be rudimentary or altogether absent; in which case there is usually imperfect development or total absence of the uterus and ovaries. These conditions call for surgical treatment only after puberty in those cases in which the presence of the developed uterus has established menstruation and vaginal malformation, or in which *atresia* causes retention of the menstrual fluid. The operative procedures required may vary from a simple puncture of a distended hymen to a long and difficult dissection between the bladder and the rectum through the connective tissue that has replaced the vagina. The practical difficulties which attend efforts to keep open a long channel that has been established by such a dissection are very great, so that in the cases where two or more inches of the vagina are occluded the surgeon would be justified in establishing an artificial menopause by the removal of the uterine appendages, rather than in attempting to overcome the vaginal atresia. The remaining blood-tumor may be left for gradual absorption, unless by its pressure-effects or through infection it require removal, when it may be opened and evacuated either by dissection along the vaginal path or through the rectum. The evacuation of a quantity of retained menstrual fluid is attended with special danger from septic infection. To guard against this, every possible antiseptic precaution should be observed. The incisions should be free, the cavity should

be thoroughly emptied and irrigated with an antiseptic solution, a fold of iodoform gauze should be placed in the vagina extending from the cavity of the uterus to the vulva to act as a drain, and an abundant absorbent dressing should be placed over the vulva, to be changed as often as it is saturated by the discharges. The irrigations may be repeated daily until the distended parts have contracted to their normal dimensions.

VAGINISMUS.—This term is applied to a spasmodic contraction of the muscles of the vaginal opening upon any attempt at coitus, which renders marriage unfruitful. The introduction of the finger for a vaginal examination may produce the same effect.

Its **cause** is sometimes the sensitive remains of the hymen, which, though they appear to be normal, yet often contain enlarged nerve-filaments: sometimes there is erosion at the entrance of the vagina, and sometimes the affection is apparently entirely nervous in origin.

The **treatment** may with advantage be at first the application of a 5 or 10 per cent. solution of cocaïne a few minutes before coitus. Whatever the cause, this will often allay the pain and irritation and permit intercourse. If this does not succeed, a careful examination should be made, and if ulceration is found it should be treated with nitrate of silver or other suitable application. If sensitive remains of the hymen are present, they may be excised. The mere stretching of the vaginal orifice will often effect a cure. After excision or stretching the vagina should be methodically dilated for some time, until painless intercourse is possible.

INJURIES.—*Lacerated wounds* of the vagina have occurred as the result of a first coitus: they are not infrequent in connection with ruptures of the cervix uteri or of the perineum. They may occur in the course of operative procedures upon the uterus. The hemorrhage is likely to be abundant. The treatment of such wounds should be in accordance with general surgical principles, and should never be attempted without first fully exposing the wounded point. Removal of clots and free admission of air to the vagina will often secure hemostasis.

The injuries of the vagina which most engage the efforts of the surgeon are those in which penetrations of the bladder or rectum are present and degenerate into permanent fistulæ. The most common cause of such fistulæ is sloughing from the prolonged pressure of the fœtal head during a difficult labor. The resulting opening into the adjacent viscus may vary greatly in its size, form, and location. In rare instances the cavity of the uterus is invaded. The two forms of fistula most commonly met with are the vesico-vaginal and the recto-vaginal.

VESICO-VAGINAL FISTULA.

These fistulæ range in size from minute openings, recognizable with difficulty, to those where much of the septum is lost and the anterior wall of the bladder prolapses into the vagina. Cicatricial contractions of the vagina are frequent complications.

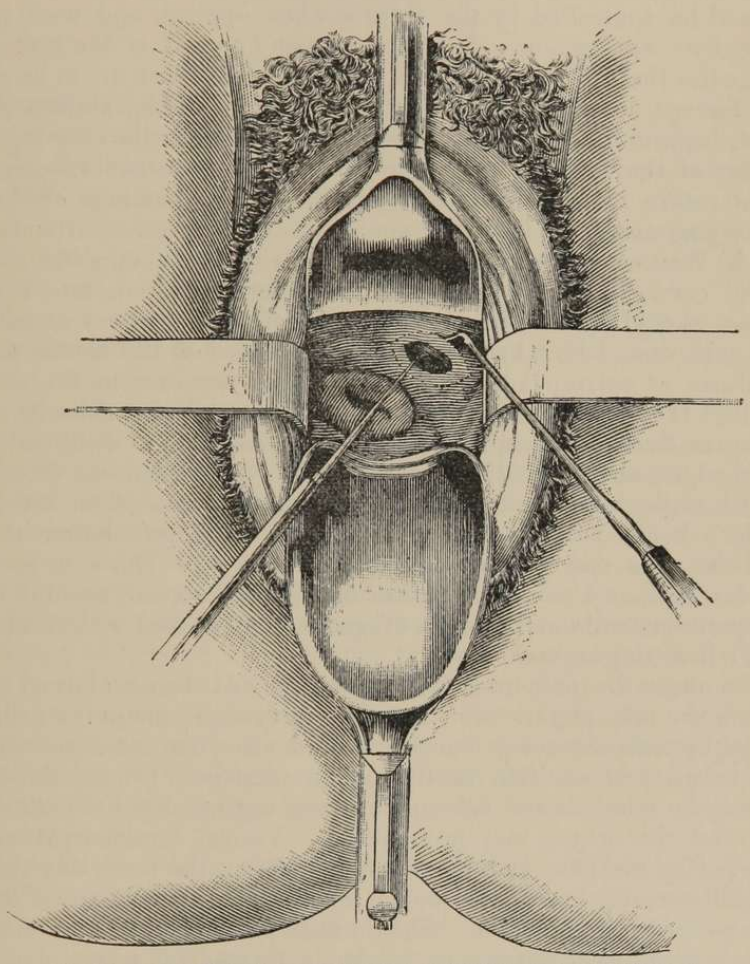
The **symptoms** are those of incontinence of urine, the external genitals being continually bathed and irritated by the urine.

The **diagnosis** is usually at once determined by inspection after the anterior vaginal wall has been brought into view. Confirmation may be had by the use of a sound or probe if needful, and, in cases where the orifice is minute or hidden by a cicatricial fold, by the injection of colored fluids into the bladder.

The **prognosis** is usually good if the case is amenable to plastic operation for its closure.

The **treatment**, except in cases of very minute fistulæ, is by plastic operation. When the opening is very small, its closure may possibly be effected by touching it with a cautery point and thus exciting adhesive inflammation. During the after-treatment of such a case the bladder should be kept drained of urine by a permanent catheter. In every case operation should be deferred

FIG. 353.



Vesico-vaginal Fistulæ exposed, edges of fistula being pared (Simon).

till the general health of the patient is well established and the local conditions are favorable for repair. All local inflammation must have been subdued and excoriations healed. Cicatricial contractions of the vagina must have been overcome by division or dilatation. The functions of the bowels and of the kidneys must have been brought into a state of healthy activity.

The fistula may best be exposed by putting the patient in an exaggerated lithotomy position, the pelvis being raised upon a firm cushion and the vagina widely opened by the use of suitable retractors, laterally, superiorly, and inferiorly. The uterus is now to be drawn down by a tenaculum so as to make

the fistula still more accessible. The edges of the fistula are now freely and evenly pared by knife or scissors, the strip to be removed being held by a toothed tissue forceps or tenaculum, bevelling the edges mainly at the expense of the vaginal portion, but taking care to remove all cicatricial tissue and to extend the removal of tissue at the points which are to be at the ends of the suture line, so that there shall be no puckering when the sutures are tied. When the tissues are thin and it is important to avoid the removal of tissue, the edges of the fistula may be split instead of pared, and thus a sufficient raw surface for coaptation secured. The rather free bleeding which follows these incisions will be controlled by the sutures when applied, and need not delay their immediate application. For the sutures fine silk is the best material. For the needles the flat, partly-curved needles of Hagedorn are to be preferred. A needle forceps adapted to them will be required. The sutures should be introduced, beginning at the most distant point, the needle entering near the vaginal edge of the incision, sweeping outward into the tissues, so as to bring within the suture loop an abundant portion of the thickness of the tissue; finally emerging at the depth of the wound just below the vesical mucous membrane, to be then entered at a corresponding point at the opposite side of the wound, and carried through its edge in a reverse direction into the vagina. The sutures should be introduced at intervals of about three-sixteenths of an inch, and care should be taken to have the two sides of the fistula penetrated by the sutures at corresponding points to ensure accuracy in the subsequent adjustment. If necessary to relieve tension—for no tension must be permitted on the suture line—relaxing sutures may be inserted a little farther from the wound-edges, and carried either below the vesical mucous membrane or through it into the bladder if need be. When all the sutures are in place, the bladder should be irrigated with a warm antiseptic lotion to remove any blood-clot that may have accumulated within it. The sutures are then tied. A few accessory points of suture finally may appear needful to secure perfect apposition. A small tampon of gauze impregnated with oxide of zinc should be left in the vagina.

For ten days the patient should remain in bed, being allowed to assume any position she may prefer. For the first forty-eight hours the urine should be removed by catheter every four hours, and after that spontaneous micturition may be allowed as often as the patient desires. On the third day the tampons may be removed and subsequent daily vaginal douches instituted. On the eighth day the sutures may be removed. Vesical tenesmus, if present, is to be relieved by morphia and hyoscyamus. After the tenth day the patient may gradually resume her wonted duties. Daily free evacuations of the bowels should be secured from the first. Should only partial success be secured by a first effort, repetitions of the operations should be made at a later date till final closure is secured.

For the partial relief of aggravated cases, in which the loss of substance is too great for any plastic operation for the closure of the opening into the bladder, closure of the vagina has been practised. In some instances this procedure has, however, entailed such serious disorders from urinary retention and decomposition in the unnatural reservoir that the vagina has had to be reopened. In other instances a portion of the recto-vaginal septum has been removed, so as to make the rectum a receptacle for the urine and menstrual secretions after the urethra and vagina have been closed up, and comfort has thus been secured. In some cases all these devices will be fruitless, and the surgeon will have to be content with advising the wearing of a

urinal, with special efforts at cleanliness, as the best that can be done for his patient.

Recto-Vaginal Fistula.—The methods of exposing and treating these fistulæ are in general similar to those just detailed. If the fistula is high up, the sphincter ani should be paralyzed by thorough stretching before the operation is begun, and the movements of the bowels be restrained by opiates for the first week thereafter. If the fistula is near the anus, the tissues of the perineum and anus should be divided into the fistula, and then the repair conducted as described for complete lacerations of the perineum.

INFLAMMATIONS OF THE VAGINA.

The vaginal mucous membrane may be provoked to inflammation by the presence of irritating foreign bodies, by the use of irritative injections or applications, by the contact of irritating secretions, by the irritation of excessive coition, and by the infection of the gonorrheal poison. The inflammation provoked by the latter cause is not distinguishable from that due to other causes, except possibly under the microscope by the detection of the gonococci in the discharge. Vaginitis may be acute, subacute, or chronic. It is usually attended with more or less vulvitis. The gonorrheal form is prone to extend to the endometrium and thence to the Fallopian tubes, provoking ultimately pyosalpinx and often pelvic peritonitis.

The **symptoms** of vaginitis depend on the acuteness and intensity of the attack. Local heat and pain, with some tumefaction, and altered secretion—scanty at first, but soon becoming copious and muco-purulent in character—are the chief symptoms. Inspection of the vaginal mucous membrane shows that it is congested and bathed in muco-pus, often with patches of excoriation. In the more intense forms an ulcerative process may become established, with subsequent cicatricial contractions and adhesions. In the mildest cases nothing may be complained of but the altered and excessive discharge or leucorrhea. Every degree of severity between the two extremes may occur. Its natural tendency is toward cure, but in many instances the persistence of causative influences prolongs it indefinitely. In some cases a granular condition of the mucous membrane is produced, constituting a very intractable and painful state. The flowing of acrid discharges over the parts at the outlet of the canal often produces excoriations and fissures at this point, which make coitus very painful, even impossible.

Treatment.—During the acute stage of an attack, rest in bed, saline aperients, and frequent hot hip-baths are indicated. The vagina should be washed out at least twice daily with a copious hot, mildly antiseptic douche, as of borax, one dram to water one quart, or of liquor plumbi subacetatis, half a fluid-ounce to water one quart. As soon as the symptoms have moderated somewhat the cure will be expedited by keeping the walls of the vagina separated by a fold of lint or gauze soaked in oxide-of-zinc cream. This should be carried well up to the posterior fornix through a speculum and protrude between the labia. It should be removed at the end of twenty-four hours, the vagina douched, and the medicated lint again inserted. This treatment should be persevered in until the cessation of the symptoms indicates that the disease has subsided. An occasional douche should be persisted in for a time thereafter, to prevent recurrences. In the more chronic forms, if the use of the zinc tampons is impracticable, recourse may be had to douches of sulphate of zinc, one dram to the quart of hot water once or twice daily. In the more inveterate forms inspection will show certain parts which are especially affected to

which direct applications of nitrate of silver or carbolic acid may be needful. In all cases, as far as possible, the exciting cause should be removed. Coitus is to be forbidden.

If *fissures* persist or are indicated by pain when efforts to dilate the canal are made, they should be sought for, and treated by distention and cauterization to their deepest point with stick nitrate of silver. Such applications should be made once a week till a cure is effected, the parts meanwhile being kept protected by smearing them with oxide-of-zinc cerate.

TUMORS OF THE VAGINA.

Solid growths are of rare occurrence. Cases of lipoma and sarcoma have been recorded, but are of extreme rarity. Myoma in the vaginal wall has been occasionally observed. Carcinoma is rare as a primary disease, though frequent by extension from the cervix uteri. Cysts are of more frequent occurrence. They may develop from persistent embryonic canal-ducts of Müller or canal of Gärtner; from dilated lymph-ducts; or more commonly from closed and distended mucous follicles.

Excision of all these growths should be done when practicable. In cases of cysts, if the cyst-wall cannot be easily excised *in toto*, the portion left should be freely cauterized to destroy its secreting surface and excite adhesive inflammation thereof.

FOREIGN BODIES IN THE VAGINA.

The vagina has been made the receptacle of many foreign substances, which become the subjects of surgical care through the inflammation and ulceration which are excited by them. Their presence is detected in the course of the explorations required for ascertaining the cause of the symptoms. They are to be removed, and the inflammation, ulcerations, or fistulæ produced by them treated on the lines already laid down.

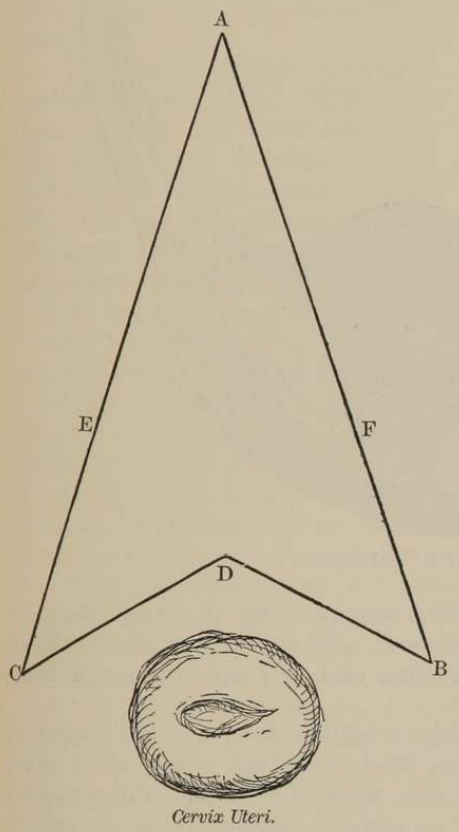
PROLAPSE OF THE VAGINA.

As the result of injuries to the perineum and loss of support from the pelvic floor, an eversion of the vagina to some extent is common. As the posterior wall rolls out it brings with it the anterior wall of the rectum, and produces a swelling of varying size upon the floor of the introitus, to which the term **rectocele** is applied. Similarly, the anterior vaginal wall in its eversion brings with it the base of the bladder, constituting a **cystocele.** Both of these conditions entail more or less functional disturbance of the organ involved. Diminution of the expulsive power of the lower part of the rectum attends rectocele. Pouching of the floor of the bladder, with retention and decomposition of urine and cystitis, is the result of cystocele. For their relief it is of prime importance that the pelvic floor be restored by perineoplasty. At the same time, the following special plastic operations may be done upon the walls of the vagina if the extent of the relaxation and prolapse seems to call for them.

Anterior and Posterior Elytrorrhaphy.—These operations consist in the removal of longitudinal strips of the vaginal mucous membrane of varying length and width, and closing the gaps thus made by sutures, so as to narrow or to reef in the relaxed membrane. The anterior wall of the vagina most frequently calls for this retrenchment, which is a most valuable accessory to the other measures instituted for renewing the supports of prolapsing pelvic organs. The denudation in anterior elytrorrhaphy should be quite free, should

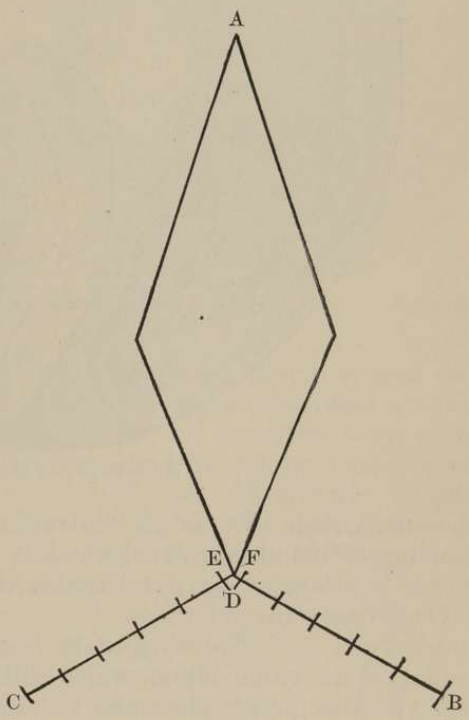
extend from half an inch behind the meatus urinarius externus backward nearly to the cervix uteri, and should be triangular, or rather arrow-shaped, in form, with the base of the triangle or arrow just in front of the cervix. The elytrorrhaphy should be done before the perineoplasty is proceeded with, and after any operation on the cervix that may have been required. The piece to be removed should first be marked out with the point of the scalpel, and then with the tissue forceps and scissors the entire piece should be dissected away, beginning behind and working forward, care being taken not to wound the

FIG. 354.



Shape of Flap to be Removed in Anterior Elytrorrhaphy (original).

FIG. 355.



First Step in Suturing the Wound of Anterior Elytrorrhaphy (original).

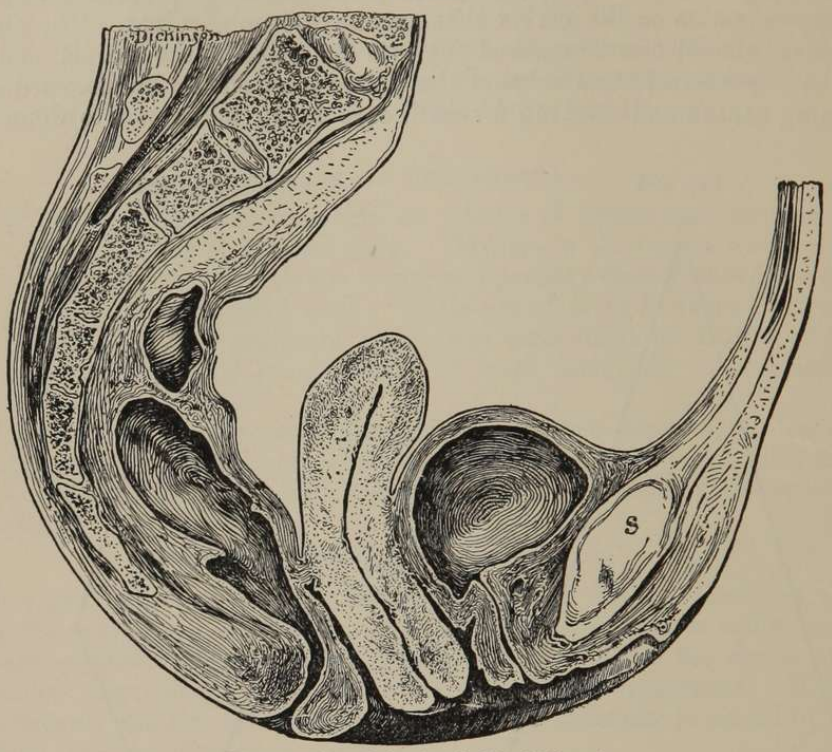
bladder. In Fig. 354 the lines A B D C A indicate the shape and relations of the denudation recommended. The application of the sutures is to be made first to the barbs of the arrow, B F being sutured to B D, and C E to C D, the sides of the lozenge D A (Fig. 355) then remaining to be sutured. Silk is the best material for these sutures. They are to be removed in eight or ten days.

SURGERY OF THE UTERUS.

HYPERTROPHY OF THE CERVIX.—A true overgrowth of the cervical portion of the uterus, unaccompanied by inflammation, due to an as yet unexplained error in nutrition, occasionally occurs. The tissues of the cervix are apparently normal in their character. The overgrowth assumes the character

of an elongation which may fill the vagina even to the extent of protruding from the vulva (Fig. 356). It is an affection occurring more frequently in

Fig. 356.



Hypertrophy of the Cervix Uteri (Skene).

the unmarried. It entails obstructive dysmenorrhea by the angulation or bending of the uterine canal which it produces; it is a source of sterility after marriage; it irritates the vagina and is a cause of much local discomfort.

Fig. 357.

Diagram of the Pieces removed in Amputation of Hypertrophied Cervix (Skene).

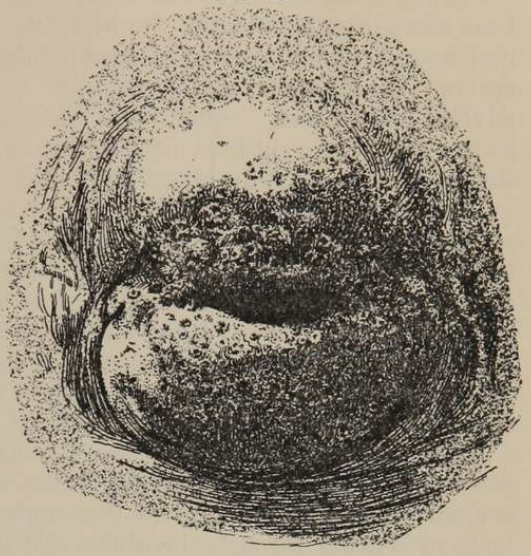
The **diagnosis** is readily established by careful bimanual examination, which will show the body of the uterus to be in its proper place and of normal size, while the finger in the vagina will trace the reflexion of its mucous membrane to the cervix at its normal distance from the introitus, notwithstanding that the elongated cervix fills the vagina.

The **treatment** is by amputation. The annexed figure, 357, shows the lines of incision adapted to obtain the best resulting stump (Skene). Subsequent shrinking is to be expected, for which reason the stump should be made a little longer than the normal cervix.

Wounds of the Uterus.—*Lacerations of the cervix uteri* are a frequent complication of childbirth. If they are extensive and are recognized at the time, immediate sutures should be applied. If neglected, they heal by granulation, leaving often permanent fissuring of the cervix, in many cases accompanied with eversion and erosion of the mucous membrane of the cervical canal, a chronic inflammatory condition of the whole endometrium, and subinvolution.

In many instances these healed fissures give rise to no symptoms, when they should be let alone. In other cases the involvement of nerve-filaments in the dense cicatrix may give rise to marked reflex nervous disturbances (neurasthenia). When examination reveals the existence of a laceration complicated with these symptoms, the repair of the laceration by appropriate plastic operation should be done after all active inflammatory conditions have been relieved by appropriate treatment.

FIG. 358.



Bilateral Laceration of Cervix Uteri of Moderate Degree (original).

The *operation for lacerated cervix* is best done while the patient is in the dorsal position, the exaggerated lithotomy position, as for vaginal fistula. (See Fig. 352.) The perineum being retracted and the labia being separated on either side, the cervix is brought down to the introitus by a tenaculum, and held by a stout thread passed through each lip for the more convenient control of the parts. With an ordinary scalpel the cicatricial tissue at the apex of the fissure is now thoroughly divided; along the limits of the mucous lining of the canal a second incision is carried, and the flaps thus marked out are dissected away, giving broad raw surfaces for coaptation. If the fissure is bilateral, both sides should be thus freshened before any sutures are introduced. Pretty free bleeding may be expected from these incisions, but it will be fully controlled by the tying of the sutures. Silkworm gut or stout silk thread is the best material for the sutures, and a strong, well-curved Hagedorn needle of small size answers well for their introduction, a suitable needle-holder being essential. The number of these sutures and the method of their introduction are governed by the general principles applicable to all plastic work. The sutures should be left *in situ* for ten days, during which time the patient should remain recumbent.

PUNCTURED WOUNDS OF THE UTERUS assume importance when they are the subjects of septic infection, as when inflicted by unskilful attempts at producing abortion. Septic inflammation of the substance of the womb and of the peritoneum may follow, with the gravest consequences. The **treatment** indicated is, first, full dilatation of the cervical canal; then thorough curetting and repeated antiseptic irrigations of the uterine cavity, aided by continuous drainage by a mesh of iodoform gauze placed within the uterine cavity and protruding into the vagina. The extension of the infection to the Fallopian tubes and to the pelvic peritoneum may call for abdominal section, ablation of appendages, and intra-peritoneal irrigations and drainage.

RUPTURE OF THE UTERUS, when occurring as a complication of difficult childbirth, presents a lacerated wound of the body of the uterus, beginning usually in the lower segment of the uterus and extending to a variable degree both longitudinally and transversely from the point of beginning. The **symptoms** of the accident include shock, hemorrhage, cessation of the ute-

rine contractions, and in most cases escape of the fœtus through the rent into the abdominal cavity.

The **treatment** should be by abdominal section, preceded, if need be, by intravenous infusion of a quart or more of a 6 : 1000 saline solution to combat the effects of hemorrhage and shock ; the removal of the fœtus and blood-clots from the peritoneal cavity ; the bringing of the uterus out through the abdominal wound, and the arrest of hemorrhage by an elastic cord drawn about the cervix ; the cleansing and suturing of the rent in the uterus after the manner advised in Cesarean section, or, if the condition of the lacerated tissues is such as to render their subsequent kind healing uncertain, the total ablation of the uterus, with vaginal drainage, as practised after vaginal hysterectomy.

Incision of the Uterus for Removal of Fœtus.—Cesarean Section.—The necessity for incising the uterus for the delivery of a child that cannot be delivered alive by other methods having been determined by the rules of obstetrics, the operation is performed as follows :

Preliminary Preparation.—Every possible antiseptic detail in the cleansing and disinfection of the patient's abdominal surface and of the vagina is to be carried out, as in all cases of abdominal section. In all the steps of the operation the most rigorous precautions against sepsis are to be observed.

The Operation.—The patient having been placed upon a proper table, preferably a short one, with her knees at its edge and her feet supported on a chair to facilitate access to the vagina, and having been anesthetized, an incision is made through the abdominal wall in the median line over the most prominent part of the tumor, beginning about three inches above the pubes and extending upward above the umbilicus, being in all from five to six inches in length. As the abdomen is opened the uterus projects into the opening : an assistant now presses the abdominal walls on each side of the incision down against the uterus, thus retracting the wound-edges and pressing the uterus still more prominently into the wound-opening. At the upper end of the incision a limited vertical incision is at once made into the presenting wall of the uterus : if it does not quite perforate the uterine wall, the finger may be used to complete the perforation. Then, the finger being pushed along as a director, the uterine incision is to be lengthened downward to the full extent of the primary incision, using preferably an angular scissors for the purpose. The amniotic sac pouts into the wound, and is next to be equally freely divided, unless, as may have happened, it has been already opened and divided with the uterine wall. If the placenta should lie in the line of the incision, the fingers should be insinuated between it and the uterine wall until its margin is reached, when the membranes are to be ruptured as before. The hand of the operator now, plunging into the uterine cavity, seeks the head of the child if it is accessible, or otherwise the feet, and quickly extracts it. If the head has previously become impacted in the pelvis, it should be pushed up by the hand of an assistant in the vagina. The umbilical cord, having been double clamped by forceps, is cut between them, and the liberated child turned over to a nurse.

Bleeding from the uterine incision, if free, should be controlled by direct compression or by compression of the neck of the uterus by the hand of an assistant. If spontaneous contraction of the uterus does not take place, a hypodermatic injection of ergotine (gr. ij) should be given. The placenta and membranes should now be withdrawn from the uterus. If not already detached, the placenta should be grasped by the hand and lifted away by compression from circumference to center.

The empty and contracted uterus may now be lifted out of the abdominal cavity, resting upon hot, wet towels that are placed beneath it and over the

abdominal wound to facilitate the application of the sutures. Or it may be sutured *in situ* if the conditions favor ready access to the wound in it.

The suturing must be done with great care, for upon this detail, more than on any other, depends the after-course of the case. Two layers of sutures are required, a deep and a superficial. Silk is the most reliable material to use for sutures. The deep sutures are first placed. A well-curved needle is introduced about a quarter-inch from the wound-edge, made to sweep outward into the substance of the uterus, and then brought out near to, but not through, the mucosa. The number of these should be from two to three to the inch. Care is to be taken that no suture shall penetrate into the uterine cavity. The sutures are to be tied firmly, but not so tightly as to strangulate the tissues. For the purpose of making the approximation still more perfect, if any defect appears anywhere along the line a number of accessory sutures may be applied between the primary deep sutures wherever the need may appear. These may include only about one-fourth the thickness of the uterine wall.

A second superficial set of sutures is finally to be introduced, in number about two to each deep suture, and of fine silk. A strip of the peritoneum with a thin layer of muscular tissue, beginning just to the outer side of the line of the primary sutures, is transfixed with a fine needle, which is carried across to the other side of the wound-line, where it again picks up the peritoneum as at the beginning. By tying these sutures the peritoneum is approximated over the whole wound-line and the primary sutures are covered in. The peritoneal cavity is now to be cleaned by irrigation and sponging, the uterus replaced, the omentum drawn down over it, and the abdominal incision closed in the ordinary manner. If at the time of the operation the uterus be found to be already the subject of septic infection, it should be extirpated *in toto*. This is to be done according to the technique for abdominal hysterectomy for other conditions.

The after-treatment of Cesarean section does not differ from that required after abdominal section in general.

Symphyseotomy.—The necessity of resorting to Cesarean section for delivery of a fœtus in cases of contracted pelves may be avoided in certain cases by a section of the interpubic articulation at the symphysis and temporarily drawing apart the pubic bones. It is practicable to carry such separation to a distance of about three inches (seven centimeters) without serious injury to the sacro-iliac articulation. When the obstetrician has determined that the space gained by such an amount of separation will enable the head of the fœtus to pass, symphyseotomy should be done.

The technique of the operation is as follows: The pubes having been shaved and cleansed, a sufficiently free incision is made in the middle line through the soft parts down to the bone, to expose the articulation. This incision should terminate below or a little above the clitoris. The wound-edges having been retracted, the glistening fibers of the symphyseal ligaments are clearly exposed by further light touches of the knife. By drawing upon the clitoris the filaments of its suspensory ligament are made prominent, and by a transverse cut these are severed and the subpubic space exposed. By pushing a finger or a blunt instrument like a periosteal elevator between the recti muscles above, the soft tissues can now be pressed back from the posterior surface of the symphysis and guarded from injury, while with an ordinary scalpel the joint is divided from before backward. Much separation of the joint is still prevented by the dense fibers of the triangular ligament or deep perineal fascia. Rupture of this fascia, if it is caused by the uncontrolled crowding down of the fœtal head from strong uterine contractions, may tear through the venous plexuses about the neck of the bladder, and even lacerate the urethra

and vagina. Profuse hemorrhage, with difficulty controlled by tampons and by mass ligatures, is the immediate result of such an accident, and sepsis and fistulæ the later. Fatal results have eventuated from these causes. To prevent these a systematic division of the deep fascia from the arch of the pubis on either side should be made at once after dividing the symphysis. A blunt-pointed bistoury by closely hugging the bone on each side can readily and safely accomplish this. The full separation possible of the bones at the symphysis should be made, and the gaping wound temporarily tamponed with iodoform gauze, after which the delivery of the child should be immediately effected. After delivery has been accomplished the external wound should be sutured, except at its lower angle, in which a small strip of iodoform gauze as a drain should be kept for the first forty-eight hours. The bones should be approximated and supported by a broad adhesive bandage encircling the pelvis. The patient should be kept recumbent for about four weeks.

Inflammations of the Uterus.—The mucous lining of the uterus, the endometrium, is the chief seat of inflammatory conditions affecting the uterus. The submucous tissues share to a greater or less extent in the superficial inflammatory disturbances of the mucosa, and in certain acute affections complicating the puerperal state a spreading septic lymphangitis and phlebitis are excited, which cause the whole substance of the uterine walls to become acutely inflamed, often with a fatal result.

Endometritis may be confined to the cervix or may involve the corporeal endometrium as well. Cervical endometritis is the most frequent variety. The inflammation may be acute or chronic. In the *acute form* the mucous membrane is congested and swollen: an abundant, viscid, muco-purulent secretion is poured out upon its surface (*leucorrhea*). The submucous tissues are congested and infiltrated with inflammatory exudates in a varying degree, dependent upon the severity of the superficial inflammation. According to the extent of the endometrium invaded, there will be swelling of the cervix only or of the whole organ. The inflammation not infrequently extends along the Fallopian tubes and may involve the pelvic peritoneum. More frequently the affection is of gradual development and assumes a subacute form, with tendency to chronicity from the beginning. In the *chronic form* the mucous membrane is swollen and pulpy, œdematous, passively congested, prone to fungoid vegetations, easily provoked to bleed. The leucorrheal discharge is abundant and acrid. The orifices of the mucous follicles of the cervix (glands of Naboth) frequently become occluded, with formation of small retention-cysts as the result. The os uteri is tumid, the cervix swollen, and, if the body of the uterus is involved, the whole organ is enlarged, with an increase in the depth of its cavity. Where lacerations of the cervix permit it, the swollen cervical flaps become everted, with erosion of their epithelial covering. As the result of long-existing congestion, proliferation of submucous connective tissue takes place, with subsequent contraction, atrophy of glandular elements, and sclerosis. When the corporeal endometrium is more especially affected the cervical appearances described will be absent.

Etiology.—A predisposition to endometritis may arise from a multitude of causes, constitutional and local, which diminish the resisting power of the tissues of the organ, interfere with its nutrition, and conduce to local blood-stasis. Bad hygiene, overwork, improper clothing, uterine displacements, suppressed menstruation, excessive coitus, abortions, subinvolution after parturition, and cervical lacerations are among the predisposing causes that should be especially mentioned. The exciting cause is always infection with pathogenic micro-organ-

isms. These may be derived from the vagina or cervix, the cavities of which always contain pyogenic cocci in abundance, though of little virulence; or they may be introduced from without by the finger of the surgeon or accoucheur, a sound, a pessary, or other instrument, or the finger of the patient herself. The puerperal uterus presents conditions especially favorable to the full activity of pathogenic micro-organisms, most of all when organic débris is retained within the uterine cavity or when unhealed lacerations of its substance are present

The infection may be of gonorrheal origin, in which case, after the subsidence of the acute vaginal symptoms, the infection may persist in the cervical follicles indefinitely, occasioning only slight symptoms until reawakened into activity by some of the conditions named as predisposing, especially abortion, parturition, and traumatism. Gonorrheal endometritis is prone to extend into the Fallopian tubes and induce an inveterate salpingitis.

The **symptoms** of endometritis comprise dull pelvic pain and tenderness; aching, referred to the sacral and lower lumbar regions; a sense of dragging within the pelvis; more or less profuse leucorrhea. Menstruation is painful or in the more chronic conditions is unduly frequent and prolonged; the bladder is irritable; the bowels are torpid; inspection reveals a viscid discharge issuing from the os externum; the cervix is tumid and congested; and epithelial erosions, granular degenerations, and cystic enlargements, if present, are detected at a glance. If the endometritis involves the body, the sound or bimanual examination shows an enlargement of the organ, and the endometrium is tender and bleeds easily when touched with an instrument. In general, the digestion is deranged, and the nervous system especially is the subject of multiform disturbances. In many cases a condition of chronic invalidism is established. In the more acute cases the attack may be ushered in with rigors and fever, and may be attended with all the recognized signs of local septic inflammation.

The **prognosis** must depend upon the extent of tissue involved, the previous duration of the affection, and the complications present, together with the constitutional conditions of the patient. To these must be added the ability and willingness of the patient to submit to the treatment required. The disease is sometimes rebellious to treatment, but, as a rule, may be expected to yield to intelligent and thorough measures. A disposition to relapses characterizes the affection, due to the lingering of infective material in the glandular recesses of the endometrium and to the frequent repetition of the exciting causes.

Treatment.—Minute inquiry must be made into the existence of predisposing and the continuance of exciting causes, and especial care must be given to their removal. Acute attacks require absolute rest in bed, the free use of saline cathartics and warm enemata, hot fomentations to the hypogastrium, and the administration of a copious hot vaginal douche twice daily, continued for thirty minutes at a time, the patient being recumbent.

In subacute and chronic conditions constitutional treatment assumes importance. Anemia and neurasthenia must be combated; constipation must be guarded against. The local treatment requires the correction of malpositions, the restoration of support to the organ, and the avoidance of the irritation of sexual congress. Frequent periods of rest in the recumbent position are important. Hot vaginal douches, as described above, may be continued. In the intervals between the douches, or as a substitute for them in part, may be used wool or cotton tampons saturated with glycerin and tannin (℈j–f℥j). Of the highest value in treating persistent endometritis is the thorough scraping away of the altered superficial layers of the mucosa (curetting), followed

by equally thorough disinfection of the remaining portion and adequate drainage thereafter.

Curettage of the endometrium should always be guarded by full antiseptic precautions. Preliminary scrubbing and antiseptic irrigations of the vulva and the vagina should be thoroughly made. Anesthesia is often required. Preliminary dilatation of the cervical canal is usually necessary. The dorsal position is to be chosen, the cervix exposed, seized with the volsella, and drawn down to the introitus. A sharp uterine curette is to be selected, and, after the direction and depth of the uterine canal have been ascertained with a sound, is introduced to the bottom of the cavity, and with firm repeated strokes is drawn over the whole endometrium until the superficial layer of the entire mucosa has been removed. The curette is then withdrawn and the interior of the uterus is thoroughly irrigated with a hot antiseptic solution. A half-dram of tincture of iodine or a mixture of one part of tincture of iodine and two parts (94 per cent.) carbolic acid is now injected by an appropriate syringe into the uterine cavity, the excess of the fluid being washed away as it flows out by continued vaginal irrigation. Finally, the irrigating current is again introduced into the uterus and all coagula and residual excess of caustic washed away. This procedure should be followed by copious vaginal antiseptic douches twice daily for a week or more.

Lacerations of the cervix should be repaired as soon as the congestion of the cervix is relieved; mucous polypi should be scraped or twisted off; if the cervix has become hypertrophied or remains persistently enlarged by passive congestion and œdema, a portion of it should be removed with the knife, as already described for Amputation of the Cervix.

DISPLACEMENTS OF THE UTERUS.

Normally the uterus lies in the pelvic cavity in a position of slight anteflexion, suspended among the other viscera of the lesser pelvis, by the uniform pressure of which on all sides it is maintained in position. The direction of its longitudinal axis varies, however, through a considerable arc, according to the position of the body and the relative fulness of the bladder and the rectum. Displacements to a degree that call for surgical intervention may occur forward—anteversion and anteflexion; backward—retroversion and retroflexion; and downward—prolapse and procidentia. The symptoms which arise in cases of displacement are not due to the mere change of axis or place of the organ, but are due to the tension upon the ligaments, the dragging upon adjacent organs, and the nervous and circulatory reactions from coincident congestions of the uterus and adnexa. Considerable displacement, in the absence of these complications, may therefore exist without causing any symptoms or disability.

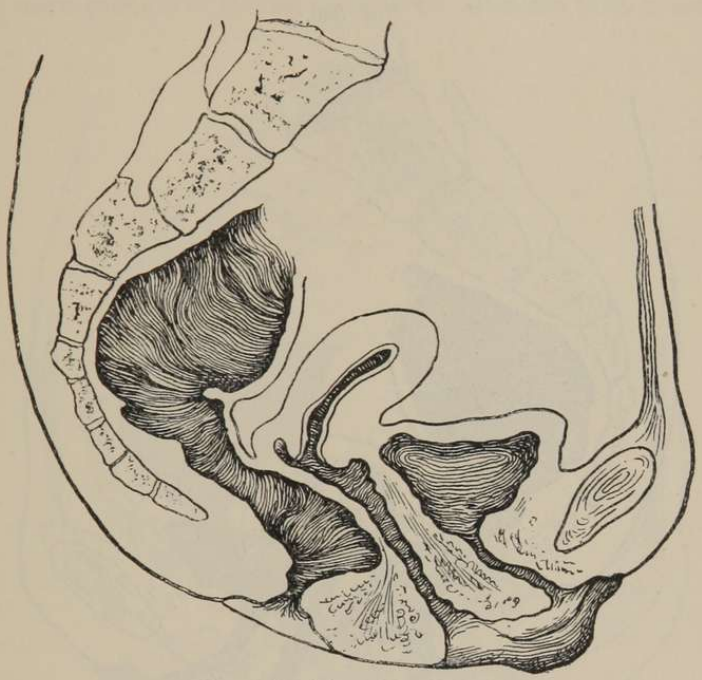
Anteversion and Anteflexion.—Mere anteversion, a position in which the uterus is inclined forward to an undue degree, causes no symptoms and calls for no treatment. When it is due to subinvolution and chronic endometritis the symptoms present are due to these conditions, and may be relieved by appropriate treatment. When it is a part of a more extended inflammation, and the uterus is bound down by adhesions, the malposition of the uterus is a relatively minor incident in the complex conditions present, and does not in itself constitute an important indication for treatment.

In anteflexion the uterus is bent forward upon itself, the angle of flexion being usually at the junction of the body and the cervix. (See Fig. 360.)

Such a flexion may be due either to defective development of the tissue of the anterior wall of the uterus during the period of developmental activity at puberty, or it may be the result of later inflammatory conditions of the uterus and adnexa by means of which the cervix becomes fixed by adhesions or the utero-sacral bands are shortened, while the swollen fundus is toppled over forward, and is not infrequently fixed by adhesions to the anterior pelvic wall.

Stenosis of the uterine cavity at the point of bending—the os internum—is the immediate effect of the flexion. The retention of secretions and the

FIG. 359.



Normal Position of the Uterus.

altered circulatory and nutritive conditions that follow in turn induce a chronic inflammatory state of the endometrium. Dysmenorrhea, and in the married sterility, result.

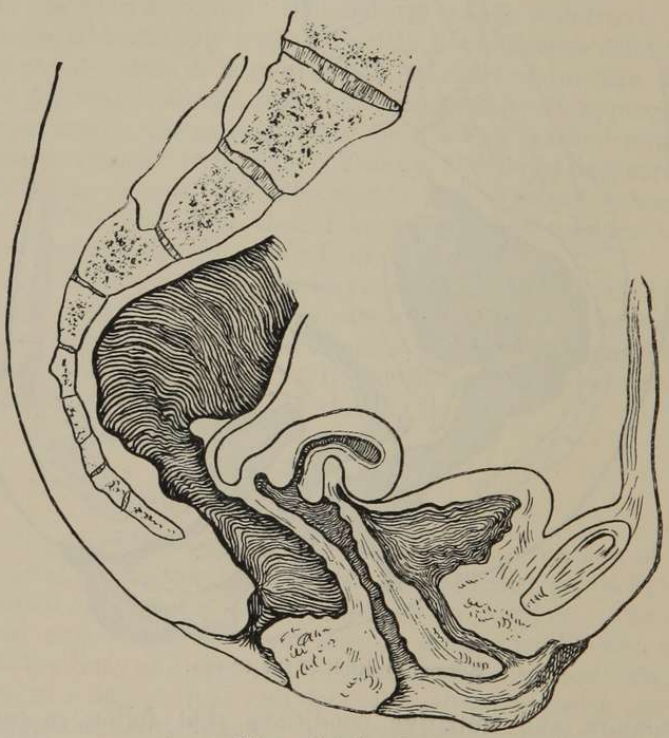
The **symptoms** are chiefly those of dysmenorrhea. Pain, referable to the uterus, precedes the appearance of each menstrual flux. It is paroxysmal in character, varies much in its intensity, but is usually in proportion to the acuteness of the flexion. As the flow becomes established the pain is relieved. The attendant endometritis produces its own special symptoms, while it also aggravates the stenosis. In some cases a considerable degree of anteflexion fails to produce any symptom.

Diagnosis.—The globular mass of the fundus, pressing forward upon the bladder, is at once felt by the examining finger when pressed up in front of the cervix, and its continuity with the cervix and the angle at their junction can readily be made out. By combined manipulation, aided, if need be, by a finger introduced into the rectum, the whole contour of the organ may be ascertained. Some uncertainty may arise when the cervix is long and is directed into the vagina, as if belonging to a retroverted uterus, and also when a fibroid seated in the anterior wall of the uterus causes the anterior surface to simulate that of an acute flexion. A sound introduced into the uterine

canal will determine the diagnosis by demonstrating the real direction of the canal. To facilitate the introduction of the sound, the cervix, after having been exposed, should be drawn downward and backward by a volsellum forceps, and the sound should be well curved.

The treatment consists, first, in the straightening of the organ by manipulation as just described; secondly, in the dilatation of the canal, either by a uterine dilator or by the introduction of sounds of successive graduated sizes; thirdly, in the curetting of the altered endometrium. These procedures are to be accompanied with abundant antiseptic irrigations of the uterine and

FIG. 360.



Uterus Anteflexed.

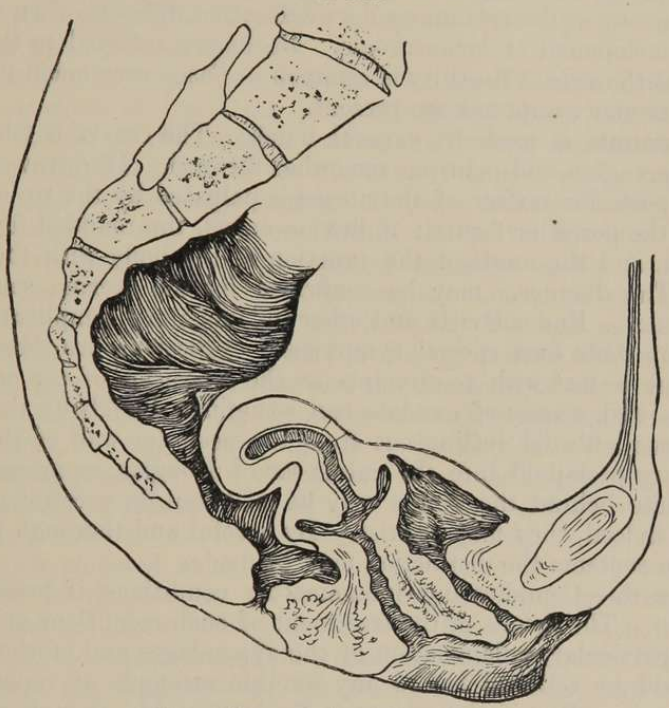
vaginal cavities and adequate disinfection of all instruments and appliances. Whenever the tendency to recurrence of the flexion is marked, resort may be had, fourthly, to the introduction of a stem-pessary of suitable length, which may be worn for two or more months. An essential requisite of this pessary is that it shall not interfere with the ready drainage of the uterine cavity. The wire pessary of Outerbridge is recommended for this reason.

If, as is often the case, the projection of the anterior lip of the cervix into the vagina is abnormally slight, it should be let down into the vagina by making a free transverse incision through the vaginal mucous membrane at its point of reflexion upon the cervix. By pulling the cervix backward this transverse incision is converted into a longitudinal one by the approximation of its lateral angles, which should be secured by sutures. If there is an excessive projection of the posterior lip, it may be shortened and the canal made straighter by taking out a transverse wedge from its posterior surface and suturing the raw surfaces. If the vaginal portion of the cervix, as a whole, is long and conical, a portion should be amputated.

Retroversion and Retroflexion.—When the fundus of the uterus habitually points toward the sacrum a *retroversion* of the organ exists. The degree to which such tilting backward extends may vary much. It is usually associated with some prolapse. In the great majority of cases which present symptoms the uterus becomes also bent upon itself backward, constituting the condition of *retroflexion.*

Backward displacements of the uterus occur more commonly in women who have borne children, being sequelæ of accidents complicating childbirth; and as a result the uterine supports are relaxed, the swollen uterus, becoming more or less prolapsed, is forced backward by the pressure of the abdominal organs, and by the same process is flexed upon itself after the further descent of the

FIG. 361.



Uterus Retroverted and Retroflexed.

cervix is arrested. In nulliparous women it is also met with. As predisposing causes may be enumerated any condition that induces laxness of the uterine supports, such as general anemia, debility from illness or fatigue, or natural flabbiness of muscular or fibrous tissue; improper posture in standing or sitting, in which the pelvis is held in a position of lessened obliquity by an undue projection forward of the symphysis, and the weight of the abdominal viscera, that should be supported by the lower abdominal wall and the pubic arch, is directed into the pelvis upon the fundus and the anterior surface of the uterus; habitual tight constriction of the abdomen, whereby intrapelvic pressure is increased; increased weight of the organ, as during menstruation or as the result of endometritis or myomatous tumors.

The immediate cause of a retroversion is intrapelvic pressure. This is usually gradual in producing its effect, but occasionally produces acute symptoms during great strain, as in lifting or coughing or by a fall. Pelvic tumors may crowd the uterus backward.

Backward displacements that cause symptoms have usually advanced to the extent of flexion, and as rule are complicated with chronic endometritis and uterine hyperplasia, most extensive in the cervical portion. In many cases these inflammatory conditions antedate the displacement, and have contributed to it, but after the displacement has developed they are perpetuated and aggravated by it; when previously absent they are produced by it. Not infrequently an intercurrent pelvic peritonitis produces adhesions which bind the uterus in its malposition.

Symptoms.—The complex of symptoms which attend endometritis and relaxation of the pelvic floor (see pp. 945 and 961) indicate the presence of those conditions. Dysmenorrhea and menorrhagia are common. The pelvic discomfort is aggravated by walking or standing, and is often sufficient to greatly restrict the following of any occupation or the enjoyment of any exercise. Pressure upon the rectum renders defecation difficult, often painful, and fosters the development of hemorrhoids. Backache, referred to the middle of the sacrum, is the rule. Sterility is common. Cases vary much in the degree to which particular symptoms are present.

The **diagnosis** is made by vaginal touch. The cervix is felt lower than normal in the vagina and pointing somewhat forward. If retroversion only is present, the posterior surface of the uterus is palpated by the tip of the finger pressed into the posterior fornix; if flexion exists, the rounded fundus is likewise detected, and the angle of the junction of the body with the cervix appreciated. The diagnosis may be confirmed by the uterine sound and by rectal palpation. Endometritis and other inflammatory complications declare themselves by their own special symptoms. Adhesions are detected by the resistance that is met with to attempts at the reposition of the organ. Perimetric bands and masses of exudate can sometimes be felt by the examining finger. A small fibroid jutting out from the posterior wall of the uterus, an enlarged ovary prolapsed into the cul-de-sac of Douglas, or masses of inflammatory exudate behind the uterus may be mistaken for a retroflexed fundus, with which, indeed, they may coexist. By careful and thorough palpation of all the pelvic contents the distinction may be made.

Treatment.—Complicating inflammatory conditions, if present, demand first attention. The details of the treatment of such conditions are given elsewhere. In particular, inflammation of the appendages and of the pelvic peritoneum should be relieved before any forcible attempts at reposition of the uterus are made. But if the uterus is freely movable, though swollen from endometritis, it may be replaced at once and supported by tampons charged with boro-glyceride or ichthyol and glycerin (12 per cent. mixtures), applied also for their primary depletive and antiseptic action.

Reposition of a retrodisplaced uterus, if it is *not bound down by adhesions*, may be readily effected in many cases by introducing a properly-curved uterine sound into the uterine canal, with its concavity toward the sacrum, and then slowly sweeping its handle around an arc of 180° until its concavity looks forward. Then, by depressing the handle against the perineum, the uterus is brought into anteversion. This maneuver should be done while the patient is in the latero-prone position. It is then aided by the force of gravity, which will also serve to retain the uterus in its restored position until suitable means for its retention may be applied. This procedure should be done with the greatest gentleness, and if the uterus does not readily follow the sound, the procedure should at once be abandoned. Special repositors have been devised to accomplish the same end. They are sounds so constructed that the portion introduced into the uterine cavity is a lever that by mechanism may be moved

so as to lift up the uterus and throw it over into anteversion. The same result can be obtained by placing the patient in the knee-chest position and then retracting the perineum. The vagina is ballooned out by the atmospheric pressure; the intestines gravitate away from the pelvis, and the uterus, freed from pressure, topples over forward. If the uterus is impacted so as not to obey the force of gravity, it may be loosened by drawing the cervix downward and backward with a tenaculum, and pushing against the fundus with a sponge pressed up in the posterior fornix by forceps.

As a preliminary to these operations the clothing of the patient must be loosened about the waist.

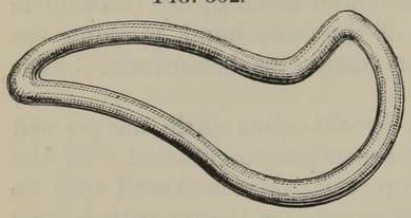
In patients with lax and thin abdominal walls the reposition may be effected by conjoined manipulation: the uterus is first lifted up by two fingers in the rectum or vagina, and then the fingers of the other hand, pressing the abdominal wall deeply into the pelvis, insinuate their tips behind the fundus of the uterus and tip it forward.

When the uterus is *fixed in retroposition by adhesions* little success will result from attempts at repositing it by the means above mentioned. If the adhesion is limited to the anterior wall of the rectum, the rectal wall may be temporarily pulled forward with the uterus, but as soon as the repositing force is withdrawn the displacement recurs. Delicate adhesions may be ruptured, but efforts to rupture any adhesions within the pelvis by force applied from without involve possibilities of rupture of intestine or blood-vessels. Such blind efforts should therefore never be made. Adhesions are best overcome by the fingers introduced into the pelvic cavity through an incision in the anterior abdominal wall. The gravity of this procedure will depend upon the extent and density of the adhesions and the character of the organs involved. Such adhesions may range from the presence of a few slender fibrous filaments, readily ruptured, through every stage up to the very solid fusion of the uterus in a mass of appendages and exudates. When adhesions are extensive or dense they should be separately dealt with under the guidance of the eye after full exposure of the pelvic cavity through a free incision of the abdominal wall, with the pelvis elevated so as to secure gravitation of the bowels out of the pelvis toward the diaphragm. A uterus thus adherent is usually associated with conditions of the appendages that call for the ablation of the latter. Great care is often required to avoid wounding the intestine or bladder. After full enucleation has been secured the uterus may present extensive denuded areas on its surface that will invite fresh intestinal adhesions. A uterus thus extensively denuded, and by the removal of its appendages made functionally useless, may very properly be also entirely ablated.

Retention of the reposited uterus in its proper position may require means of widely differing character. When there are no adhesions; when no tender prolapsed ovary makes pressure behind the uterus intolerable; when no inflammatory conditions of the vagina, uterus, or adnexa are present; when the pelvic floor is intact and the tonicity of the uterine supports is sufficient to prevent any marked degree of prolapse; when the retro-displacement has been the result of the relaxation caused by temporary anemia or by increased intra-pelvic pressure caused by improper dress or habitual positions of the body, which conditions may be remedied,—the reposited uterus may be kept in its usual position by a properly-adapted, closed, double-lever pessary. (See Figs. 362 and 363.) Such a pessary acts by making tense the natural supports of the uterus, especially the utero-sacral ligaments. If it is, as it should be, somewhat conical, with the larger end lying behind the cervix, the contraction of the vaginal wall upon it tends to crowd it upward, and thus to prevent the

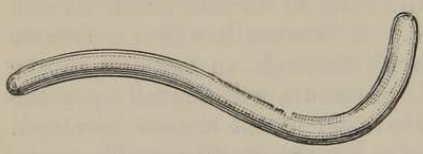
uterus from descending, while the cervix is forced backward. It should never make undue pressure at any point, and its presence in the vagina should not be appreciated by the patient except by the comfort experienced from it. It should be adapted to the capacity of the vagina in which it is to be placed. Its length should correspond to the distance from the posterior fornix to the upper end of the urethra; its width, to the transverse diameter of the vagina measured across the cervix. The depth of the posterior fornix should be the measure of the posterior curve. Hard rubber is the best material from which a pessary should be made. Immersion for a short time in boiling water will soften such a pessary so that its shape may be readily altered as required. A temporary

FIG. 362.



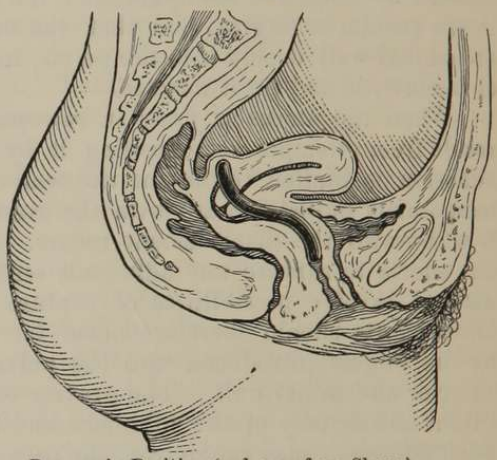
Closed Double-lever Pessary.

FIG. 363.



Pessary, side view.

FIG. 364.



Pessary in Position (redrawn from Skene).

substitute for a pessary may be improvised by adjusting pledgets of cotton or lamb's wool in the vagina so as to distend the posterior fornix and the canal. Such tampons should be rendered antiseptic by charging them with oxide of zinc or boro-glyceride and glycerin. They may be left *in sitû* as long as a week without becoming offensive.

When a pessary is to be introduced, the patient should be in the latero-prone position; the uterus should first be reposited; the pessary, after being oiled, is seized by its narrower end, turned on its edge, introduced into the introitus, and, by pressing the perineum strongly back, is pushed on into the vagina. Here it is turned so that its broader end is transverse. Usually the posterior bar comes in front of the cervix at first, and it is necessary that the index finger be introduced to depress it and guide it past the cervix into the posterior vaginal fornix. The removal of the pessary is accomplished by grasping its lower end between the thumb and finger and steadily withdrawing it, pushing the perineum strongly backward with it as it emerges. As long as a pessary is in use the vagina should be douched with borax and hot water daily. Should irritation or local tenderness in the vagina be caused by it, it should be withdrawn. It is either imperfectly shaped for the case or further treatment to relieve local inflammatory conditions is required. A properly-fitted pessary may be left in the vagina for periods of two or three months at a time. Should its prolonged use be required, it should be removed at intervals of at least three months, and not be replaced for some days, preferably a week.

From the limitations enumerated at the beginning of this section it is plain that in a very large proportion of cases of retro-displacement of the

uterus pessaries will either be inefficient or undesirable for maintaining the organ in its proper place after it has been reposited. They are always to be regarded as temporary palliative agents to be dispensed with as soon as possible; that is, as soon as the natural tonicity of the uterine supports has been so regained that the uterus is held by them in normal position.

Sagging of the pelvic floor, which is a frequent complication, should in all cases be remedied by the appropriate surgical procedures, perineorrhaphy and colporrhaphy. Certain cases in which pessaries could not be used before the restoration of the pelvic floor may then be employed. But, inasmuch as much uncertainty must always exist in this respect, it is preferable that cases which have to be submitted to operations upon the pelvic floor should at the same time be given the benefit of some additional measure to make more secure the retention of the uterus in anteposition. Many operative procedures have been devised for this end. Among these two are especially to be recommended as practical and efficient—viz. first, shortening of the round ligaments; and, second, suturing of the posterior surface of the fundus of the uterus to the anterior abdominal wall.

Shortening of the Round Ligaments.—The proper function of the round ligaments, to preserve the fundus of the uterus in slight anteversion, and thus indirectly to aid in supporting the uterus in its normal position in the pelvis, depends upon the tonicity of its fibro-muscular structure. When from any cause the uterus is chronically retroverted, and especially through lacerations or over-distention of the pelvic floor, the uterus is also prolapsed, the tissue of the round ligaments is prevented from contracting to its normal length, and a condition of permanent elongation is induced which entirely destroys its function as a uterine support or guy. The retention of the uterus in its normal position after the employment of other means required to restore the pelvic floor and overcome subinvolution and endometritis will be much more certainly ensured by so shortening the round ligaments that they again make sufficient traction on the fundus of the uterus to bring it well up toward the symphysis pubis. This is practicable only in cases free from adhesions.

The credit of establishing this procedure as a proper resource in suitable cases is to be given to Mr. Alexander of Liverpool, with whose name the operation is often associated.

Technique of the Operation.—The field of operation should be cleansed with the same care that has been directed in connection with abdominal sections, and rigorous antiseptic precautions should be observed in all particulars. The location of the internal abdominal ring having been identified (at a point midway between the anterior superior spine of the ilium and the spine of the pubes and half an inch above Poupart's ligament), a two-inch incision through skin and superficial fascia, parallel with Poupart's ligament, should be made over the internal ring, about one-third of it being to the outer side of the ring, and the other two-thirds running along the line of the inguinal canal. The aponeurosis of the external oblique muscle being exposed, and the diverging fibers of the roof of the inguinal canal being identified, the inguinal canal is freely opened, so as to expose the internal ring. The overhanging fibers of the internal oblique muscle are to be drawn upward, so that the tissues emerging through the ring may be clearly identified. A little teasing of the connective tissue that binds together the parts will soon make plain the outlines and the structure of the round ligament as it runs forward along the floor of the canal. As soon as it is identified it should be isolated, and with gentle traction drawn out from the pelvis: as this is done the connective-tissue fibers that invest it and hold it will have to be carefully stripped from it by suitable forceps; as

the cord is further drawn out, it will soon become apparent that a cuff of peritoneum is being stripped back from it. A little inadvertence may easily tear this peritoneal investment and the peritoneal cavity be opened—an accident, however, which has no serious significance. The pulling out of the ligament is thus continued until it no longer emerges with any freedom through the ring; from two to three inches of the ligament may easily be drawn out; the uterus, meanwhile, should be lifted up from below by the finger of an assistant in the vagina to facilitate the running of the ligament and to determine when the control over the uterus by the ligament has been regained.

A strand of gauze is now passed under the loop of the portion of the ligament that has been brought out, and a temporary antiseptic tamponade and covering of the wound applied, while the ligament of the other side is in the same manner found and drawn out.

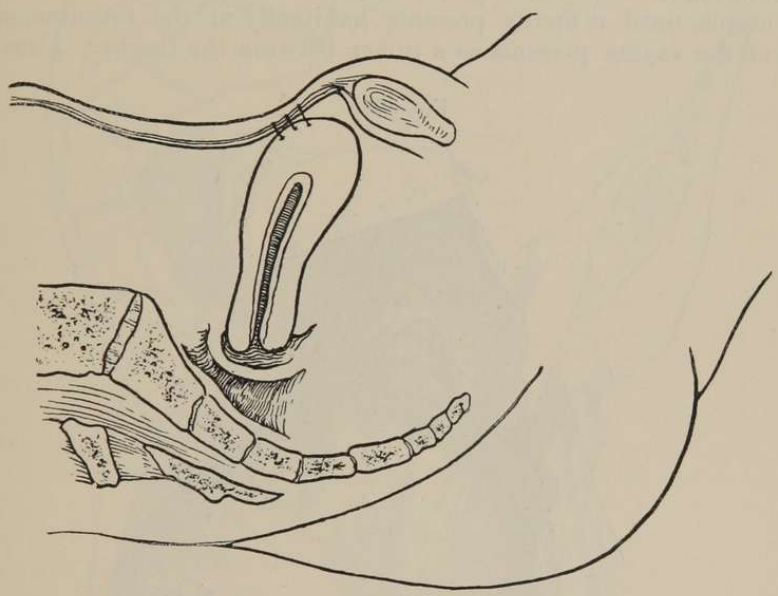
Beginning with the second ligament, suture of the ligaments is next to be done. Silkworm gut is the best suture material to be used. While the ligament is strongly drawn out a needle is passed through the integument, and each layer of the wound-edge in turn, down to the border of the internal ring which it pierces, and then, transfixing the ligament, is made to pass out on the other side in the same way. Similar sutures are passed at intervals of about one-third of an inch along the course of the inguinal canal until the apposition of the deep wound is secured and the fixation of the ligament is accomplished. The slack of the ligament is tucked up under the aponeurosis of the external oblique muscle at the inner end of the wound. A few strands of silkworm gut may be introduced at the outer angle of the wound down to the internal ring for drainage, and enough points of superficial suture applied to bring the wound-edges fully together. A proper protective and absorbent dressing is to be applied. Primary union is to be expected. The patient should remain recumbent for four weeks. The sutures may be removed at the end of two weeks. The uterus should be supported by a lever pessary or tamponade of the vagina for some months.

Suturing of the Posterior Surface of the Fundus of the Uterus to the Anterior Abdominal Wall.—Whenever the abdominal cavity has already been opened for the separation of adhesions or for dealing with diseased appendages, to antevert the uterus and suture it to the anterior abdominal wall is a natural step when a retroversion has previously existed. The anteposition and the security from prolapse obtained by such suturing seems more absolute and more certainly reliable than even that obtained from shortening the round ligaments; for which reason surgeons who are able to so control their operative conditions as to avoid all dangers of sepsis are warranted in opening the abdominal cavity for the special purpose of thus securing the uterus. The time occupied for this operation and the amount of operative traumatism inflicted are very much less than in the operation for shortening the round ligaments; for this reason, especially in feeble patients and in those in whom for any reason prolonged anesthesia is to be avoided, utero-ventral suture would be preferred. The adhesions which result from this procedure gradually elongate, so as to give considerable play to the uterus, but not sufficient to permit of its retroversion. Experience has shown also that the dilatation of the bladder with urine is not embarrassed. Subsequent pregnancy may pursue a normal course.

Technique of the Operation.—The preliminary preparations should be those prescribed for an abdominal section for any other purpose. In all the steps of the operation rigid asepsis must be observed. A general anesthetic is required. A three-inch incision should be made in the middle line of the

abdomen, beginning just above the symphysis. Through this incision two fingers are introduced, which lift up the fundus of the uterus and bring it into view while the sides of the incision are held apart by retractors. As soon as the fundus is exposed it is seized at its middle by vulsellum forceps, lifted up and drawn forward against the symphysis. By these maneuvers the uterus is anteverted and the posterior surface of the fundus is made to present in the lower part of the abdominal incision, and the insertion of the sutures required is made easy and safe. The sutures may be of silk or of silkworm gut, preferably the latter. Three should be inserted at intervals of one-third of an inch. A slightly curved needle, grasped by a needle-holder, is desirable. The lowest suture should be introduced first, the point of introduction being about an inch below the fundus where grasped by the vulsellum. The needle, armed with a strand of gut, is carried transversely through the uterine tissue, penetrating to the depth of an eighth of an inch, and emerging about three-quarters of an inch from its point of entrance. The two other sutures are introduced in the same manner, the last and highest passing underneath the prongs of the vulsellum. The serous surface of the uterus within the area

FIG. 365.



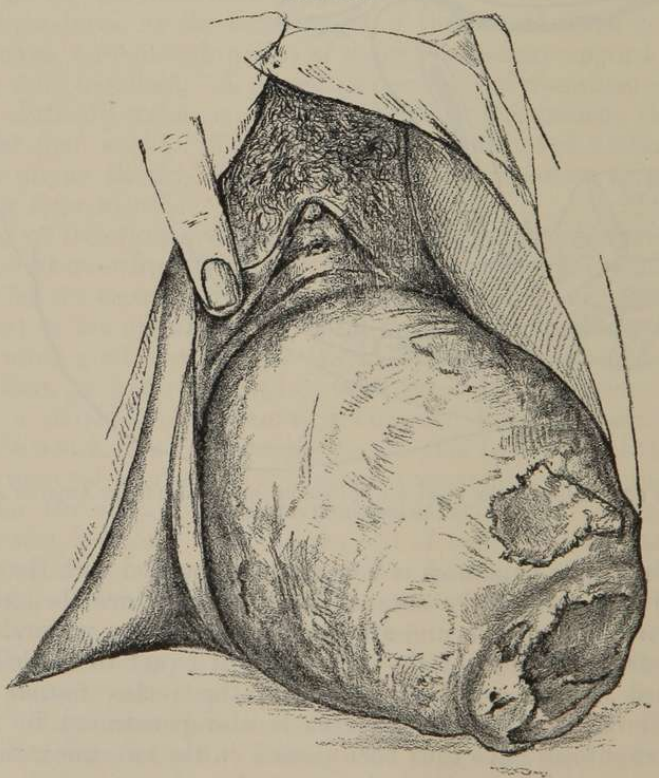
Position of Uterus after Suture of the Posterior Surface of the Fundus to the Anterior Abdominal Wall (utero-ventral suture).

enclosed by the suture-punctures is now slightly scarified with the point of the scalpel. The free ends of the sutures on either side are then each in turn threaded into a curved needle, and are passed through the parietal peritoneum at a distance from the edge of the incision in it equal to one-half the width of the scarified uterine area. A portion of the rectus muscle and of the aponeurotic fibrous sheath of the rectus is also penetrated by this needle. When the three sutures have thus been passed on the two sides, they are to be tied, the one nearest the symphysis first, and the others in the reversed order to that in which they were introduced. The ends of the sutures are then cut off close, and the sutures buried by the subsequent closure of the superficial portion of the wound. In this manner the lower part of the peritoneal opening is closed, and a broad and even apposition of the serous surfaces of the

uterus and parietes secured. Any slight bleeding which may have occurred from the pricks and scarification of the uterus is at once arrested by pressure when the sutures are tied. The cul-de-sac of Douglas should be sponged out, and the entire wound then sutured as in any other abdominal section. No tampon or pessary in the vagina is required. The after-care is the same as in other simple abdominal sections. As a rule, the convalescence is smooth. The buried sutures create no irritation. In a small proportion of cases they may after a time excite a local irritation and the development of a sinus, for the cure of which the suture will have to be exposed and removed.

Prolapse and Procidentia.—Any descent of the uterus below its normal position in the pelvis is a prolapse. The association of the lesser degrees of prolapse with retroversion has already been considered. When the prolapse becomes so aggravated that the cervix tends to protrude at the vulva, or the uterus by eversion of the vagina escapes *in toto* from the pelvic cavity (*procidentia*), the displacement assumes characters of its own requiring separate consideration. To the same causes which unite to produce the lesser degrees of prolapse and retroversion are due the more extreme degrees. A more marked weakening of the pelvic floor, a greater relaxation of the uterine ligaments, an increased or longer-continued abdominal pressure, suffice to urge farther downward the sinking uterus, until it finally presents habitually at the introitus, or by an eversion of the vagina presents as a tumor between the thighs. Usually pro-

Fig. 366.



Complete Prolapse of the Uterus, with Eversion of Vagina.

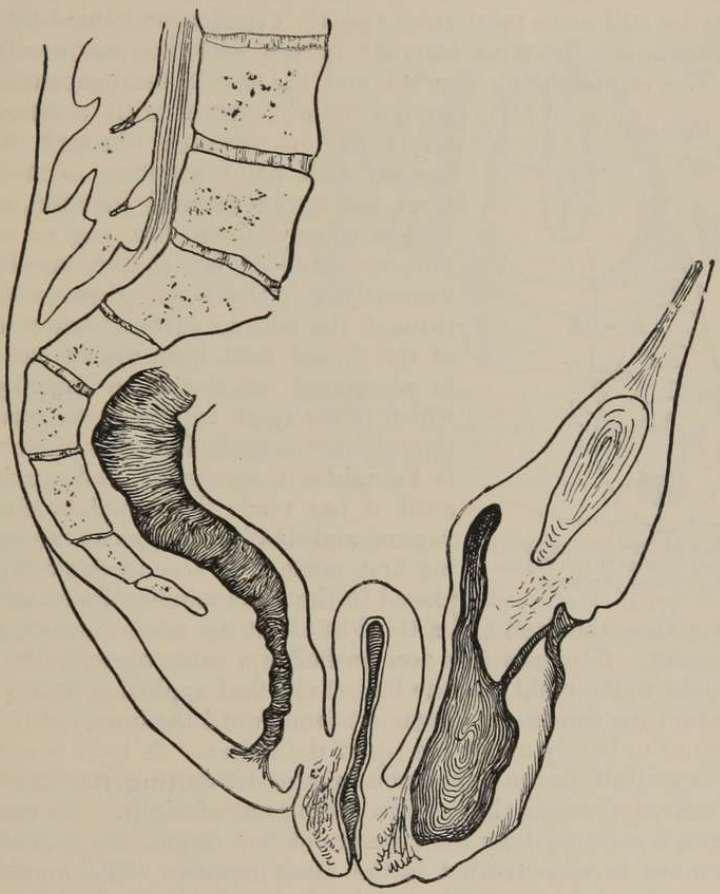
lapse of the vagina precedes that of the uterus; the anterior vaginal wall gives way most easily and brings with it the floor of the bladder.

In less degree, but with much frequency, the posterior wall rolls out, car-

rying with it the anterior wall of the rectum (rectocele; see p. 945). An apparent prolapse may be due to hypertrophic elongation of the cervix (Fig. 356, p. 956). Some hypertrophy of the cervix, often considerable, attends real prolapse, and is the result of hyperplasia due to congestion and to the dragging of the cervical attachments. Endometritis is always present. The prolapsed mucous surfaces are thickened and toughened, often excoriated and ulcerated.

The severity of the subjective symptoms produced is not necessarily gauged by the amount of prolapse present. The lesser degrees are most

FIG. 367.



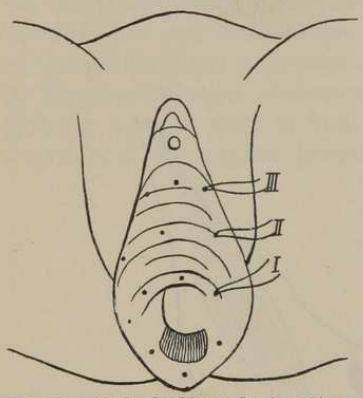
Uterus Prolapsed, with Complete Eversion of Vagina and extreme dragging downward of bladder.

frequently attended by pain and invalidism; in the more severe types the complaint is more from the mechanical inconveniences of the tender tumor hanging from the vulva.

Treatment.—Palliation may be secured by the pressure of a perineal pad attached to an abdominal bandage. The uterus having been pushed back into place, a rubber ball may be introduced into the vagina and kept in place by the perineal pad; or a shallow cup, supported upon a stem bent to follow the curve of the vagina, may be made to support the uterus, the stem being held in place by a perineal band. Such supports are at best inefficient and obnoxious, and should be advised only when the patient positively refuses operative relief.

To relieve prolapsus permanently resort must be made to a combination of whatever procedures are required to restore the integrity and tone of the pelvic floor and of the uterine supports, and in the most aggravated cases to reinforce these natural supports by additional sources of support. As a preliminary the size and weight of the uterus itself will first require operative interference. The degenerated and chronically inflamed endometrium should be curetted and treated; the enlarged cervix will often require amputation, or lacerations call for plastic repair; the thickened and relaxed vaginal walls should be retrenched by excising longitudinal strips from them; to the operation on the anterior wall (described on p. 954), for cystocele, being added the excision of ovoid strips from the lateral walls, if need be. The retrenched vagina may be still more reinforced and its eversion prevented by a series of circular submucous ligatures inserted in the following manner (method of Freund): The vagina being everted and the cervix uteri protruding, a well-curved needle, armed with a strand of silk-worm gut, is inserted through the vaginal mucosa at a point about an inch and a half from the vagino-cervical junction, and is carried circularly about the vagina in the submucous tissue as far as the needle will conveniently go; the needle then is brought out through the mucous surface; after some inches of the thread have been drawn out the needle is re-entered in the same opening through which it emerged, and made to traverse again the submucous tissue farther around the vagina, is brought out, reinserted, and again passed on until it has made the complete circuit of the vagina, and finally emerges at the needle-opening first made. A second encircling suture is placed in the same manner about an inch and a quarter away from the first, and a third at about the same distance again away from the second. The uterus is now pushed up, carrying with it the vagina. As the vaginal walls infold and the line of the first applied suture is turned in, the two ends of the thread are drawn out firmly until the lumen of the vagina is narrowed so as to barely admit the tip of the finger. A knot is now tied, and made to bury itself in the submucous tissue by cutting the ends short and pushing the knot through the needle-opening out of sight. As the reposition of the uterus is continued by the pressure of the finger, the second and third sutures each are in turn treated in the same manner. The number of such encircling sutures may vary with the exigencies of the particular case. They act by interposing a mechanical barrier to the eversion of the vagina, and are of special value during the early months after the operation, until the natural tonicity of the parts has been regained. They may also, by their irritation, provoke inflammatory deposits along their course, which may act as permanent sources of vaginal constriction. They should be reserved for cases which have passed the childbearing age. If at any time they ulcerate through into the vagina at any point, they are easily removed.

FIG. 368.



Showing Method of Introducing Circular Submucous Sutures in the Vagina for relief of Prolapse (Freund).

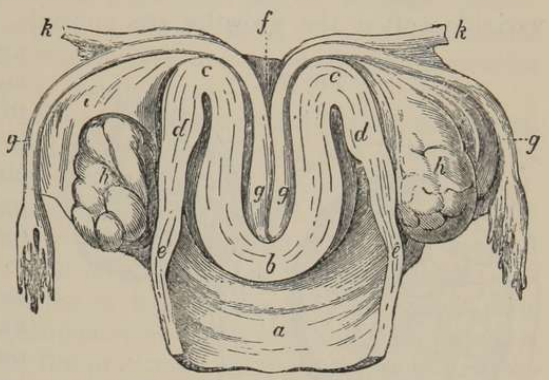
The relaxed and lacerated perineum will require perineoplasty. These measures should be still further supplemented by shortening the round ligaments or by anterior utero-ventral suture. If, despite the combination of these measures, the prolapse occur, it would be justifiable to remove the uterus as a part of an extensive plastic operation.

INVERSION OF THE UTERUS.

The uterus may become turned inside out as the result of a force dragging down upon the fundus while the cervix is relaxed and dilated. Such inversion, which may be partial or complete, is a very rare accident. It has taken place most frequently as a complication of childbirth; in other instances a polypoid growth, attached to the fundus, but driven down by the uterine contractions, has dragged with it the fundus.

The uterus when completely inverted forms a pear-shaped body distending the vagina; it may be associated with prolapse to such a degree that it projects through the vulva as an external tumor. The mucous membrane, tumid and congested, bleeds easily. In long-standing cases it may by atrophy and cicatrization lose much of its peculiar glandular structure.

FIG. 369.



Inversion of Uterus; *a*, vagina; *b*, fundus uteri; *c*, *c*, angles of inflection; *c*, *c*, *d*, *d*, extent of uninverted cervix; *e*, vaginal wall; *f*, the peritoneal cul-de-sac of the inverted uterus; *g*, *g*, Fallopian tubes passing down into the inverted uterus; *h*, *h*, ovaries; *i*, *i*, broad ligaments; *k*, *k*, round ligaments.

The **symptom** most prominent is hemorrhage. When the inversion is sudden and complicates childbirth, this hemorrhage is severe, at times uncontrollable and fatal. In the more chronic conditions every degree of metrorrhagia may be present. The symptoms of endometritis and prolapse will be added, according to the degree of each which may be present.

Diagnosis.—Vaginal examination reveals the tumor filling the vagina. By deep palpation of the pelvic cavity by the rectum, or from the abdominal surface in thin subjects, may be made out the funnel-shaped depression formed by the inverted peritoneal surface of the uterus, into which the Fallopian tubes, the round ligaments, and in some cases the ovaries, are drawn. (See Fig. 369.)

Treatment.—In recent cases reposition may be effected by a process of taxis, the patient being anesthetized. The manipulations must be conducted so as to produce dilatation of the cervical ring and pressure upward of the inverted mass. These manipulations should not be persisted in for more than an hour at a time. In the event of failure, and from the first in more chronic cases, some form of continuous elastic pressure must be devised. This will consist of a suitable hard-rubber shallow cup to embrace the presenting portion of the tumor, to which a strong stem is attached that protrudes from the vagina externally. To this elastic tapes are attached that lead in front and behind to an abdominal bandage above. By means of these elastic bands the requisite elastic pressure is exerted. Anesthesia is not required while such an apparatus is in use. The process of replacement is slow in its progress, and may require the pressure to be kept up for as long as forty-eight hours. In the event of failure to reduce the inversion after a forty-eight hours' trial of elastic pressure, it would be justifiable to open the abdomen above the pubis and dilate instrumentally the contracted cervical ring from above, while pressure is made from below on the vaginal tumor. In the event of final fail-

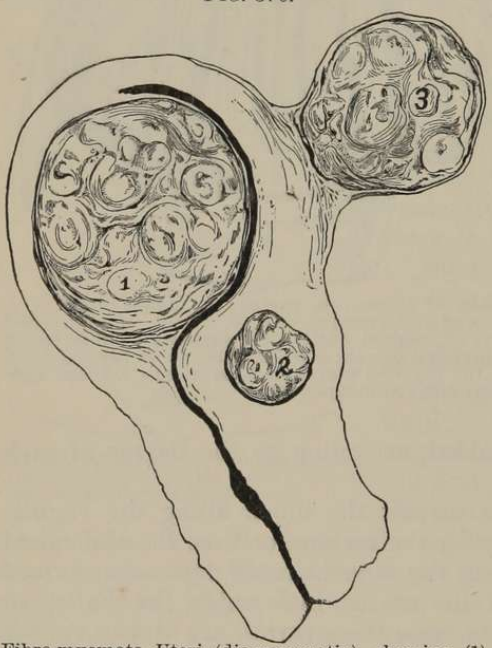
ure to accomplish reposition by this means the total excision of the uterus should be done.

TUMORS OF THE UTERUS.

FIBRO-MYOMATA.—Tumors composed of the unstriped muscular fibers and of the connective tissue normal to the uterus are frequently developed in the walls of the uterus. The relative proportion of muscular and fibrous tissue varies greatly: to those tumors in which the former preponderates the term *myomata* is applied; to the latter, *fibromata*. The class is best designated by the compound term *fibro-myomata*.

The number of such tumors which may develop in a single uterus is variable: often the growths are multiple, in some cases occurring in large numbers, in others singly. They may attain great size, and are liable to degenerative changes. According to the location of these tumors a clinical subdivision of them is established. Those which are near the external surface of the uterus tend to protrude under the peritoneum, and in that case form the *subserous* variety; those which are more centrally located in the wall of the uterus are *interstitial* or *intramural* growths; those which grow toward the cavity of the uterus form the *submucous* group. (See Fig. 370.)

FIG. 370.



Fibro-myomata Uteri (diagrammatic), showing (1) submucous, (2) intramural, and (3) subserous growths (original).

The tumor-mass is usually differentiated from the surrounding uterine tissue by a layer of loose connective tissue that forms a kind of capsule to it and facilitates its enucleation. When the tumors protrude from a free surface, their position tends to luxuriant development, and as the growth proceeds the bond of connection with the uterus becomes relatively smaller, forming a distinct pedicle. A tumor floating in the peritoneal cavity is apt to provoke irritation of the serous surfaces with which it comes in contact, and to contract adhesions with them as a consequence. Such adhesions are most frequent with the omentum and the intestines. Tumors originating in the tissues of the cervix may push outward between the layers of the broad ligament or may protrude into the vagina. A general hypertrophy of the whole uterus to some degree always attends the development of these growths. The endometrium becomes hyperplastic and swollen, and is prone to inflammatory changes with consequent menorrhagia. Fibro-myomatous growths belong to the period of functional activity of the uterus. Their natural tendency is to grow as long as menstrual life continues, while their presence tends to delay the natural menopause. After the menstrual climacteric has been passed they tend to undergo involution and atrophy, but in exceptional instances their growth remains unchecked.

Fibro-myomata occasionally share in the process of involution following an intercurrent pregnancy, and thus disappear. Defective nutrition, due to

elongation or torsion of the pedicle or other interference with the blood-supply, may arrest growth or induce atrophy. In this shrinking a process of calcification sometimes occurs. Defective nutrition of an overgrown myoma may induce liquefaction of the growth at points in its interior, leading to the formation of spaces filled with fluid, *cystic degeneration*, or to the permeation of a portion of it with serous or mucoid fluid, *œdematous* or *myxomatous degeneration*. Occasionally an enormous development of blood-vessels and blood-spaces takes place, *angiomatous degeneration*. Such a change may also involve more particularly the lymph-vessels and lymph-spaces, constituting a *lymphangiomatous degeneration*. A fibro-myoma may become the seat of pyogenic infection, with abscess-formation. Sloughing is a not infrequent occurrence in submucous growths as the result of injury and infection, in which case spontaneous elimination may occur, or if the necrotic masses are retained the phenomena of septic absorption in a high degree result.

The **symptoms** caused by fibro-myomata are variable and multiform, being dependent upon the location and size of the growth, the changes produced in the uterus, and the complications that may arise. Interstitial and subserous growths may attain considerable development without provoking especial symptoms. Submucous growths, however small, determine at once marked hemorrhages, uterine discharges, and the whole complex of symptoms attending chronic endometritis. The tendency to hemorrhage and the consequent anemia are always marked accompaniments of this class. Menstruation is usually painful as well as profuse, and the protrusion of these polypoid growths into the uterine cavity is sufficient to occasion strong expulsive pains in the organ. Growths imbedded within the pelvis, even though not very large, may give rise to much suffering from pressure upon adjacent organs—*e. g.* the bladder, the ureters, the rectum, the nerves, and the blood-vessels. Growths which have ascended into the general abdominal cavity cause annoyance chiefly by their weight, unless they have attained great size, when renal, hepatic, and cardiac lesions may result. The presence of adhesions may give rise to painful traction symptoms.

The **diagnosis** of fibro-myomata is to be established by bimanual palpation, by which the changes in the form and size of the uterus are appreciated. If a distinct tumor is visibly pushing forward the abdominal wall, or upon pressure may be felt within the pelvis, such manipulations and counter-pressure are to be made as may be required to determine whether or not the tumor springs from the substance of the uterus. When the abdominal walls are thin, and the case is otherwise also favorable for examination, the relations and shape of the tumor in the pelvis may be mapped out with much distinctness, especially under general anesthesia. In less favorable cases uncertainty may arise as to whether a given mass is an outgrowth from the uterus, or is distinct from it, but closely attached to it. The depth and course of the uterine canal give important evidence in settling this question, for it is always elongated and often tortuous in cases of fibro-myoma. Careful palpation, both rectal and vaginal, will usually enable the surgeon to detect the outlines and estimate the volume of the uterus, and thus aid in differentiating tumors of tubal or ovarian origin from those belonging to the uterus. (See the sections on Tubal and Ovarian Diseases.) Even small nodules on the serous surface of the uterus may be felt by the finger: small interstitial growths may be difficult or even impossible to recognize, but may be inferred from the complexus of symptoms, especially if the uterine canal is elongated and tortuous. In some cases of interstitial growth in their earlier course it may be difficult to differentiate the condition from pregnancy, but continued observation cannot fail in due time to

develop the distinguishing characteristics of the latter condition. Small submucous growths are to be detected by the sound, and even more certainly by the curette in the course of the curettage to which the organ will be naturally subjected for the relief of the persistent endometritic symptoms present. Protruding polypoid masses are detected by the finger or exposed by the speculum.

The **prognosis of Fibro-myomata,** as far as regards direct danger to life, is in general favorable. Only a small proportion of such growths determine symptoms of sufficient gravity to bring them to the attention of the surgeon. Of these, the most atrophy and cease to become sources of suffering after the menopause; in rare instances of the submucous variety spontaneous expulsion into the uterine cavity or gradual breaking down by sloughing and escape through the vagina have occurred. In other instances, however, the growth is so rapid or so uninterrupted even by the menopause as to entail serious risks to life from the compression of other organs, from its interference with the normal processes of life, from the pains and disabilities it entails, or from the profound anemia caused by persistent and profuse hemorrhages. When comparatively young women become the subjects of troublesome fibromyomata, the case assumes a serious aspect, for many years of invalidism and of exposure to intercurrent complications are probable before the favorable influence of the menopause can be expected. The occurrence of cystic degenerations destroys the hope of later disappearance by involution; the occurrence of septic infection with suppurative and gangrenous processes immediately threatens life. Growths springing from the cervical portion and extending between the layers of the broad ligament occasion early and severe symptoms from pressure upon adjacent pelvic viscera. Submucous growths have a special danger from the hemorrhages which they induce. Sarcomatous degeneration of fibro-myomata has been reported in a number of instances. It must be acknowledged, therefore, that the prognosis of a growing fibromyoma is always a serious one. Such a growth possesses possibilities of death, through the exhaustion consequent upon a complexus of sufferings; through renal, cardiac, or digestive disturbances; through the prolonged anemia and consequent general nutritive failure and lessened power to withstand intercurrent maladies; through thromboses originating in the sluggish current of dilated blood-spaces in vascular growths; or, finally, through septic or malignant changes in the tumor itself. Further than this, in a large proportion of cases in which life is not directly threatened the presence of these growths very greatly restricts the usefulness of the patient, prevents her from gaining a livelihood, and entails upon her a prolonged condition of invalidism.

Treatment is called for only in cases in which troublesome symptoms have arisen or are impending, and must be directed to the relief of symptoms, the arrest and retrogression of the growth, if possible, and, lastly, the removal of the tumor by operative measures.

Hemorrhage is to be combated by rest in the recumbent posture during the menstrual periods; by the administration of ergot and opium or cannabis indica in full doses; and by thorough curettage of the endometrium, followed by applications of saturated solution of the persulphate of iron, or by the caustic action of a galvanic electrode introduced into the uterine cavity, through which an electric current of sufficient power is passed. In the event of these measures failing, the removal of the Fallopian tubes and ovaries will induce an artificial menopause, and thus put a stop to the bleeding with rare exceptions.

Arrest of growth and retrogression of tumor may be secured in some cases—1. *By prolonged administration of ergot.* This may best be given hypodermatically, from 1 to 2 grains of purified ergotin in an antiseptic solution (1 part

of ergotin to 10 parts of the menstruum) being used for each injection twice daily. If no improvement is manifest after two months' continuance of such injections, they may be abandoned. The best effects of ergot may be expected when the tumors are of recent development, are soft, and have caused only moderate symptoms.

2. *By Electrolysis.*—A current of from 75 to 250 milliampères' strength when passed through the substance of a fibro-myoma, if continued for a sufficient length of time or repeated often enough, has been demonstrated to be capable of inducing in some instances rapid retrogression of the tumor. Submucous and interstitial growths of moderate size are the ones most likely to be benefited by electrolysis. If possible, the uterine electrode should be introduced into the cavity of the uterus, and each introduction should be preceded by thorough disinfection of the uterine and vaginal cavities and of the electrode itself. When the introduction of the electrode into the uterine canal is impracticable, and the growth is readily accessible through the vaginal wall, a spear-pointed electrode may be thrust directly through the vaginal wall into the substance of the growth, the most scrupulous antiseptic precautions being used. The abdominal electrode should cover a broad surface and be closely in contact with the skin over its whole extent. Experience has shown that the usefulness of electrolysis for the dispersion of uterine fibro-myomata is much restricted, since it not only fails favorably to influence a large proportion of such growths, but also introduces risks of provoking septic and gangrenous complications, of causing peritoneal irritation and consequent adhesions, and in some cases of postponing needed operative interference, which has to be resorted to ultimately under much less favorable conditions for success than would have been present earlier.

3. *By Removal of the Fallopian Tubes and the Ovaries*, thus inducing artificially the menopause. The reported results of this procedure in suitable cases are very uniform in their success. The largest number of cases reported by one surgeon is that of Tait, who in 1891 reported 271 operations of the kind for myomata. Of these, 6 (2.2 per cent.) died as the result of the operation; in 8 no favorable effect resulted, the patients having subsequently to undergo hysterectomy or having died; in the remaining 257 cases complete relief ensued, the troublesome symptoms ceased entirely, and the tumor either disappeared or ceased to grow. The reported results of other surgeons are equally favorable as regards the ultimate effects upon the tumor and the hemorrhages, but the rate of mortality has been greater.

Resort to the removal of the tubes and ovaries is indicated in all cases in which growths or hemorrhages persist despite treatment, and in which the technical difficulties and dangers are less than would attend hysterectomy. Early operation is more especially indicated when the patients are comparatively young. In cases of very large tumors removal of the appendages is contra-indicated on account of danger of inducing œdema and necrosis of the growth. (For the technique of the operation see the sections on Diseases of the Tubes and Ovaries.)

Removal of Fibro-myomata by Operative Measures.—*Extirpation through the vagina* is feasible for growths occupying the vaginal portion of the cervix, for polypoid growths springing from the body of the uterus and protruding into the uterine cavity, and for moderate-sized submucous growths which are being pressed into the cavity by violent uterine contractions. Dilatation of the cervix and bilateral division of it up to the vaginal junction may be done when required to give sufficient access to the growth. The pedicles of small polypoid growths may be twisted and cut with scissors. Irrigations with

hot water and tamponade with iodoform gauze will suffice to control the hemorrhage, or, if not, a suitable clamp forceps may be left applied to the stump for a few hours. Large polypoid growths which fill up the vagina require a preliminary process of diminution by piecemeal excision until their volume is sufficiently reduced to make it possible to reach their pedicles for final division.

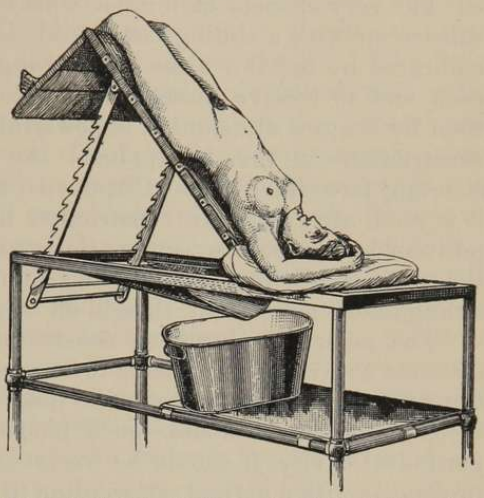
Submucous fibroids of moderate size, not larger than a fœtal head, which are being expressed into the uterine cavity are susceptible of removal through the vagina if the latter is roomy or distensible. The capsule is first split freely with the knife and peeled back to each side, while the tumor, held and drawn upon by suitable hooked forceps, is worked out by blunt-edged, spoon-shaped enucleators, assisted by the scissors as required. The work is usually tedious and laborious: attempts of this kind should be restricted to small growths or to moderately large ones which have become spontaneously pressed down by uterine contractions against the internal os uteri, with some dilatation of the cervical canal. Care is to be taken to guard against hemorrhage, shock, peritonitis, and septicemia, which have been the chief causes of the mortality attending these operations.

Extirpation through Abdominal Incision.—Tumors which have persisted in growing despite the intelligent use of the measures already described, and are accompanied with symptoms that threaten the existence of the patient, or which seriously compromise the usefulness or the happiness of life, and which are not accessible through the vagina, may be reached and extirpated through suitable incision in the abdominal wall. The character of the operation will vary according as the tumor (*a*) projects freely into the peritoneal cavity and is attached to the uterus by a distinct pedicle; (*b*) is sessile upon the peritoneal surface of the uterus, or, if imbedded in the wall of the uterus, lies near the peritoneal surface and can be enucleated without opening the cavity of the uterus; (*c*) embraces so much of the substance of the uterus, and has deformed it to such an extent, that the removal of the tumor requires the removal of the uterus at the same time; (*d*) when in addition to the latter condition the tumor has developed low down beneath the parietal peritoneum or into the folds of the broad ligament.

In varieties (*a*) and (*b*), after the abdomen has been opened and the tumor and uterus exposed, the tumor is to be removed with the knife as if it were upon any other part of the body, the character of the incisions being determined by the principles applicable to growths in general. Growths imbedded in the uterine wall are readily enucleated as soon as they have been freely exposed by incision of the overlying tissue. Bleeding, which usually is not great, is to be controlled by ligatures to bleeding points and by the pressure of the sutures; ligatures in mass may be required. In cases of large pedunculated growths the pedicle may be provisionally secured with an elastic ligature, or by transfixion with a double ligature, or by strong compression forceps, while the tumor is cut away. Apposition and suture of the wound-surfaces are to be effected by fine silk passed deeply so as to bring the surfaces fully into contact. When all bleeding has been fully staunched and the wound well sutured, the uterus is allowed to resume its place in the pelvis, the abdominal cavity is cleansed from blood, and the incision in the abdominal wall is closed. These steps constitute the procedure of *myomectomy*. In varieties (*c*) and (*d*) a portion or the whole of the uterus is removed with the tumor, and the operation becomes one of *supravaginal partial hysterectomy* or of *total hysterectomy*, as the case may be. For the purpose of gaining the required access to these tumors, which are usually large and often complicated by adhesions, the abdominal incision should be made free at the outset or should be

enlarged at once if the necessary manipulations are found to be hampered by the restricted length of the primary incision. Care must be taken at the lower angle of the cut not to wound the bladder, which is often carried up much beyond its usual location upon the anterior face of the tumor. Adhesions must be systematically searched for, and separated as they are exposed, especial care being taken to control hemorrhage from them, if they are vascular, by double ligature both upon the side of the tumor and upon that of the surfaces to which it is adherent. Finally, the hand is able to slip underneath the tumor, to dislodge it from its bed, and to bring it out through the abdominal incision. The further manipulations within the pelvis will be much facilitated by the elevation of the pelvis, as shown in Fig. 371, the position being known as Trendelenburg's position.

Fig. 371.



Trendelenburg's Position: elevation of the pelvis for facilitating intrapelvic manipulations.

After the disengagement and delivery of the tumor immediate attention should be given to its relations to the bladder, which often will be found extensively attached to its anterior face. If so, it must be carefully detached well down to the neck of the uterus.

The relations of the broad ligament and the appendages to the tumor next require attention. If the tumor has developed laterally between the folds of the broad ligament upon one or both sides, suitable incisions of these folds must be made to admit of the enucleation of the tumor. This will be facilitated by preliminary ligation of the ovarian artery. The denuded surfaces of the broad ligament left after enucleation or detachment of the tumor should be brought into apposition, and complete hemostasis secured by a row of sutures running from its upper free border down to the cervix uteri. Where the broad ligament, though carried up on the tumor, still presents appreciable normal folds, these are to be treated as lateral pedicles by tying them off with successive double ligatures in mass, applied on the sides next the pelvis and the tumor respectively, between which they are severed. Clamp forceps may be substituted provisionally for the ligatures, especially upon the side next the tumor, often with advantage in the saving of time. When the tumor has developed mainly in the fundus in such a manner that the broad ligaments have not become involved with it, they demand no special attention from the surgeon, except in cases of total extirpation, in connection with which procedure they will again be referred to. In other cases they become engaged, to a greater or less degree, in the constrictor which is thrown around that portion of the uterus which is to constitute the pedicle, by the division of which the tumor is finally completely detached and removed, together with the tubes and ovaries.

By the means now described the isolation of the tumor will have been accomplished, and only a somewhat narrow mass of uterine tissue will remain to be divided, which will be drawn up to the abdominal wound. This, the pedicle, will usually be composed of the cervical portion of the uterus. Its treatment is a vital point in the operation, and may be conducted in various ways.

The *pedicle* is at once to be strongly constricted. This may most quickly

be done by an elastic cord, using for the purpose strong rubber tubing or solid cord of about one-quarter inch (6 mm.) diameter, which, while strongly stretched, is passed two or three times around the part and its crossed ends secured by tying them with silk or by compressing them together with a strong clamp forceps. Just above the ligature two large pins should be thrust through the pedicle, in order to prevent slipping of the ligature when the tumor is cut away. If the pedicle is very thick, it may be transfixed by the elastic cord and ligated in two parts. Care must be taken in applying this ligature that neither bladder nor intestine is caught in its bite. A different but very efficient method of constriction may be found in the use of a wire constrictor with a sliding bar forced down by screw pressure. The pedicle is embraced by the two arms of a strong copper wire loop; the bar, pierced at each end to receive these arms, is slid along them down to the pedicle, and then by a screw attachment is powerfully pressed against it. Any amount of constriction can thus be applied: the positiveness and certainty of the constricting force have made this device a favorite with many operators. When it is used, after suitable constriction has been effected the bar is secured in position by a small set-screw, the main screwing apparatus is detached, and the wire is left in place, resting on the surface of the abdomen, until the strangulated mass shall slough off and set it free.

The pedicle having been constricted, the tumor is cut away at a sufficient distance above the constrictor to ensure against its slipping off. The toilet of the peritoneal cavity is now to be made, with close examination to discover any bleeding points. Should much blood-clot or fluid have accumulated in the peritoneal cavity, it should be freely washed out with warm water, 110° F., or preferably with a normal salt solution (6 : 1000) poured into it. The sponges and instruments should have been counted and their number written down before the operation, and they should be now recounted to ascertain that none have been left in the abdomen. The cavity having then been carefully dried, the abdominal wound is to be closed. At the lower angle of the wound the pedicle is first to be fixed by carefully suturing with catgut the adjacent edges of the parietal peritoneum to the peritoneal surfaces of the pedicle just below the constrictor; then the remaining wounded peritoneal surfaces are to be sutured, followed by suture of the remaining abdominal planes. The superficial sutures are not inserted for a little distance from the pedicle, but the parts are allowed to gape a little to receive the disinfecting tampon with which it is best to surround the pedicle while sloughing. Upon the cut surface of the pedicle is now placed a thin pledget of cotton squeezed out of a saturated solution of chloride of zinc; the gutter about the pedicle is freely dusted with a drying and antiseptic powder (as tannin three parts and salicylic acid one part) and packed with sterilized cotton. An abundant sterilized absorbent dressing is placed over all, and may remain undisturbed for a week or more. Subsequent dressings will be made as required to meet the needs for cleansing and antisepsis which the necrotic stump may present. During the second or third week the separation of the pedicle slough may be expected: when all necrotic tissue has cleared away, a deeply-depressed granulating surface will be left, which will rapidly shrink and heal.

The delay, annoyance, and possible danger of infection from the sloughing stump when treated in the way described may be avoided by hollowing out the cut surface of the pedicle with the knife, cauterizing well the accessible portion of the cervical canal with the thermo-cautery, and sewing together the opposite walls of the cup-shaped cut surface of the stump by, first, a series of sunken catgut sutures to close the deeper parts, and then by a row of silver

sutures to close the more superficial parts; the ends of the silver sutures are to be left long, so that they may be brought out through the lower angle of the abdominal wound, there to be fastened to a transverse bar or simply grasped in the bite of a long-nosed clamp forceps laid across the abdomen, by which the stump of the pedicle may be held up in contact with the anterior abdominal wall. The suturing of the pedicle stump is to be done while the elastic constrictor is still in place; then the uterine arteries are to be ligated below the constrictor by a silk suture passed deeply into the lateral surface of the cervix on each side and firmly tied; the rubber constricting cord is now removed; any oozing of blood from between the lips of the stump-wound is to be controlled by the introduction of additional sutures so placed as to compress the sources of oozing when tied tightly on its free margin. The toilet of the peritoneal cavity is now to be made, as already described, the peritoneum of the stump united on all sides by catgut sutures to the parietal peritoneum, and the abdominal wound above closed in the usual manner, except at its lower portion, where it is allowed to gape to expose the suture-line of the attached pedicle stump. The silver suspensory sutures project through the gaping wound here, and are to be secured to a transverse support, as already mentioned. Care should be taken in the original application of these wire sutures to twist them all in one direction, and to give to all a certain recorded number of turns in order to facilitate their later removal when the points of twisting will have become concealed at the bottom of a retracted granulating pit. The suspension of the pedicle stump having been effected, a tampon of iodoform or oxide-of-zinc gauze is gently crowded between the wires and the adjacent wound-edges; the general wound-line above is treated as usual, and over all an abundant sterilized protective dressing applied (Kelly). By this method the pedicle incision is for a time kept extra-peritoneal, and hemorrhage or infection from it can be readily observed and treated. If no such complication occurs, the primary dressing may be left in place for a week, and by the tenth day the suspensory sutures may be removed and the unclosed portion of the abdominal wound be brought together by secondary sutures or allowed to heal by granulation. In some cases enough of the peritoneum will have been detached to allow of its inversion and suture. The pedicle is then dropped into the abdomen. The canal should have been disinfected by the Paquelin cautery, and will serve for drainage.

Total Hysterectomy.—Rather than leave any portion of the cervix behind, whether treated as a pedicle fixed in the abdominal wound or as a stump covered over by peritoneum and dropped back into the pelvis, it is better to excise it totally whenever practicable. Usually this can be done quite as readily and speedily as the partial excision. In every case the preliminary disinfection of the vagina and of the cervical canal should be made preparatory to total excision. For this purpose the patient, after anesthetization, should be placed in the lithotomy position, the pudenda and the vagina thoroughly scrubbed with soft soap smeared upon a sponge on a handle, the cervix curetted and swabbed out with a solution of chloride of zinc, 1 : 10, and tamponed with iodoform gauze; copious antiseptic irrigations of the vagina and pudenda should follow: then the cervix should be detached from the vagina by an incision at the cervico-vaginal junction, which should be deepened anteriorly sufficiently to detach the bladder from the cervix, and posteriorly sufficiently to strip up the posterior peritoneal covering from the cervix to an equal distance. The spaces thus opened up should be packed with sterilized gauze, and the vagina below should also be tightly stuffed with the same material. The patient should then be placed in the usual dorsal position and

the abdominal incision made. After the peritoneal cavity has been opened the pelvis should be elevated into the position of Trendelenburg, and the remainder of the operation conducted with the patient in that position. The tumor should now be lifted out of the abdomen through the incision, which should have been made long enough to admit of its easy delivery; all adhesions are dealt with as they appear according to the methods elsewhere described. If the ovaries and tubes appear diseased, they should now first be separately extirpated; if they are healthy, they require no special attention. The relations of the bladder to the tumor are then identified, after which an incision through the peritoneum across the anterior face of the uterus should be made just above the line of the vesico-uterine reflexion; this incision should extend laterally on either side to the broad ligament: this peritoneal flap is now stripped from the uterus by blunt dissection; soon the cellular interspace between the uterus and bladder is entered, and the ready separation of the bladder from the uterus is proceeded with until the wound-space previously made below from the vagina is opened into. This is made more facile by the way it has been distended and made prominent by the gauze packing. By careful tearing of the connective tissue of the broad ligaments at either side of the cervix, thus exposed from the front, the uterine vessels are identified and partially isolated; by means of a suitable ligature-carrier a catgut or silk ligature is passed around them subperitoneally, and they are tied, first on one side and then on the other, close down to the vaginal insertion. Care must be taken not to include the ureters in this ligature. If the precaution is observed to keep close to the cervix in passing the ligature, there is little danger to the ureters, which have been carried well forward with the bladder. The greatest danger of such an accident attaches to cases in which, on account of growths springing from the cervix low down and extending outward into the broad ligament, the relations of the structures have been changed. In such cases especial caution must be used in identifying and isolating the structures about which ligatures are to be tied. The broad ligaments are next tied off, outside the ovaries and tubes, by two or more catgut or silk ligatures on either side. The chief vessels supplying the uterus have thus been tied, and the tumor and uterus may now be removed in one piece between the ligatures; as the section of the broad ligaments reaches their base, the tumor should be carried forward upon the symphysis so as to expose the posterior face of the uterus; an incision through the peritoneum across the posterior face of the uterus at about the juncture of the cervix and the body is now made, and a posterior flap of peritoneum bluntly dissected down until the posterior wound-cavity previously made from the vagina is entered. This posterior and the anterior vaginal opening are now connected by cutting with scissors inside the ligatures on the uterine vessels, and the whole mass, thus freed, is taken away. Nothing but the most insignificant bleeding will have attended any of the steps of the operation until the final section of the lateral connections. After the last cut one or two small vaginal branches will probably spurt, but are readily caught by hemostatic forceps and ligated. The pelvic cavity should now be carefully sponged out: after an assistant has withdrawn from below the preliminary vaginal packing, a fold of iodoform gauze should be passed from above through the superior opening of the vagina, so that it may be seized by the assistant and drawn through until its end protrudes at the vulva, while the upper portion of this gauze is left as a loose packing in the wound made by the ablation of the uterus. Over this packing the peritoneal flaps are drawn and sutured from side to side, so as to close off from the general peritoneal cavity the entire wound-area with its ligature. Special care should be taken

to cover with a peritoneal fold the stump of the infundibulo-pelvic ligament on either side. When this suturing is completed, the pelvic cavity is seen to be closed below by a smooth peritoneal diaphragm which shuts off the wound-cavity, which latter remains extraperitoneal and well drained through the vagina by the iodoform gauze previously inserted. The abdominal wound is now closed in the usual manner.

In cases in which the tumor is too bulky to be readily handled, as required for carrying out the technique as now described, an elastic rubber cord may be cast about the cervix after the anterior peritoneal flap has been reflected and the greater part of the mass amputated. The remaining stump may then be removed in the manner described above, after disinfecting the exposed cervical canal by cautery.

During the after-treatment an antiseptic absorbent pad at the vulva receives the vaginal discharges. At the end of four days the iodoform-gauze drain may be removed and the granulating cavity irrigated with an antiseptic solution. A new light packing of iodoform gauze is placed in the vagina. At the end of another week this may be removed, and no further drain will be required. A mildly antiseptic douche should be used daily as long as there is any discharge. During the first four days after operation the bladder should be emptied by catheter. After the first change of vaginal drains spontaneous urination may be allowed. At the end of the third week the patient may be allowed to get up, and gradually thereafter to go about.

GENERAL CONSIDERATIONS PERTAINING TO ABDOMINAL SECTIONS FOR DISEASES OF THE FEMALE GENERATIVE ORGANS.

The Preparation of the Patient.—Especial care should be given to have the bowels empty. For three days or more beforehand the diet should be of soft, easily-digested food. On the day before operation a saline purge should be given, supplemented, if need be, by a simple enema. During the same period a daily warm bath should be given and the skin of the abdomen should be well scrubbed with soap and brush, especial care being taken with the umbilicus. During the night preceding the operation the abdomen should be kept covered with gauze saturated with the boro-salicylic solution, this to be replaced in the morning with gauze saturated with corrosive-sublimate solution, 1 : 2000, after a final scrubbing and shaving of the pubes. The vagina should be subjected to copious antiseptic douching twice daily, and if total hysterectomy is contemplated the more thorough and vigorous sterilization already described should be done. The patient should empty her bladder voluntarily before being taken to the operating room; the use of a catheter is rarely required. The general antiseptic precautions which must be observed as to the room, instruments, etc. will be found detailed in the chapter upon this subject.

The Position of the Patient.—Large growths which have pushed up into the general abdominal cavity and are readily accessible and removable without requiring much manipulation in the true pelvis, and small pelvic masses which are enucleable by the fingers alone without the aid of the eye and can readily be brought up to and out of a small abdominal wound, may be satisfactorily dealt with while the patient is in the ordinary horizontal dorsal position. When, however, any of the steps of the operation are embarrassed by the presence of intestinal coils or where it is desirable to bring into sight the recesses of the pelvis, the patient's pelvis should be raised sufficiently to place the trunk at an incline of from 45° to 60° to the horizontal. (See Fig. 371.)

The Incision through the Abdominal Wall.—The position and length of this

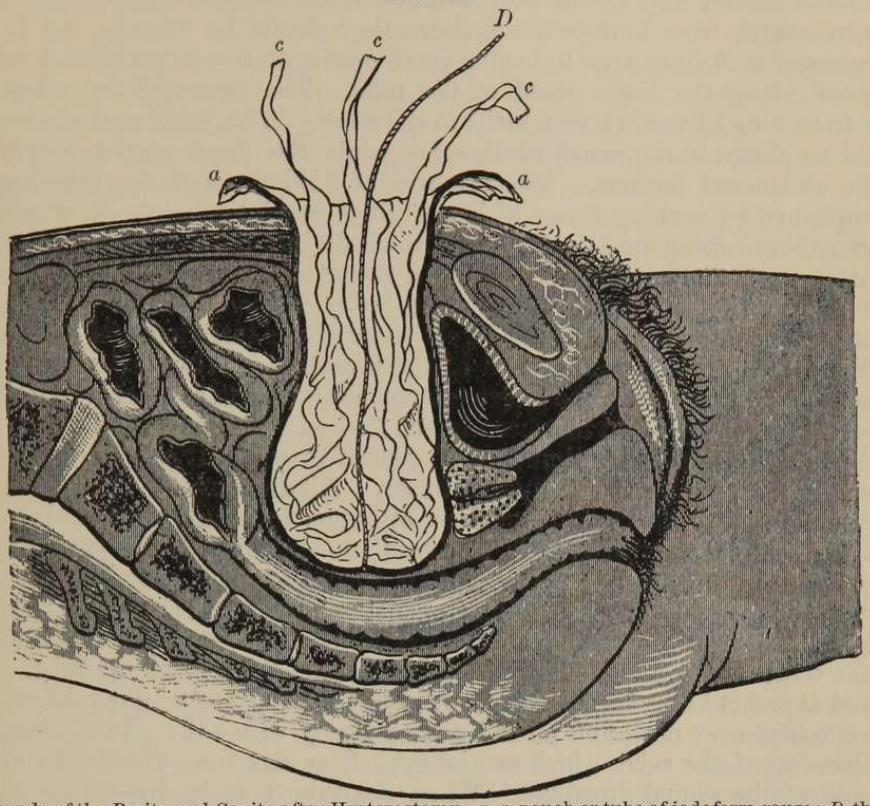
must be determined by the special case, and are referred to in connection with each condition treated of. In general, however, it should be midway between the pubes and the umbilicus, and as short as is consistent with the accurate, ready, and rapid performance of the manipulations required for the exploration, the separation, and the removal of the tumors. When the growths are cystic in character and free from adhesions, an incision from two to three inches in length will usually suffice, whatever the size of the tumor, the collapsed sac of which, having been emptied by tapping, is readily drawn out of the relatively small opening. The operator should not permit himself to be embarrassed by an unduly restricted incision at any time, but should enlarge it with scissors at once according to the needs of the case.

Adhesions.—The search for adhesions is usually to be reserved until in the case of cysts these have been emptied of their contents, or in the case of solid growths these have been freely exposed so that their attachments can be readily recognized and dealt with. If the adhesions are soft and recent, they are easily separated by the finger-tip or sponge. If they are firm and vascular, they should be secured by double ligatures or clamp forceps, and cut between them. At times the adhesions to intestine or bladder will be so close and firm as to prevent this double ligation; in this case a portion of the wall of the growth must be dissected away and left attached to the viscus. If possible the raw surface thus left attached should be folded in upon itself and sutured so as to leave a peritoneal covering exposed. Firm omental adhesions are to be treated by tying the omentum in sections and cutting it away. If intestine or bladder be lacerated in the attempts to separate adhesions, immediate suture of the wound should be done, and the wounded part, if possible, brought up and secured in juxtaposition to the abdominal wound, and protected by a tampon of iodoform gauze for some days until the possibility of fecal or urinary extravasation has passed away.

Arrest of Hemorrhage.—The sources of hemorrhage are chiefly three—adhesions, the pedicle, and raw surfaces left by the enucleation of non-pedunculated growths. The temporary use of clamp compression forceps, to be later replaced by permanent ligatures if necessary, is of the greatest value in expediting the removal of abdominal growths. The elastic ligature for the compression of thick pedicle stumps has been already described. Mass ligatures are often required, and can be resorted to freely with comparative impunity in consequence of the fact that the tied-off parts do not necrose, but soon become again vascularized after having been nourished for a time through imbibition. Silk, as a rule, is the best material for ligatures. Masses that are too large to be included in a single loop may be transfixed and tied in sections, two or more as the case may require. Each succeeding loop should catch the preceding one. Membranous edges or folds may be secured by a sort of hemstitch or shoemaker's stitch. Broad oozing surfaces may often be best treated by cauterization with the thermo-cautery. Cases occur in which none of the methods described avail fully to arrest bloody oozing from a deeply-placed raw surface. For such conditions is reserved the use of an antiseptic tampon by stuffing the cavity with iodoform gauze. For this purpose a pouch of iodoform gauze of suitable depth and capacity may be carried down upon the bleeding surface and its cavity stuffed with long strips of the same material, the ends projecting through the lower end of the abdominal incision. (See Fig. 372.) More positive compression may be exerted by stuffing successive layers of a long strip of iodoform gauze into the cavity, and finally bringing the end of the gauze out through a glass drainage-tube, the end of which is made to press down upon the tampon below. Later, by raising the tube somewhat, the entire

strip can readily be drawn out through it. Such a tampon should be removed after forty-eight or seventy-two hours, according to the amount of oozing.

FIG. 372.



Tamponade of the Peritoneal Cavity after Hysterectomy: *a*, *a*, pouch or tube of iodoform gauze: *D*, thread fastened to center of pad; *c*, *c*, *c*, strips of iodoform gauze (Pozzi).

If the bleeding is too copious to be controlled by such a tampon, clamp forceps may be applied and left *in situ* for from twenty-four to forty-eight hours, their handles being brought together out through the lower angle of the abdominal incision.

Cleansing of the Peritoneal Cavity.—All blood and other fluids that have escaped into the peritoneal cavity should be carefully removed before closing the abdominal wound. If there is much such material to be removed, washing out of the cavity should be resorted to by pouring into it, while the relaxed parietes are held apart, several pitcherfuls of warm salt solution, 6 : 1000, and 110° F. in temperature. Most of this fluid at once escapes upon squeezing the parietes together; the rest is to be carefully sponged out. Finally, the utmost caution is to be used not to leave in any of the recesses of the cavity any sponge or instrument, a deplorable accident which has happened many times, and to guard against which it should be the *invariable rule* to begin such an operation with a definite known number of sponges and forceps, all of which should be accounted for before the incision is closed.

Drainage.—Whenever the separation of extensive adhesions has left behind surfaces from which considerable sero-sanguinolent oozing is to be expected, and especially if any suspicion of possible infection of such secretions exists, provision should be made for drainage. If the question is a doubtful one, the benefit of the doubt should be given to the drainage-tube, since it can be

removed at an early day if found superfluous. In cases where secondary hemorrhage is feared a drain should be employed until the period of reaction has been fully established. Straight glass tubes are to be used as a rule; tubes somewhat curved may better meet the indications of some cases; these tubes vary in length from four to six inches; they should be open at the bottom and pierced with from nine to twelve small openings, not larger than 1 mm. in diameter, along the lower third of the tube. The lumen of the tubes may vary from 8 to 12 mm. ($\frac{3}{8}$ to $\frac{1}{2}$ inch) in diameter. The lower end of the tube should be placed in the pouch of Douglas, while the upper portion should rest in the abdominal incision. The removal of fluid through the tube may be accomplished by sucking it out with a syringe to whose nozzle is attached a bit of rubber tubing small enough to slip easily into the drainage-tube, or by the continuous and capillary suction of a strand of sterilized absorbent cotton wicking or gauze left in the tube. The latter method is to be preferred, as equally efficient, more simple, less likely to introduce infection, and demanding much less frequently a disturbance of the dressings. When hemostatic tamponade has been required, the gauze tampon likewise acts as an energetic drain. When the capillary drain has been introduced and the outer end of the tube has been covered with an abundant absorbent dressing, it can be left undisturbed for from twelve to twenty-four hours. All dressings of the tube should be conducted with the same scrupulous attention to antisepsis that characterized the original operation. To facilitate the dressing of the tube without disturbing the dressings of the wound, it should be long enough to protrude through the general wound dressing; over its exposed end should be sprung a piece of thin sheet rubber, fifteen by fifteen inches, having a small perforation in the center to be stretched over the flange near the end of the tube. The desired absorbent dressing having been placed upon the tube, this rubber envelope is folded over it all and pinned or tied firmly with silk. This constitutes the dressing of the tube, which can be opened at any time without disturbing the rest of the wound dressings. When the tube is to be dressed the rubber envelope is opened, the saturated dressings are removed, the capillary drain is taken out, and with long, slender forceps bits of absorbent cotton or gauze are passed down to the bottom of the tube repeatedly until they come up dry. A new capillary drain is then placed in the tube and the dressing completed as before. At each dressing the tube should be gently lifted and rotated three or more times; this prevents the omentum or intestine from becoming caught in the lateral openings.

As long as a fairly copious flow of secretion escapes from the tube it should be retained. As soon as it becomes scanty in amount the tube should be removed; as long as the tube is in it is a menace of infection, and it should be dispensed with as soon as the conditions which made it necessary have subsided. If no infection has taken place about the tube, the opening exposed by its removal should be closed by suture at once; if slight suppuration has been established along its track, a mesh of iodoform gauze should be introduced into the sinus, to be gradually shortened and lessened in amount until finally advancing cicatrization makes its removal possible.

The Closure and Dressing of the Abdominal Wound.—The first precaution is to secure union of the peritoneal edges: to ensure this, separate sewing of the peritoneum may be done with a running suture of catgut. Many surgeons deem this unnecessary. If a pedicle stump has been brought out at the lower angle of the wound, the peritoneal edges adjacent to it should be carefully sewed around the pedicle below the constrictor. If at the same time a drainage-tube is inserted, it should be brought out an inch or more above the pedicle and

the intervening space sutured. By many operators all the remaining tissues along the wound-line are now brought together at once by a series of interrupted sutures, silk or silkworm gut being used as the material. A more perfect safeguard against subsequent hernia will be obtained, however, by separate suture with catgut of the edges of the fibrous structure of the linea alba or of the sheath of the rectus muscle, and this should be done if the condition of the patient will warrant the slight additional delay which it may cause. Lastly, the superficial fascia and skin are sutured. If a drainage-tube is used, one or two silkworm-gut sutures should be introduced through the whole thickness of the edges at the place where the wound must gape to receive the tube. These sutures, having been loosely tied when introduced, are to be drawn tight when the tube is removed, so as to secure, if possible, immediate union also of that part of the wound. If during the introduction of the peritoneal sutures the intestines tend to protrude, they should be kept back by a flat sponge placed over them until the sutures have been introduced, enough of the last introduced sutures being left momentarily untied to admit of the final withdrawal of the protecting sponge. The external dressing should be sterile, soft, and absorbent, and a sufficient mass of it should be placed over the wound to protect it from accidental infection. The wound may be still further protected by a layer of iodoformized collodion (1 : 15) painted thickly over it, or by a free dusting with a powder of iodoform and boric acid (1 : 7) or with oxide-of-zinc powder. The main dressing is to be kept in place by several broad strips of adhesive plaster or by a suitable binder.

After-treatment.—Shock is to be combated upon general surgical principles. Severe pain must be relieved by the hypodermatic use of morphine, but the use of opium in any form is to be avoided as much as possible. Vomiting, if persistent and distressing, is to be alleviated by small frequent doses of hot water, by an ounce of strong infusion of coffee, or by cocaïne in doses of gr. $\frac{1}{4}$–$\frac{1}{2}$ every two hours, and by rectal feeding. The vomiting attendant upon peritonitis, should that condition develop after some days, is to be met by the relief of the condition which causes it. Tympanites is to be relieved by the introduction high up of a rectal tube and the occasional administration of a turpentine enema or one containing half an ounce of tincture of asafetida and twenty grains of bisulphate of quinia. Peritonitis, if developed, calls for the application of an ice-coil to the abdomen and for the use of free saline purges. If unrelieved by these, the wound should be reopened, collections of septic fluids sought for and evacuated by free antiseptic irrigations, and thorough drainage provided for. Hemorrhage into the peritoneal cavity may occur from a slipped ligature or from a vessel which, though not bleeding when the wound was closed, has begun to bleed with the establishment of reaction. Symptoms of progressive anemia and shock beginning to show themselves a few hours after an operation indicate such bleeding, and call, at any risk, for immediate reopening of the wound, exploration of the peritoneal cavity, and arrest of the hemorrhage.

In general, cases of abdominal section which escape any of the complications named demand simply the ordinary attentions proper to a person seriously ill. For the first twenty-four hours nothing should be introduced into the stomach except an occasional sip of hot water. Thirst, if great, can be slaked by enemata of hot water; ice and the drinking of cold water should be avoided. As soon as the nausea and vomiting have subsided, the administration of small quantities of liquid food may be begun. Milk with lime-water or Vichy water, thin gruels, beef-juice, and such-like preparations, are to be used. If the patient will take it, peptonized milk is best of all. As the convalescence pro-

gresses, a gradual advance to a more solid and varied dietary will be made according to the judgment of the surgeon in the particular case. If the irritability of the stomach persists beyond the first forty-eight hours, feeding by the rectum should be resorted to and continued until the stomach becomes able to tolerate food. Peptonized milk, beef peptonoids, eggs beaten up with salt and milk, are recommended for rectal feeding. The bladder should be emptied, if possible, voluntarily, but if at the end of about eight hours spontaneous urination has not occurred, a catheter should be used, every precaution being taken against the introduction of septic matter into the bladder, the introduction of the catheter being always preceded by a cleansing of the external meatus with an antiseptic wash. The catheter should be passed at intervals of eight hours until the power of normal urination is regained. The bowels should be moved on the third day by an ordinary enema if they have not been spontaneously evacuated before.

Re-dressing of the abdominal wound in an uncomplicated case will not be required until the end of ten days or two weeks. At the end of this time, the primary dressing having been removed, the wound will be found firmly healed and the sutures may be taken out. If any stitch-hole abscesses should be discovered, they will be treated on general principles; otherwise a small protective pad is simply laid over the recent cicatrix and suitable strips of adhesive plaster are applied to prevent any undue tension. During the third week the patient may be allowed to sit up, and according to the more or less rapid return of her strength may thereafter be allowed to resume her usual life. A protective abdominal binder should be worn for at least six months thereafter.

Intestinal Adhesions, with consequent Angulation and Obstruction, constitute a complication to be feared whenever extensive raw surfaces have to be left within the peritoneal cavity. It is difficult to differentiate this accident from general peritonitis, both conditions declaring themselves by obstinate vomiting, constipation, and tympanites, and tending to speedy death. In either case reopening of the wound and exploration are called for. If angulation is found to be present, the adhesions must be broken up and the intestine set free. Re-adhesion and renewed obstruction should be prevented by the use of saline purges to provoke peristalsis. Martin suggests anointing the raw surfaces that are to be left behind with sterilized olive oil as a possible preventive of adhesion. In any case, a cardinal rule is always to draw over every raw surface as much of a peritoneal covering as possible by sliding and suturing before closing an abdominal wound.

CARCINOMA OF THE UTERUS.

According to the statistics of Williams, 31 per cent. of all cases of carcinoma occurring in women have their seat in the uterus. The cervix is the region most frequently affected primarily; the body is, nevertheless, not rarely the point of origin. It is rare for it to occur in women under thirty years of age. About two-thirds of all cases occur between the ages of forty and sixty. In addition to the influence of age as a predisposing cause, there is much ground for assigning a marked influence, as contributing to its development, to chronic inflammatory conditions of the uterus, especially when combined with neglected lacerations of the cervix.

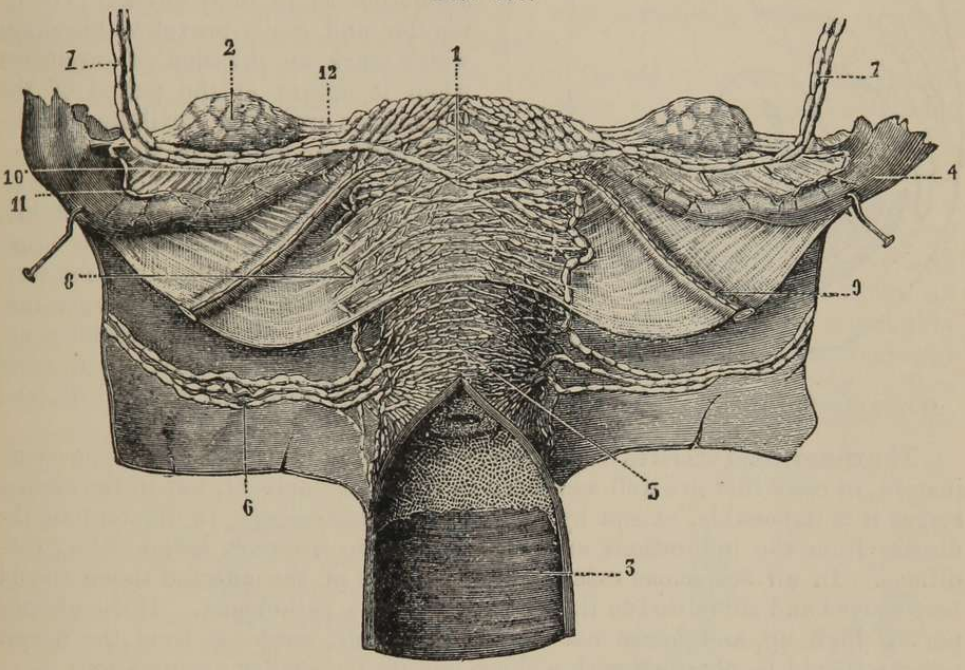
Carcinoma of the Cervix Uteri may present itself primarily either as an affection of the vaginal portion or of the mucous membrane of the canal, or as a nodular infiltration of the wall of the cervix. The first form, the cancroid

of some authors, may remain for a long time limited to the vaginal portion. Its further spread, as a rule, is particularly marked toward the vagina.

Carcinoma of the Corpus Uteri occurs as a primary disease more rarely than that of the cervix. It originates in the glandular structures of the endometrium, and thence extends as a diffuse infiltration with rapid disintegration.

In all forms of cervical cancer the vagina is frequently invaded early; extension upward to the body of the organ is, as a rule, slow. The vascular and lymphatic streams tend outward from the cervix along the base of the broad ligament (Fig. 373): hence the extension of the disease in this direc-

Fig. 373.



Lymphatic Vessels of the Uterus: 1, lymphatics coming from body and fundus of uterus; 2, ovary; 3, vagina; 4, Fallopian tube; 5, lymphatics coming from neck of uterus; 6, lymphatic vessels coming from neck of the womb and going to the iliac glands; 7, lymphatic vessels coming from the body and fundus of the uterus and going to the lumbar glands; 8, anastomosis uniting the vessels of the neck and body of the uterus; 9, small lymphatic vessel situated in the round ligament and terminating in the inguinal glands; 10, 11, lymphatic vessels of the Fallopian tube emptying into the great lymphatics of the body of the uterus; 12, ligament of the ovary (Pozzi).

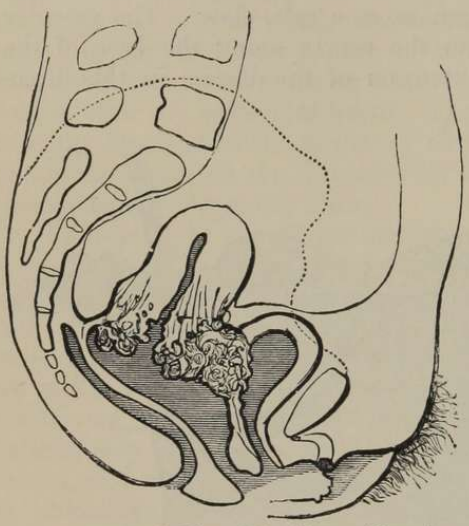
tion outward into the broad ligaments before the proper body of the uterus is involved. The inguinal lymphatic glands become affected only after a widely-disseminated pelvic disease has been created.

As the infiltration characteristic of the disease increases, the contiguous tissues and adjacent organs become involved; the bladder, uterus, or rectum (Fig. 374) may become more or less seriously damaged, and the symptoms referable to their irritation or obstruction be added to those existing previously. The early involvement of the connective tissue of the broad ligaments thickens and shortens them and anchors the uterus firmly, while it may cause compression of the pelvic vessels, giving rise to œdema of the lower extremities and to pain along the involved nerve-trunks. A more or less rapid disintegration of the new growth supervenes early; the processes of infiltration and ulceration follow close upon each other: as a result, the bladder or the rectum, one or both, may be opened into, and one great foul cloaca,

receiving urine, feces, and the débris and discharges from the uterus, be created. A forerunning adhesive inflammation alone prevents the frequent opening of the peritoneal cavity also.

The **symptoms** in its earlier stages are indefinite and uncertain. Carcinomatous degeneration of the uterus may attain considerable proportions without provoking any noticeable symptoms, and may finally be detected only by accident. More frequently the occurrence of vague pains, irregular hemorrhages, and a somewhat profuse and offensive vaginal discharge invites examination as to their cause. The irregular and easily-provoked bleedings which mark an invasion of carcinoma when it occurs at the period of the menopause are often attributed to the menstrual irregularities which so frequently attend it. The occurrence of such bleedings at that period of life, therefore, is to be considered a suspicious circumstance and to call for careful examination. The discharges that attend a disintegrating carcinoma are thin, watery, and dirty, often acrid and mixed with shreddy débris, and exceedingly offensive.

Fig. 374.



Cancer of both Lips of the Uterus (Skene).

The **diagnosis** declares itself at once to the eye and to the touch, upon examination, in cases that are well advanced in their development, but in the earliest stages it is impossible, except by the aid of the microscope, to differentiate the disease from the indurations and erosions due to ordinary inflammatory conditions. In all suspicious cases a small section of the affected tissue should be removed and submitted to the examination of a pathologist. If the affected part is high up, and hence not readily accessible, scrapings from the deeper mucosa should be obtained with a sharp curette for similar examination.

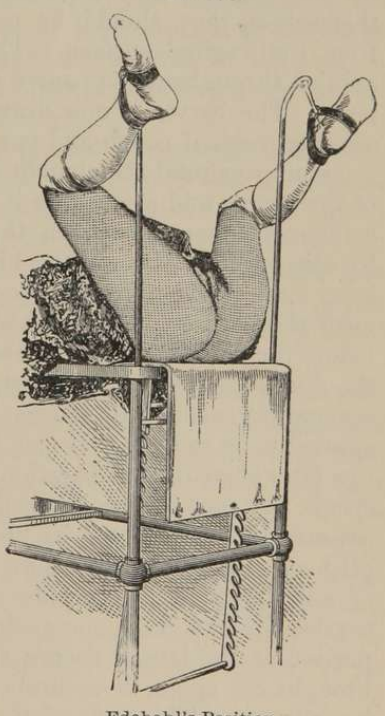
The **prognosis** is that which attends like malignant disease elsewhere. The average prolongation of life when the disease pursues its natural course is from twelve to eighteen months. The younger the patient the more rapid the course of the disease. If the disease is detected early enough to admit of the absolute removal of all affected tissue, permanent cure may sometimes be expected. The early extension of the disease outward along the lymphatic channels of the deep pelvis, which for some time it may be impossible to detect, makes the prognosis in any given case uncertain. In estimating the proportion of cases in which permanent relief is obtained by extirpation, the consideration of all cases in which the clinical diagnosis has not been confirmed or established by the microscopical findings as determined by a competent pathologist must be excluded. This is especially important in dealing with malignant disease of the vaginal portion, for which simple inflammatory conditions are often mistaken. The principles which govern the prognosis of carcinoma of the uterus are the same as obtain in other organs of the body, modified by the special anatomical relations of the uterus. Cure is to be expected only from operative measures that will secure the removal of a very considerable zone of apparently healthy tissue around and beyond that which is manifestly diseased. Since carcinoma of the portio vaginalis is usually detected at an earlier period of

development, and naturally extends slowly at first, it will always present the largest proportion of cures of any of the forms of the disease.

Treatment.—The prevention of the development of carcinoma of the uterus has a practical side through the probable predisposing influence of chronic endometritis, especially when accompanied with laceration and erosion of the cervix. The proper treatment and early cure of such conditions, therefore, assume importance in the prophylaxis of cancer. The occurrence of irregular hemorrhages or the development of leucorrheal discharges in women who are approaching or have passed the menopause should be the signal for immediate and thorough examination of the uterus. The presence of cancer having been determined, its total extirpation is to be done at the earliest possible moment if the disease appears to be still sufficiently limited to afford ground for hope that its removal is practicable.

Cancer of the portio vaginalis, when still limited in extent, even though some extension to the vagina may have taken place, may be attacked with some hope of permanent cure by excision of the diseased tissue and thorough cauterization of the tissue left behind. The cervix having been drawn down to the vulva, a provisional ligature is first passed around the uterine arteries by a curved needle armed with a stout thread introduced in each lateral vaginal fornix. This having been tied, the diseased tissue is freely cut away with scissors or scalpel until apparently healthy tissue alone remains. When all bleeding has ceased a thermo- or electric cautery point should be thoroughly applied, so as to produce a deep cauterizing effect. The subsequent treatment is simple: the eschar separates in due time, leaving a granulating surface which heals rapidly, requiring only the use of daily antiseptic douches for cleansing purposes. For some time the parts should be carefully watched, and the appearance of any suspicious change should be met by the immediate repetition of the treatment.

Fig. 375.



Edebohl's Position.

Cases originating in the mucous membrane of the cervical canal, or presenting much infiltration of the cervical substance, or involving any portion of the corpus uteri, call for the total extirpation of the uterus, provided the disease is apparently still limited to the uterus. This removal of the uterus should be done as soon as the diagnosis is clearly established. If possible, it should be done through the vagina alone, but if this is rendered difficult by the large size of the uterus or the contracted condition of the vaginal passage, an incision through the abdominal wall may be added. A thorough preliminary disinfection of the vagina and of the uterine canal should be done. For the latter the cervix should be thoroughly curetted, and cauterized either with the actual cautery or by a tampon moistened with a saturated solution of chloride of zinc. If the latter is used, it should be applied three days before the major operation is to be done.

Vaginal Hysterectomy.—As an immediate preliminary to the operation the rectum and bladder should have been emptied,

the pubes shaved, and thorough disinfection of the external genitals and thighs made. For the operation the patient should be placed upon her back with pelvis raised in an exaggerated lithotomy position. (See Fig. 375.)

The labia and perineum having been retracted, the cervix is seized by a suitable volsella forceps and drawn as far down as possible; the excavation in the cervix left by the curetting and cauterization is first well irrigated with sublimate solution, 1 : 1000, and then filled with a tampon of iodoform gauze, and its lips sewed as closely together as possible by a continuous suture. The cervix is then lifted strongly forward, so as to put the posterior vaginal pouch on the stretch. A transverse incision is next made just behind the cervix through the vaginal wall, opening into the sac of Douglas. A series of sutures is then passed so as to unite the posterior edges of the peritoneal and vaginal incisions, and thereby control bleeding from the vaginal vessels severed by the cut.

The cervix is now drawn strongly to one side, and a moderately large curved needle, armed with a strong thread, is thrust through the lateral reflection of the vagina as close as possible to the uterus, deeply into the base of the broad ligament, and after executing a sharp curve is brought out again about a quarter of an inch from its point of insertion. This manœuver may be aided and guided by the forefinger introduced into the posterior incision already made. The cervix having been permitted to drop back into its natural position in the middle line, this ligature is tightly tied, and thus the uterine artery encompassed by it is ligated. After the same manœuver has been executed upon the opposite side, the cervix is further separated from the vagina by prolonging the incision already made, laterally, inside the ligatures; the cervix is separated from the broad ligaments on each side up to the limit of the tissue grasped by the lateral ligature applied. If bleeding points present themselves, they should be controlled by the insertion of additional sutures from the vaginal surface. These hemostatic sutures, as, indeed, all ligatures applied throughout the course of the operation, should be tied with great firmness. The cervix is now drawn backward and downward so as to expose the anterior vaginal pouch and put the bladder attachments upon the stretch. The remaining vaginal attachment is now divided by a transverse incision in front of the uterus and as close to it as possible. This incision should open into the cellular interspace between the uterus and the bladder. By the finger, aided by scissors if necessary, the bladder is stripped off—great care being taken to keep close to the uterus in the work of separation, lest the bladder be injured—until the peritoneum is reached. The extent of tissue to be worked through before the peritoneum is reached will vary considerably in different subjects, but the diminished sense of resistance communicated to the finger when the peritoneum is reached will suffice to indicate its presence, even though it be not recognizable by the eye. It may be at once opened, or its incision may be deferred to a later stage of the operation, whichever may seem the more convenient. The cervix has now become freed for some distance above the vaginal attachment: its safe liberation from its broad-ligament attachments remains to be accomplished. Having been drawn down as much as possible, a ligature, by means of a strongly curved needle upon a suitable handle (Deschamps' needle), is carried upward close alongside the uterus, so as not to encompass too great a portion of the lateral tissues still holding the uterus; the thread, having been brought out again, is securely tied, and the greater part of the tissue grasped by it is cut. The ends of the ligatures should be left long. By a succession of ligatures thus applied, taking care to include in each ligature a portion of the tissue held by the preceding one, followed by successive snips of the

scissors, the broad ligaments are gradually tied and cut off. The application of the higher ligatures may be facilitated by retroverting the uterus by the help of a finger passed through the posterior incision over its fundus, together with volsella forceps to make traction, and pulling it down as far as possible. By this act the upper part of the broad ligament, twisted upon itself, is made readily accessible. The lateral attachments being all finally cut, the anterior peritoneal reflection, if not cut before, is now cut across and the uterus entirely liberated.

After the removal of the uterus, if the appendages present readily, they may also be removed. No prolonged search for them, however, should be made, as their retention does not subject the patient to any serious subsequent annoyance. If at any time in the course of the manipulations the intestines tend to protrude through the peritoneal opening, which is uncommon, they should be crowded back by a sponge, to which a marked string is attached to identify it for subsequent removal, passed into the pelvic cavity. The sponge tampon, if one has been inserted, having been withdrawn, and all bleeding having been absolutely controlled by ligatures, sutures, or clamp forceps, the parts should be irrigated with a mild antiseptic douche, and finally dried with sponges upon suitable holders. The vaginal wound may be diminished in extent by a suture applied at either lateral commissure, but this is not important.

A strip of iodoform gauze is next pushed up into the pelvic cavity for drainage purposes, its lower portion being coiled up in the vagina. The ligature ends should now be gathered up, those from each side being made into a separate twist, and then gently pulled down so as to invert into the open vault of the vagina the raw surfaces to which they are attached. They are left coiled up in the vagina to act as drains, to be ultimately removed after from one to two weeks as they gradually become detached by the separation of the stumps which they hold. A separate small piece of iodoform gauze should be stuffed into the introitus, to be frequently changed as required by the exigencies of urination. An abundant soft absorbent pad is placed over the vulva, to be changed whenever saturated with the discharges.

The after-treatment is very simple, and is guided by general principles. An easy convalescence, free from pain and constitutional disturbance, is usual. At the end of the first week the long gauze drain is withdrawn and the vagina gently irrigated. After another week the patient may be allowed to sit up. From time to time gentle traction should be made upon the ligature threads until they finally have all come away. Careful vaginal douches may be given daily as required for cleanliness. After three weeks, walking and gradual return to ordinary life may be begun.

Instead of tying off the broad ligaments, as above recommended, it will often be found practicable and more expeditious to clamp the broad ligaments by suitable long-jawed clamp forceps, which are left *in situ* protruding from the vulvar opening for from forty-eight to seventy-two hours, when they may be gently loosened and removed without fear of further hemorrhage. If the clamps are to be used, the posterior and anterior peritoneal pouches are to be opened first, and through these openings the blades of the clamps are to be adjusted close to the uterus. If the operation is embarrassed by rigidity and narrowness of the introitus or of the vagina, the perineum may be incised so as to obtain more room. The proper sutures to close the incision are to be inserted after the uterus has been removed.

Hemorrhage, sepsis, ligature of a ureter, and wound of the bladder are accidents against which the surgeon must be especially on guard. The liability of some tissue to slip out from the jaws of a clamp when a large mass of

tissue is held in its grasp is an important objection to the use of clamps in such a manner. In the application of ligatures, also, too great a mass of tissue should not be embraced by the loop of a single ligature, for the same reason. In any event, great care should be taken to see that perfect hemostasis is obtained at each step of the operation. As to sepsis, the chief source of infection is likely to be the uterus itself, owing to defects in the attempts at sterilizing it. Special care should be taken to make this preliminary work thorough. The ureter is liable to be wounded or to be included in the grasp of a ligature or clamp if care is not taken to keep close to the uterus in all the manipulations involving the base of the broad ligaments. When such an accident happens, if not fatal, it results in a ureteral fistula. A tear of the bladder is also possible during its separation from the cervix if the operator is not careful to confine his dissections to the tissues close to the uterine substance. If the bladder is torn, immediate suture of the rent should be done, and a soft catheter retained in the bladder for five days.

The mortality attending the operation of vaginal hysterectomy is governed largely by the operative skill and experience of the surgeon and the varying resisting power of individual patients. The results of the latest-gathered experience indicate that in general the mortality inherent in the operation is less than 5 per cent. The immunity from recurrence which it secures is difficult to estimate properly, owing to the impossibility of determining with precision, in any given case, that no extension of the disease beyond the limits of the uterus has not already taken place. It is evident that the earlier hysterectomy is done, the more probable will be the total extirpation of the disease and the greater the probabilities of future immunity. Sufficient experience has not yet been published to warrant exact statements on this head, but it is not likely that results will be much different from those which are known to follow the extirpation of carcinoma in other parts of the body, as the lip and the breast, in which parts freedom from recurrence is known to follow in a large proportion of cases radically operated upon.

Palliative Treatment of Advanced Cases.—Unfortunately, a large proportion of cases of cancer of the uterus do not present themselves to the surgeon until the disease has extended beyond the limits of the uterus, especially along the lymphatics of the pelvic connective tissue in the base of the broad ligaments. This is indicated by the fixation of the uterus and by the indurations perceptible to the finger in the parametric tissues. Disintegration of the carcinomatous growth is also more or less advanced, hemorrhages are frequent, and the discharges are copious and offensive. Such cases may be temporarily much benefited by free curetting of the softening tissue, followed by thorough cauterization. The curetting should be done with a sharp curette, and should be radical in its extent. If the bleeding provoked by it is not quickly checked by irrigations with hot water and compression with an iodoform tampon, hemostasis may be secured by deep sutures introduced so as to encompass the bleeding points. When the bleeding has been stopped the cauterization is to be done. For general use chloride of zinc is the most convenient and efficient caustic. The technique of its use is as follows: Small pledgets of absorbent cotton, soaked and wrung out of a saturated solution of zinc chloride, are stuffed into the cavity left by the curetting until it is filled up. The adjacent surfaces of the vagina are smeared with an ointment of bicarbonate of sodium and petrolatum, 1 : 3, and the vagina filled with a tampon of absorbent cotton wrung out of a saturated solution of bicarbonate of sodium, the latter provision being adopted to prevent cauterization of the vagina. On the third day the tampon and as much of the caustic packing as will easily

come away are to be removed. By the fifth day all the packing will have been removed. Between the fifth and tenth days the eschar will come away, leaving behind a granulating surface, which will to a large extent contract and cicatrize during the subsequent weeks, while simple cleansing douches are used. A notable amelioration of all symptoms at once occurs, and is maintained until the processes of infiltration and breaking down have again become far advanced.

Malignant Adenoma of the corporeal endometrium is a transitional form of disease between simple inflammatory hyperplasia of the glandular structures of the endometrium and carcinomatous degeneration. It is characterized by an abundant new formation of glandular tissue that tends to infiltrate the deeper tissues. It is slow in its growth, possibly taking some years to develop serious symptoms: its most prominent symptom is hemorrhage, which, if the affection is developed before the menopause, is a menorrhagia; if later in life, is irregular in its attacks. If subjected to the curettings and cauterizations efficient against simple inflammatory glandular hyperplasia, it quickly recurs, and after a lapse of a more or less prolonged period, from three to five years, develops into typical carcinoma, with involvement of adjacent tissues, metastasis, and death.

The **diagnosis** is to be made by comparison of the histological findings from microscopical examination of deep scrapings, with the clinical course. The microscope shows the marked and irregular proliferation of the glands with diminution of interglandular tissue, and the history of the case is characterized by repeated recurrence after treatment. Such an assemblage of conditions, particularly if a new development in a woman who is approaching or has passed the menopause, is sufficient to establish the probable diagnosis of malignant adenoma and to make radical treatment justifiable.

The **treatment** is the same as for true carcinoma of the body of the uterus—viz. total hysterectomy, by the vagina if possible.

Sarcoma of the Uterus is rare: it may occur at any period from childhood to old age; its most frequent development has been noted as a degenerative change in fibro-myomata. Its symptoms and cause are not essentially different from those of other forms of uterine malignant disease, and its treatment is the same.

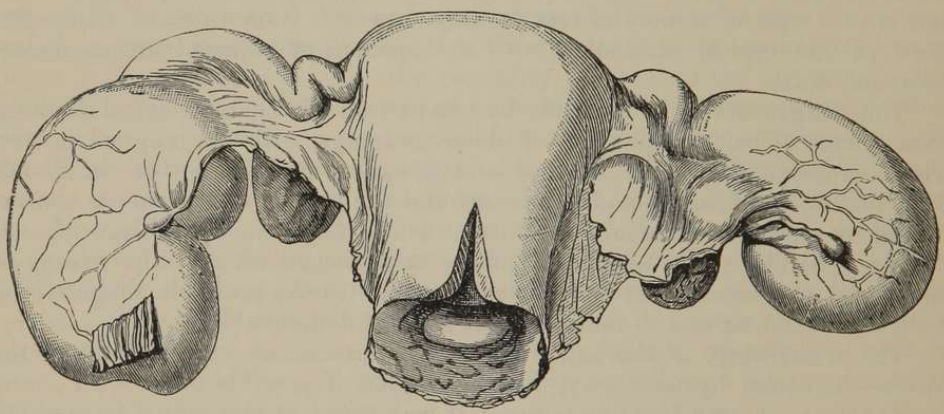
THE FALLOPIAN TUBES.

Inflammation of the Fallopian Tubes, or Salpingitis, is a frequent condition, being secondary to a similar condition of the endometrium. Septic endometritis and gonorrheal endometritis stand in a direct causative relation to nearly all cases of salpingitis. Tuberculosis occasionally develops in the Fallopian tubes and determines its own type of inflammation. Cancer of the uterus, as it disintegrates, is accompanied with secondary septic infections that may be propagated to the tubes and determine there inflammatory complications of more immediate danger and suffering than the primary disease. Both tubes become affected in about one-half the cases. When but one tube is diseased, the left tube is the one most frequently affected.

Pathology.—The changes in the mucosa of the tubes are those common to inflamed mucous membranes in general, and depend, as to their extent, upon the intensity and depth of the inflammation. The tissues of the tube become infected, swollen, and succulent; the secretion is increased in amount, and in the more severe cases is purulent. The tube elongates and becomes somewhat convoluted. The most important changes are those which result from the involvement of the peritoneum in the inflammatory processes.

Local peritonitis may be excited either by extension of the inflammation through the wall of the tube to its investing peritoneum or by the escape of infective secretions from the open abdominal end of the tube. Diffuse, rapidly-fatal peritonitis may result, but in general the peritonitis remains localized within the pelvis, and by its exudate cements together to a varying degree the pelvic organs. In the majority of cases the peritoneal inflammation is limited to the immediate neighborhood of the abdominal end of the tube, the fimbriæ of which become agglutinated and adherent to the ovary or other adjacent structure. The minute uterine orifice of the tube early becomes blocked by inflammatory swelling of the mucosa, so that the occlusion of the abdominal opening determines an accumulation of its secretions within the closed tube and its greater or less distention, forming a convoluted sausage-like body hanging down by the side of the uterus. (See Fig. 376.)

Fig. 376.



Hydrosalpinx (Hennig).

If the retained fluid is purulent, the condition is that known as *pyosalpinx;* if the secretion is mucoid and limpid, possibly chocolate-colored, a *hydrosalpinx* is present. A bloody effusion constitutes *hematosalpinx*. There is reason to believe (Bland Sutton) that nearly all cases of blood-effusions into the Fallopian tubes are results of a tubal pregnancy.

The ovary becomes involved early when the inflammation extends to the peritoneum. Its capsule undergoes inflammatory thickening; its follicles are unable to discharge their contents and become converted into cystic dilatations (Fig. 378); the suppurative process may extend to one of these dilatations, and an ovarian abscess result.

Pus enclosed in a Fallopian tube is practically an abscess within the cavity of the pelvis, and has often been spoken of as pelvic abscess. If the infection is active and the local conditions are favorable, the pus may continue to accumulate until great distention of the tube has been produced; meanwhile, extensive adhesions to adjacent organs are formed, so that the ultimate opening of the abscess may be into intestine, vagina, or bladder, or it may find its way to the surface in the inguinal region. Less frequently it bursts into the free peritoneal cavity. In more favorable cases the obstruction at the uterine orifice may be overcome and the tube discharge itself into the uterus; in other instances the active suppuration is arrested, the secretion becomes inspissated, and a thickened, chronically inflamed tube, enclosing a limited

amount of thick pus, remains. A slow accumulation of serous fluid may take place into such a cavity, converting it into a hydrosalpinx.

Salpingitis may from the outset be less severe in its type than has been described, may never determine peritoneal complications, and, like any other mucous catarrh, may subside and leave no permanent damage behind it. The swelling of the mucous lining of the tube leads to temporary obstruction of the uterine orifice, and to the production of the symptoms of tubal distention with the increased mucous secretion. Under treatment the inflammation subsides, the orifice again becomes patent, and the retention is relieved by the escape of the secretion into the uterus. Such attacks are liable to recur.

The **symptoms of salpingitis** will vary according to the acuteness of the attack, the virulence of the infection, the involvement of the peritoneum, and the existence of occlusion and distention of the tubes. *Acute suppurative salpingitis* is ushered in by rigors, fever, and pain in the lateral regions of the pelvis. Pressure into the pelvis, either from above or from the vagina, shows great tenderness. Conjoined manipulation makes evident to the finger in the vagina or the rectum the more or less swollen tube. The involvement of the peritoneum is signalized by a more diffused pain and tenderness, with some tympanites. The pouring out of exudate into the pelvic pouch and the cementing together of the organs give to the examining finger a sense of a hard mass filling up more or less of the pelvis, enveloping the uterus and appendages, and immobilizing the uterus. The later general symptoms are those of chronic septicemia attending pus-collections anywhere, leading to exhaustion and death.

Chronic Salpingitis.—If the acute onset is limited in its invasion and subsides into a chronic state, there will persist a dull pain in the pelvis, which is aggravated by motion, as in walking, or by coition; there is local tenderness; menstruation will be painful, the flow being increased in frequency and amount; the enlarged tubes, more or less obscured by adhesion to adjacent viscera and by inflammatory exudations, will be perceptible to the examining finger as elongated swellings at the side of or behind the uterus. The patient is rendered a chronic invalid by reason of continual pain and the aggravation of her sufferings which any attempt to engage in the activities of life produces. If the affection is bilateral, sterility results.

Catarrhal Salpingitis declares itself by pain, tenderness, and swelling along the course of the tubes, which fall short of the more threatening and severe symptoms already detailed. A sudden amelioration of all symptoms may occur, with disappearance of what may previously have been a well-defined tumor, as the inflammation subsides sufficiently to permit the tube to empty itself into the uterus.

The **diagnosis** requires a careful comparison of the history of the case with the symptoms and conditions evident to physical examination. The differentiation of salpingitis from other pelvic conditions which may be confounded with it is often difficult, and sometimes impossible, previous to operation. Doubt may arise, more especially in cases of small ovarian and parovarian growths, early tubal pregnancies, small pedunculated uterine fibro-myomata, exudations into the substance of the broad ligaments, and even retroflexions of the uterus, all of which may simulate closely the conditions of chronic salpingitis. A history of a labor or abortion complicated by the development of peritoneal symptoms as the beginning of the trouble in question, or of trouble developing after some minor gynecological procedure, or of the previous existence of an acute vaginitis and endometritis possibly or confessedly gonorrheal, creates a strong presumption in favor of salpingitis. Pain, tenderness, and a definable

intrapelvic mass, all may attend the conditions enumerated as liable to be confounded with salpingitis, but the characteristic history is likely to be lacking. Ovarian affections form swellings that are not so directly continuous with the uterus as are tubal swellings; broad-ligament effusions, comparatively rare, are lower down in the pelvis and depress the vault of the vagina; a retroflexion of the uterus will escape recognition only through haste or lack of practice in the examiner. Notwithstanding these academic distinctions, it is often the case that adhesions and exudations and distentions so alter the relations and contour of parts in the pelvis as to make their positive identification impossible to the most experienced examiner. Salpingitis may coexist with other intrapelvic affections, another source of confusion being thus added to the diagnosis.

Tubercular salpingitis may be suspected when, in young women whose life is above suspicion as regards gonorrheal or other common septic infection, the usual signs of tubal inflammation and enlargement develop. If tuberculosis in other parts of the body coexists, the suspicion is strengthened.

The **prognosis** of the milder forms of salpingitis is good: even in cases whose onset is acute and severe, under proper treatment speedy amelioration and ultimate recovery may be hoped for. This occurs only when the disease is arrested and subsides without having caused occlusion of the abdominal opening of the tubes. In some of these cases, however, the recovery is not absolute, but a latent infection remains for an indefinite time that may be reawakened into severe activity by some new exciting cause in after-years. Under proper treatment decided amelioration, and occasionally entire recovery, may at times be secured in cases that presented every evidence of occlusion of the tube: in a large proportion of such cases, however, the condition persists uninfluenced to any marked extent by treatment, and is to be relieved only by extirpation of the tube. When the suppuration is frankly declared and is progressive, its spontaneous evacuation through the vagina or the rectum may be followed by ultimate recovery or by gradual wasting from prolonged septic absorption. The danger of the bursting of such an abscess into the general peritoneal cavity, with rapid death, is always considerable.

The **treatment** in the acute stage requires, first of all, absolute rest in the recumbent position. Hot fomentations should be kept applied to the hypogastrium; copious hot vaginal douches at intervals of four or six hours should be administered; the bowels should be freely moved by salines; pain, if severe, should be controlled by opiates, but the amount given should be kept at the minimum consistent with the relief of pain. As the acuteness of the symptoms subsides the fomentations are omitted, the douches are diminished in frequency, and a gradual restoration to activity is allowed. If with the subsidence of the acute symptoms the evidences of permanent change, involving intra-peritoneal inflammatory exudates, occlusion, and distention of the tubes, persist, the further adoption for a time of means for promoting absorption of inflammatory exudates is to be recommended. The iodides and saline laxatives may be administered; the vault of the vagina may be painted with tincture of iodine once or twice a week. A weekly insertion of a vaginal tampon charged with boro-glyceride may be resorted to. The regular use of a copious hot vaginal douche twice daily for a prolonged period is to be kept up. As long as improvement attends these measures they should be continued. In a fair proportion of cases a gradual return to health takes place: many, however, remain rebellious, any temporary improvement being quickly overcome if the patient attempts to go about or to perform any work. When the disease has been demonstrated to be incurable by these means of treatment,

extirpation of the diseased tubes by abdominal section should be done. This extirpation should not be deferred until the patient is worn out through long suffering, but should be resorted to as soon as the inefficiency of less radical measures has been unmistakably demonstrated. The technique of the operation required for removal of the tubes will be considered in connection with that required for the extirpation of degenerated ovaries, with which they are usually associated.

When the suppuration within the tube is abundant from the outset, and causes the rapid accumulation of a considerable amount of pus within the dilated tube or in spaces outside of the tube shut in by adhesions, attended by all the local and constitutional symptoms of an acute abscess, the pus-cavity must be evacuated as speedily as possible by puncture from the vagina if it tends to bulge into that canal and its fluctuation is appreciable there; otherwise by abdominal section and enucleation if possible: in any event, the cavity must be opened and emptied, the contact of its contents with the general peritoneum prevented as far as possible, and free drainage provided for by means of glass tubes reinforced with iodoform gauze tampons.

Neoplasms of the Fallopian Tube are very seldom met with, and hardly merit special attention. Descriptions of one or two isolated cases of myoma and of primary carcinoma may be found in literature. According to Bland Sutton, adenomata are not infrequent, being met with as papillomatous masses springing from the tubal mucosa distending the tube and sprouting out into the free pelvic cavity. They determine a copious effusion into the peritoneal cavity, and are possible causes of some otherwise inexplicable cases of obstinate ascites. Tubes thus affected should be extirpated by abdominal section.

Tubal Pregnancy.—For details pertaining to the etiology and pathological anatomy of tubal pregnancy reference must be made to treatises upon obstetrics. Its diagnosis and treatment, however, engage in a special degree the attention of the surgeon. When rupture occurs, in a great majority of instances the immediate and bold intervention of the surgeon is required to avert impending death. In the few instances in which the conditions after the primary rupture of the tube make any further development of the embryo possible, the ultimate intervention of the surgeon will be required, according to the special conditions of the particular case, either to avert disaster from a second rupture, to secure the removal of a sac filled with an infected mass of decaying débris, to liberate a feeble or imperfectly-developed fœtus, or to rid the body of the encumbrance of the degenerated remains of a fœtus that has perished. All forms of extra-uterine gestation pass their primary stages in the Fallopian tube. As the growth of the ovum proceeds, the structure of the tube is such as to make inevitable one of the following events:

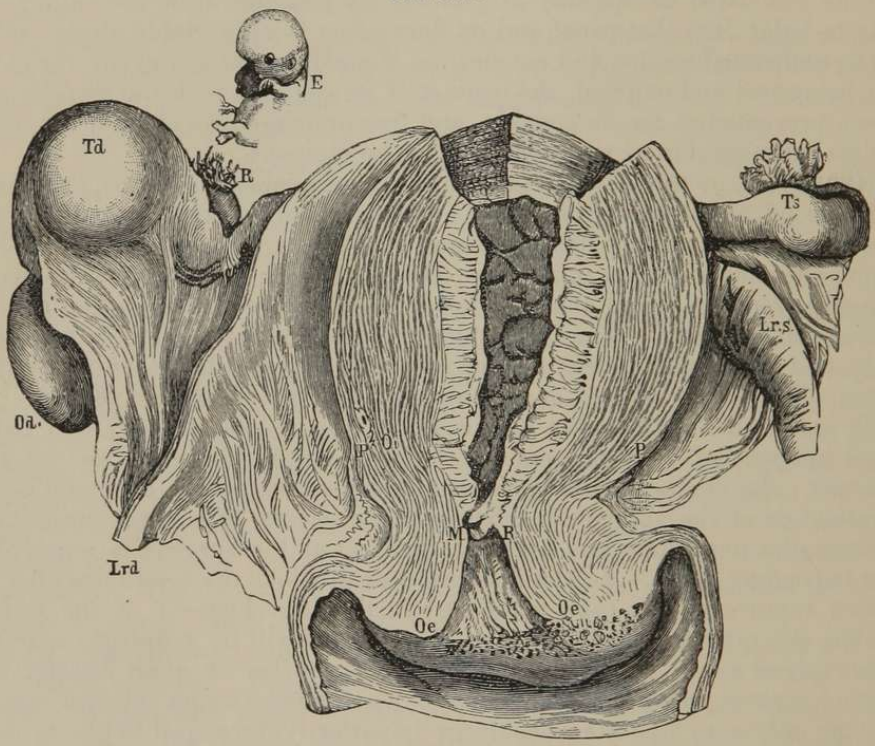
1. The vascular relations of the ovum may be so defective that after a few weeks it perishes; an extravasation of blood from ruptured chorionic villi produces or attends this result; the rapidly-increasing distention of the tube from this hemorrhage may be so great as to cause its rupture, or, if not, there persists a blood-tumor of the tube, a *hematosalpinx*, which may rupture at some later time or remain as a source of local irritation, attended with pain and producing disability.

2. If the ovum has become fixed in the outer third of the tube, it may during the first eight weeks of its development become extruded into the peritoneal cavity through the still open ostium abdominale. Shock and hemorrhage accompany this accident. This is the most frequent source of intra-peritoneal pelvic hematocele.

3. If the ovum continues to grow, or if it is suddenly enlarged by a copi-

ous hemorrhage into its villi, rupture of the tube inevitably results (Fig. 377). Such rupture is frequent between the third and tenth weeks after impregnation, and is rarely deferred beyond the twelfth week. If the site of the ovum is along the middle third of the tube, the line of rupture may be through the floor of the tube into the connective tissue of the broad ligament, but in the great majority of instances the rent opens into the free peritoneal cavity, with discharge of the ovum and a variable amount of blood directly into it. The loss of blood and the shock attending the rupture may be sufficient quickly to induce death. When the effused blood is moderate in amount, it may be shut off from the general peritoneal cavity by adhesions and eventually be absorbed,

FIG. 377.



Tubal Pregnancy, rupture at end of second month: *Td*, ruptured tube; *R*, site of rupture; *Od*, right ovary; *Lrd*, right round ligament; *Ts*, left tube; *Lrs*, left tube round ligament; *PP*, peritoneum; O_1, section of frozen specimen; *M R*, Müller's internal os; *Oe*, external os (Bandl).

or it may become the subject of infection and septic changes. If the primary rent is too small to permit the escape of the ovum through it, recurrences of bleeding are induced until fatal anemia results.

4. If the rent in the tube opens into the connective-tissue spaces of the broad ligament, the hemorrhage becomes restrained by the resistance of the tissues, and a more or less extensive hematoma or hematocele of the broad ligament results. If the ovum is already dead, or dies as the result of the rupture, it and the effused blood will in time become absorbed, and recovery after a prolonged illness may result. If the ovum survives the accident, room for its further growth for a time is provided for by the gradual opening up of the broad ligament.

In the majority of cases the fœtus, after a variable period of feeble struggle for life in its new relations, dies. If it escapes infection, it may be retained for an indefinite time, undergoing mummification or saponification or becoming

encrusted with lime-salts. More frequently infection is transmitted to it through adjacent tissues, and the decomposition and suppuration resulting produce a highly septic pelvic abscess. If, however, the life of the fœtus is prolonged, its growth is attended by the formation of a sac by the stripping up of the peritoneum from all the adjacent parts. Rupture of this sac may occur at any time: if the rupture should involve the site of the placenta, profuse and rapidly fatal bleeding results; otherwise the fœtus may escape into the free peritoneal cavity, and, being still nourished by its previous placental attachments, continue its growth there; again, rupture may never occur, but the development of the fœtus may go on to term and spurious labor take place, the fœtus die, the liquor amnii be absorbed, and indefinite retention of the degenerated fœtus follow. In any case in which abscess-formation takes place the collection may find vent externally through the rectum, vagina, bladder, or uterus, or may point through the abdominal wall.

The **diagnosis** of tubal gestation before rupture is very difficult. A distinction is to be made from inflammatory conditions of the Fallopian tube or of the broad ligament and from small ovarian growths. At best, the decision can rarely, if ever, be a positive one. The early symptoms of conception when the ovum is fixed in a tube do not differ so much from those attending uterine pregnancy as to attract attention, so that it is not until rupture takes place that suspicion of the presence of any trouble is awakened. The symptoms that attend rupture are pain, shock, vomiting, and the signs of internal hemorrhage. There is usually some bloody vaginal discharge, accompanied with shreds of decidual membrane from the uterus sufficient to suggest abortion. The abdominal pain and general depression are like that attending acute intestinal strangulation or perforation or axial rotation of the pedicle of an ovarian cyst. The condition may be confounded with that due to the passage of renal or biliary calculi. The analysis of the symptoms and the attendant circumstances should, however, so strongly indicate the presence of a progressive internal hemorrhage as to justify immediate opening of the abdomen, thereby to corroborate or disprove the diagnosis. If the rent is minute and the hemorrhage slight, possibly frequently recurrent, the signs of acute anemia are absent and the case resembles one of an inflammatory nature.

When the rupture takes place into the connective-tissue spaces of the broad ligament, the pain and shock are considerable, but are less threatening of immediate dissolution, and pass off after a time, while to the touch an effusion into the substance of the broad ligament is perceptible. If the embryo lives, its further growth will cause a gradually increasing laterally placed tumor to develop, in which in advanced cases the outlines of the fœtus may become perceptible.

The **treatment** of a tubal pregnancy should, if possible, consist in its immediate extirpation by abdominal section. The improbability of the condition being recognized in its earliest stages will render operation for its extirpation at that period, before rupture, very rare, although then it could be done with facility. The comparative safety of abdominal section, the clearing away of obscurities that may have hung about the diagnosis, and the definite removal of the disease which it secures combine to render such operative interference desirable as soon as reasonable ground is found for believing a gravid tube to be present, rather than the adoption of the electric currents and interstitial injections which have been proposed for destroying the ovum and leaving it *in situ*.

When rupture has occurred and dangerous hemorrhage is going on, the abdomen must be opened at once by an incision several inches in length, free

enough to permit the easy inspection of the cavity of the pelvis: the ruptured tube must be removed and perfect hemostasis be effected by suitable ligatures, after which all blood-clots and other effusions must be sponged out, followed by copious flushings of the pelvic cavity with warm salt solution. In many instances great advantage will be derived from a simultaneous intravenous infusion of salt solution to the extent of a quart or more, to overcome anemia and shock. If the operation has been preceded by a more or less prolonged history of recurrent hemorrhages, with formation of adhesions and inflammatory exudates, the cleansing of the peritoneal cavity must be imperfect, and drainage by tube and gauze tampons will be required. If a secondary rupture of a broad-ligament sac has taken place, after the peritoneal cavity has been cleansed the rent in the sac, if possible, should be sewed into the abdominal wound, and the cavity treated thereafter as an abscess-cavity till it becomes obliterated.

In cases in which primary rupture into the connective-tissue spaces of the broad ligament has been attended with the death of the embryo, no operative interference is called for. But if the embryo survives and continues to grow, it should be removed without delay. Before the fifth month the gestation mass can be readily enucleated as a whole. From the fifth month onward the involvement of neighboring parts by the expansion of the sac will have become such as to prohibit enucleation. The sac must then be sewed into the incision in the abdominal wall, and incised, the fœtus removed, and the placenta removed if it is detached; otherwise left for subsequent spontaneous detachment, while the cavity of the sac is irrigated, tamponed with iodoform gauze, and treated as an open abscess-cavity. Especial risks attend attempts to remove a growing extra-uterine fœtus of this class, owing to the possibility of the placental site being at the place of incision; in which case a copious hemorrhage will result, to be arrested only by compression of the abdominal aorta.

Whenever infection of an extra-uterine fœtal mass has taken place, the decomposing suppurating collection must be dealt with according to the general principles applicable to such abscesses. It is only in cases in which the abscess tends to point into the vagina that attempts should be made to reach it and evacuate its contents through that canal.

The hope of securing the ultimate delivery of a viable child should never cause postponement of operative interference after a diagnosis of extra-uterine pregnancy has been arrived at, since such children, if they arrive at term and are delivered living, are generally puny and malformed and rarely survive many weeks, while postponement of operative relief is always attended with increasing risk to the life of the mother.

SURGERY OF THE BROAD LIGAMENTS.

Parametritis or Pelvic Cellulitis.—Inflammation of the connective-tissue substance of the broad ligaments is comparatively rare as a primary disease. Its general cause is sepsis conveyed through some abrasion or other injury of the vault of the vagina or of the wall of the uterus, by means of which an infective inflammation is excited in the course of the veins or lymphatics of the broad ligament. The resulting phlegmon may cause an inflammatory infiltration of varying extent of the pelvic subperitoneal connective tissue which imbeds and fixes the uterus. The overlying peritoneum shares in the inflammation, and adds its own exudates and adhesions to those caused by the changes in the cellular tissue. The inflammation tends to terminate in suppuration: not infrequently a chronic non-suppurating inflammatory condition is engen-

dered, which produces infiltrations and contractions sufficient to cause permanent displacements and impairment of function in the pelvic viscera.

The **symptoms** do not differ from those already described in connection with inflammations of the endometrium and of the Fallopian tubes; which conditions are usually in some degree associated with the cellulitis itself. In the more acute forms the pain is severe: rigors and fever attend the onset of the attack, and are continued by the establishment of suppuration. The pus may discharge itself by way of the vagina, rectum, bladder, or abdominal wall, and by the formation of imperfectly drained pus-cavities may give rise to a wasting septicemia.

The **diagnosis** is to be made by careful bimanual examination, which will show the existence of an infiltration into the spaces of the broad ligament, protruding downward into the vagina, displacing, possibly, the uterus to one side, and spreading upward and outward within the broad ligament to the brim of the pelvis. If the peritoneal pouches can be felt to be empty and the ovaries free, the diagnosis is corroborated. The existence of other inflammatory complications will usually make all these conditions obscure.

The **prognosis** in recent cases, under proper treatment, is in general good, but when by long-standing chronic inflammatory conditions permanent atrophy of tissue, with displacement and adhesions of organs, has developed, a state of permanent invalidism is created which at best can be only ameliorated.

The **treatment** is the same as that which has already been detailed for other pelvic inflammations. An especially definite good result may be expected in these cases, when the acute symptoms have subsided, from the use of local resolvents, as painting of the vault of the vagina with tincture of iodine, prolonged and frequent hot vaginal douches, and the use of boro-glyceride vaginal tampons. The prolonged and free use of saline cathartics is likewise of great value.

Pelvic Hematocele may be accepted as a general term for all blood-effusions into the pelvis. Effusions into the free peritoneal cavity are designated by the term *intra-peritoneal hematocele;* those into the connective-tissue interstices of the broad ligaments, by the term *hematoma of the broad ligament.* By far the most common source of intra-peritoneal blood-effusions is tubal gestation, and they have already been considered in connection with that condition. The production of hematoma of the broad ligament as the result of rupture of a gravid tube has also been described. Such hematomata may also be caused by the rupture of varicose veins situated in the tissue of the broad ligament. Such accidents have commonly associated with them the sudden arrest of the menstrual flow.

Extravasations of blood in considerable amount into the tissue of the broad ligament are likewise among the common accidents from imperfect hemostasis after operations for the removal of growths from that structure. The after-course of these hematomata does not differ from that of similar effusions in other parts of the body. The fluid portion is absorbed; the residual elements gradually disintegrate and are slowly absorbed; and ultimately the effusion disappears. In exceptional instances an accidental infection is introduced and suppuration complicates the course of the case.

The occurrence of the hemorrhage is marked by sudden sharp pain in the pelvis and well-marked shock, soon passing off with the rapid development of a more or less extensive tumor within the layers of the broad ligament. In the more aggravated effusions the pressure of the blood-mass dissecting into the connective-tissue spaces about the rectum and bladder provokes marked tenesmus of those parts, and in the rectum mechanical constipation. Local

examination reveals to the touch a diffused tumor within the broad ligament, which, when of sufficient extent, can be appreciated by abdominal palpation as a mass rising up laterally from the pelvis, distinctly confined within membranous barriers. This tumor is free from the extreme sensitiveness which attends inflammatory effusions, and later will be observed to undergo gradual contraction, finally to disappear. The suddenness of the attack and of the development of the tumor and the absence of the characteristic signs of acute inflammation will serve to diagnosticate a hematoma from an inflammatory effusion: the distinct limitation, the nodular feel, the lateral position, and the speedy cessation of the constitutional signs of hemorrhage which attend hematoma will differentiate it from the soft, limitless, shifting mass, pushing downward the posterior vaginal vault, which results from bleeding into the free peritoneal cavity—a form of hemorrhage which, if extensive enough to produce marked symptoms, almost invariably goes on to a fatal end if not arrested by operative measures.

Small or partly absorbed hematomata may be confounded with tumors of the Fallopian tubes, with fibro-myomata of the uterus developing outward into the folds of the broad ligament, and with cysts of the broad ligament; but careful study and repeated observation of the later course which the pelvic mass pursues should suffice for the distinction.

The treatment of hematoma of the broad ligament is purely expectant. Intra-peritoneal hematocele requires abdominal incision, exposure, and ligation of the bleeding point, involving the ablation of the distended and ruptured tube and the cleansing of the peritoneal cavity from the effused blood.

SURGERY OF THE OVARIES.

Ovarian Hernia.—An ovary has occasionally been found in a hernial sac, in which relation it may present itself as a tumor as far down as the labium majus. Unless it becomes inflamed or the subject of other disease, such displacement has no pathological significance and produces no symptoms nor disability. Suspicion of the presence of an ovary in a hernia will be aroused if a somewhat hard, elastic, ovoid body is detected in a labium or in the inguinal canal, which resists pressure and temporarily swells during the menstrual epochs. If upon examination the uterus is found to have its fundus tilted over to the affected side, and a connection between the uterus and the ovoid body can be established by manipulation, the diagnosis is rendered certain. If the ovary can be reduced into the abdominal cavity, it should be done, and its further escape prevented by a suitable truss; if the ovary is diseased and the cause of suffering, it should be extirpated, otherwise no treatment is required.

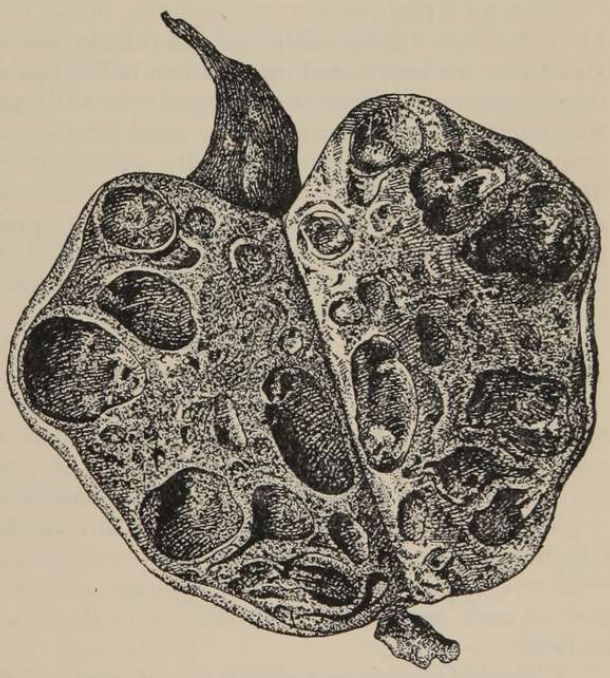
Prolapse of the Ovary downward into the peritoneal pouch behind the uterus, where it may readily be felt by the examining finger, is not uncommon. It may be due to relaxation of the broad ligament from imperfect involution after labor or to increase in weight of the organ from disease. The pressure of a fecal mass from above may have dragged it down, or the prolapse may be consequent upon the changes attending retroversion of the uterus. The mere change in its position has no special significance and gives rise to no symptoms, but when the ovary is enlarged and congested its presence in the cul-de-sac may expose it to such pressure during defecation, walking, or coition as to cause pain and disability. When such symptoms are present, it is generally the case that the displacement of the gland is only an incident in inflammatory disturbances of the ovary, and the tube is often firmly bound by

adhesions in its place. If the ovary is movable and there is no coexistent disease calling for its ablation, and yet the disability from its presence in the cul-de-sac is such as to call for relief, it may be lifted up by shortening the round ligaments.

Inflammation of the Ovaries.—Three classes of inflammatory affections of the ovaries may be distinguished: 1. An acute septic inflammation, tending to rapid disorganization, the organ being implicated in an acute, often fatal, spreading septic inflammation of the uterus, tube, and pelvic peritoneum. 2. An inflammation likewise excited by infection from a pre-existing salpingitis of subacute or chronic type, in which first the capsule of the ovary, and later the deeper structures of the organ, become involved. 3. A slowly-developing, primary inflammation of the tissue of the ovary itself, chronic in its tendencies, having its beginning in a chronic hyperemia of the gland, due to functional derangement and sexual excitation, and displaying but little tendency to involve adjacent organs. Between the first two of these classes there is no distinct dividing-line: the difference is one of degree and not of kind—one of clinical rather than of etiological or pathological importance. In both classes the ovarian inflammation is an incident in, or a part of, a widespread affection involving the endometrium, the appendages, and the contiguous peritoneum. The conditions attending the development and extension of this septic inflammation, and the manner in which the ovary becomes involved in it by infection, have already been described in the sections devoted to Inflammations of the Uterus and of the Fallopian Tubes.

The changes which are produced in the ovary are those incident to glandular inflammations in general. In the more acute and virulent attacks tissue-necrosis and suppuration quickly supervene, with destruction of more or less of the gland, and with subsequent history of pelvic abscess in those cases in which limiting adhesions form early enough to shut off the general peritoneal cavity and to avert speedy death from diffuse septic peritonitis. In the milder cases the investing tunic of the ovary is thickened by interstitial proliferation and by deposit upon it of plastic peritoneal exudates, which at the same time bind it more or less extensively and firmly to adjacent surfaces. The ovary is for a time swollen by congestion and inflammatory exudates both into the follicular cavities and among the fibers of its stroma. Later, this enlargement gives place to atrophy and condensation through absorption of effusion, organization and contraction of new-formed connective tissue, and

Fig. 378.



Chronic Ovaritis with Multiple Cysts (Winckel).

general process of sclerosis of inflammatory origin. This atrophy of the tissue of the gland may be more than compensated for by persistent and increasing cystic dilatation of altered follicles, by blood-effusions, and by limited suppurative foci, so that a very manifest enlargement of the organ may persist indefinitely (Fig. 378).

Every degree of disease in respect to acuteness or chronicity, and to the amount of tissue-damage inflicted, may be presented in different cases. Both ovaries may be affected, or but one. When but one ovary is affected, a later affection of the other is prone to occur.

The **prognosis** will vary according to the character and extent of the tissue-changes. Under favorable circumstances, with proper treatment, in the less severe cases recovery may be secured with more or less atrophy and loss of secreting structure. In many cases, indeed, there will be preserved sufficient normal structure to carry on the process of ovulation and to make impregnation possible if the Fallopian tube is also patent. In the more severe cases, when abscesses have formed, spontaneous evacuation may occur, most frequently through the rectum, with subsequent contraction and obliteration of the cavity, and gradual absorption of inflammatory exudates and atrophy of the remnants of the destroyed organ. In a large proportion of cases, however, the inflammation of the organ persists for an indefinite time, with alternations of remission and exacerbation of its symptoms, a constant source of suffering and of disability. When the pus-cavities exist in the ovary they may determine the signs indicative of retained pus, and when not relieved by art or nature may lead to exhaustion and death from septic absorption, or in more favorable cases may undergo resorption. The prognosis in a given case will be closely bound up with that of the complicating salpingitis and perimetritic peritonitis, of which account must always be taken.

The **symptoms** are not definite, being usually obscured and dominated by those due to the pre-existing tubal and peritonitic conditions. Often a tube and an ovary are bound up together indistinguishably in a mass of inflammatory exudate. Pain in the ovary is constantly present as a dull ache, rendered worse by physical exertion or by local pressure or concussion, as in defecation or coition. Violent pain is usually excited at each menstrual period: if the loss of blood is profuse, the pain may be alleviated after the flow has become well established. Multiform reflex pains are prone to be manifested in distant parts, with marked emotional and neurotic disturbances of the most varied character. The general health suffers, digestion is interfered with, and in the chronic forms permanent invalidism is entailed. Sterility is the result of the changes in the tubes and ovaries and of the impossibility of enduring the marital approach by reason of the pain it produces.

In cases in which the surrounding disease is comparatively slight, or in which its results have been modified by time and treatment, the enlarged, nodulated, sensitive ovary may be isolated and recognized by the finger in the vagina or the rectum with the help of bimanual palpation.

The **treatment** is that which has already been described as required for inflammation of the Fallopian tubes—rest, purgation, local antiphlogistic and resolvent applications, general hygiene, and, finally, in default of recovery under such measures, extirpation of the diseased organs by abdominal section.

Chronic Ovaritis not due to direct septic infection is slow and gradual in its development, being preceded for a prolonged period by simple hyperemia. This long-continued congestion eventuates in degenerative changes, the more aggravated cases presenting thickening of the investing tunic with degeneration

of the follicles into small cysts, and an increase in quantity of the connective-tissue stroma, with atrophy of the proper glandular tissue.

The **etiology** of this ovarian congestion and inflammation is obscure: it is apparently closely associated in many instances with deranged ovarian innervation; it develops most frequently with excitable, unstable, emotional natures; it may be associated with ungratified, perhaps unrecognized, sexual desire, and in some instances it is excited by unnatural sexual gratification.

The **symptoms** are pain in the region of the ovaries, aggravated at the menstrual periods; menstruation tends to excess both in quantity and in frequency; the ovaries are tender and swollen; backache and headache, with the myriad vague pains of neurasthenia and hysteria, are frequent attendants.

The **diagnosis** is to be made by bimanual palpation, by which the tenderness and the enlargement of the ovaries are directly ascertained and the significance of the symptoms confirmed.

The **prognosis** is favorable, as a rule, under proper treatment. But when profound structural changes have taken place in the ovaries, a less favorable prospect is to be acknowledged, and in some cases nothing short of the ablation of the diseased organs will bring relief.

In the **treatment** those measures which have to do with the regulation of the general life play an important part. All occasions of emotional and sexual excitation are to be removed. Moderate exercise, the avoidance of everything likely to induce or aggravate pelvic congestion, regular hours of sleep, rest in bed during the menstrual periods, regulation of the bowels, and general tonics, are to be enjoined, combined with prolonged counter-irritation by repeated blisters to the abdominal surface over the site of the ovaries. As a last resort, when all measures have failed to afford relief, and chronic suffering and invalidism are unavoidable, the affected organs may be extirpated by abdominal section.

Ablation of the Uterine Appendages by Abdominal Section.—The names of different surgeons are often attached to this procedure, and the practice may possibly be convenient in the direction of brevity, but the above simple descriptive term is much to be preferred. The term oöphorectomy is also in frequent use. This term, however, does not in itself include the idea of the removal of a part or the whole of the Fallopian tube, which, as a rule, is as important a part of the operation as the removal of the ovary. As a general term, therefore, the designation "ablation of the uterine appendages," being brief, comprehensive, and descriptively correct, deserves to be used to the exclusion of all others.

Ablation of the uterine appendages has been advised in the preceding pages for the following conditions: 1. Insuperable vaginal atresia; 2. Cases of uterine fibro-myomata attended with serious menorrhagia; 3. Chronic inflammation of the Fallopian tube, with retention of inflammatory products within the distended tube; 4. Chronic and intractable inflammation of the ovary, attended with pain and disability; 5. Early tubal gestation.

In addition to these indications, the operation has been resorted to many times for the relief of marked nervous disturbances of maniacal, epileptic, and hysterical character, which were aggravated or elicited by each recurring menstrual epoch. In a few instances marked improvement has followed the operation, but in so small a proportion of cases that at present the weight of authority is against the operation in these neurotic cases unless distinct evidences of disease of the ovaries can be obtained. In severe and intractable dysmenorrhea due to such arrested development of the uterus that the normal function of the uterus in the processes of menstruation is imperfect, while the ovaries

are sufficiently developed to produce their regular monthly molimina, the removal of the appendages is the only treatment available, and is to be resorted to without hesitation after failure of prolonged efforts to stimulate the growth of the uterus.

Operative Technique.—The preparation of the patient and all the attendant details for the prevention of septic infection are the same as have been elsewhere described (p. 985). The incision through the abdominal wall is short, midway between the umbilicus and the pubes; the opening in the peritoneum should be simply large enough to admit two fingers, which at once seek the fundus of the uterus and thence trace the tubes outward to the ovaries. If there are no adhesions, the conclusion of the operation is very simple, and is quickly accomplished by pulling the ovary up into the incision by the fingers or by suitable forceps. The broad-ligament pedicle is transfixed by a needle or pointed forceps, which carries through a loop of strong silk thread with which the pedicle is tied in two parts; into the loop on the uterine side the tube is pulled, so as to secure the removal of most of its length. The knots having been strongly and securely tied, the pedicle is severed about a quarter of an inch beyond the ligature, and the stump, after having been carefully inspected to detect any possible hemorrhage, is dropped back into the pelvis.

In cases of uterine fibro-myoma, if the tumor is large and adherent, great difficulties may be experienced in finding and removing the ovaries. The situation of the ovary will vary greatly according to the site and direction of growth of the tumor. The tumor must be pulled aside and each ovary sought for after such enlargement of the abdominal incision as may be demanded to secure ease and precision of manipulation. If the difficulties in securing the ovaries are found to be insurmountable, hysterectomy may be substituted.

When the appendages are matted together or are glued by inflammatory adhesions to adjacent structures, their enucleation and removal introduce complications into the operation which demand time and the greatest amount of patience and skill upon the part of the operator. Especial difficulty and danger attach to adhesions to the urinary bladder and to the intestine. As a rule, enucleation can best and most safely be accomplished by the fingers. It is to be remembered that the ovary, swollen and heavy, naturally sinks down into the posterior peritoneal pouch, where it becomes covered in by inflammatory exudate. Here, therefore, it is to be sought by the finger, which begins its work by breaking down adhesions at the lowest point of the posterior pouch as it proceeds to dig out the ovary from its bed of exudate. Carefully keeping close to the ovary, it is gradually enucleated; the swollen or thickened tube may be identified as the enucleation proceeds, and is in turn liberated, until finally the mass is sufficiently unfolded to be brought up into sight. Should the broad ligament be so shortened and rigid as to prevent the formation of the usual pedicle, it will have to be sewed off, as has been described. The arrest of bleeding from the bed out of which the appendages have been enucleated, and the subsequent use of drainage, are to be governed by the principles previously laid down.

If the sense of sight is required to deal intelligently with any complications that may be met with, the pelvis should be raised into the Trendelenburg position (Fig. 371), and the abdominal incision prolonged as needed to secure the required exposure. This is especially desirable if the tubes or ovaries are distended with pus, on account of the danger of rupture of the sacs. In dealing with such accumulations of pus the general peritoneal cavity should be shut off by flat sponges or compresses before much manipulation of the pus-filled sac is attempted. If the sac ruptures, the effused pus should be carefully

sponged out, rather than washed out, and drainage instituted. If there is a large pus-cavity which cannot be enucleated, the opening into it should, if possible, be sewn into the abdominal wound and a drainage-tube be carried through its bottom into the vagina. If the abdominal walls cannot be depressed sufficiently to reach the abscess-opening, reliance will have to be placed on iodoform-gauze packing and the usual glass drain. The toilet of the peritoneum, the question of drainage, the closure of the wound, and the subsequent care are to be governed by the principles applicable to abdominal operations in general.

The *mortality* following operations for ablation of the uterine appendages depends much upon the skill and experience of the individual operator and upon the character of the cases operated upon. It is susceptible of reduction to a very small figure. Different surgeons have reported long series of cases, amounting to hundreds, with a mortality of less than 5 per cent.

Ultimate Results.—The proportion of cases in which restoration to health is secured to the extent of freedom from pain and restoration to comfort and usefulness is by no means commensurate with the proportion of recoveries from the operation. In many cases, although the diseased appendages are safely removed, there remain intrapelvic indurations and adhesions which cause persistent pelvic pain, uterine congestions, and vesical and intestinal disturbances. Fatal intestinal obstruction from angulation of adherent intestine is an occasional sequel. Immediate relief to pain is the exception. Usually the pelvic pains persist for months, gradually but ultimately disappearing, possibly not until after the lapse of some years; in some cases the relief is never perfect. Ventral herniæ, fistulæ from retained infected ligatures, and fecal and urinary fistulæ are among the occasional sequelæ.

Mental disturbances sometimes occur after the removal of the appendages. In most instances the lapse of time, the subsidence of pain, the improvement in general health, and the influence of reassuring advice suffice to allay these, although in certain instances an unstable mind is pushed over into confirmed insanity. Such a remotely possible event should have no weight, however, in determining in a given case whether the appendages should or should not be removed. Fecundity has already been destroyed by disease, but the possibility of marital congress is in most cases restored. The sexual appetite is, as a rule, restored to its normal condition; in some cases it is diminished, in some it is increased. The menstrual function is generally quickly abolished, but occasionally its arrest is delayed for months, and in about 10 per cent. of all cases, menstruation continues with its usual regularity. No changes in the tastes, personal appearance, or sexual characteristics result from the removal of the appendages of adult women, other than those resulting from the relief of disease and the abolition of pain.

OVARIAN TUMORS.

The ovaries are frequently the seat of new growths, especially of cysts. Of 10,290 tumors examined by Williams, 804 had their origin in the ovaries, including 87 more properly classifiable as cysts of the broad ligament. Of the whole number, 752 were cysts, 27 were carcinomas, 24 were sarcomas, and 1 was a fibroma. Of the cysts, 30 contained dermoid elements. These figures will give a clear idea of the relative frequency of the various neoplasms to which the ovaries are liable.

Ovarian Cystomata.—The pathology of cystic growths of the ovary can be understood only by a study of their incipient stages. For what follows

credit is to be given to Mr. Bland Sutton, by whose work on *Surgical Diseases of the Ovaries and Fallopian Tubes* much light on the pathology of these affections has been shed. In Fig. 379 is given a diagrammatic repre-

FIG. 379.

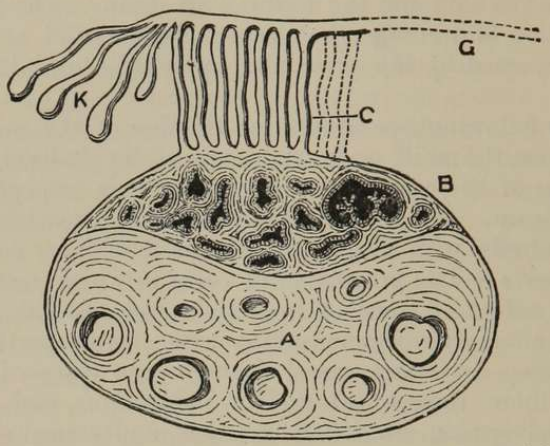
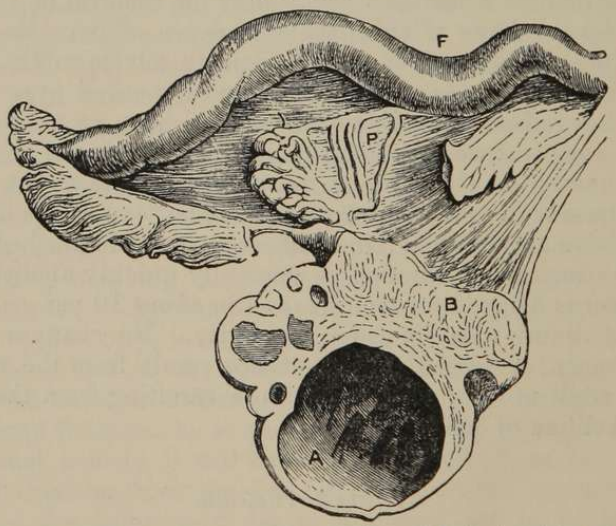


Diagram representing the Cyst-regions of the Ovary: *A*, oöphoron; *B*, paroöphoron: *C*, parovarium; *K*, Kobelt's tubes; *G*, Gärtner's duct (Sutton).

sentation of the ovary and parovarium, showing its division into an egg-bearing portion, the oöphoron; a region in which ova are not found, the paroöpho-

FIG. 380.



A, incipient oöphoritic cyst; *B*, paroöphoron; *P*, parovarium; *F*, Fallopian tube, natural size (Sutton).

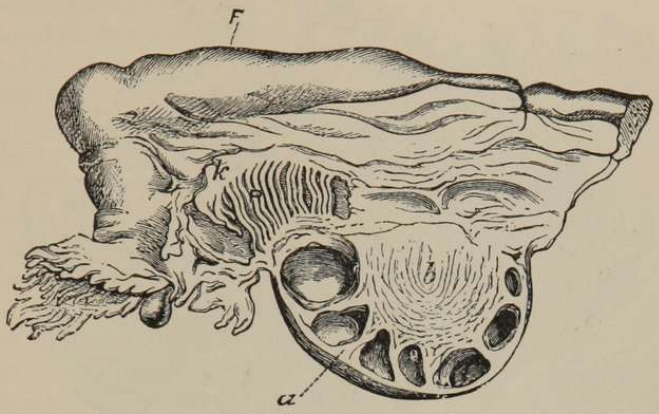
ron; and the parovarium. Cysts developing in each of these present distinctive features.

Incipient oöphoritic cysts are shown in Figs. 380 and 381, representing the two clinical varieties, unilocular and multilocular cysts.

The development of these cysts is due to changes in the normal ovarian follicles. In their earlier history they are lined with epithelium, which later disappears through the atrophic changes in the walls of the cyst caused by the

pressure of the accumulating fluid. As the cyst enlarges it causes rapid absorption of the paroöphoron. In size these cysts may vary from the smallest appreciable follicular dilatation to a cyst containing gallons of fluid. The

FIG. 381.



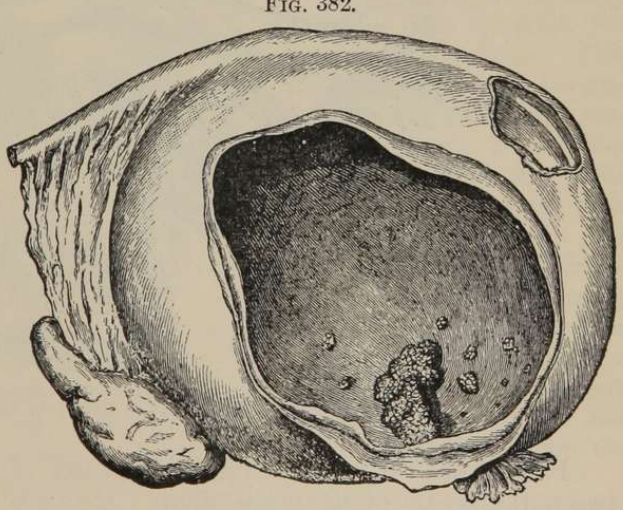
Human Ovary in Section, showing a multilocular cyst in an early stage: *a*, oöphoron; *b*, paroöphoron; *P*, parovarium; *k*, Kobelt's tubes; *F*, Fallopian tube (Sutton).

contents may be a thin, colorless fluid or a thick, tenacious mucus. The fluid may be grumous from admixture with blood.

Frequently in multilocular cysts the epithelium exhibits very active changes, resulting in the development of glandular masses and the production of a complex tumor, a *cysto-adenoma*.

Ovarian dermoids are cysts in whose walls skin elements occur in varying degree. In such cysts hair, sebaceous glands, sweat-glands, teeth, mammæ, horn, nail, bone, unstriped muscle, and brain-matter have at times been identified. They contain a pultaceous matter formed of shed epithelium and epithelial débris, sebum, and shed hair, oil, and cholesterin.

FIG. 382.



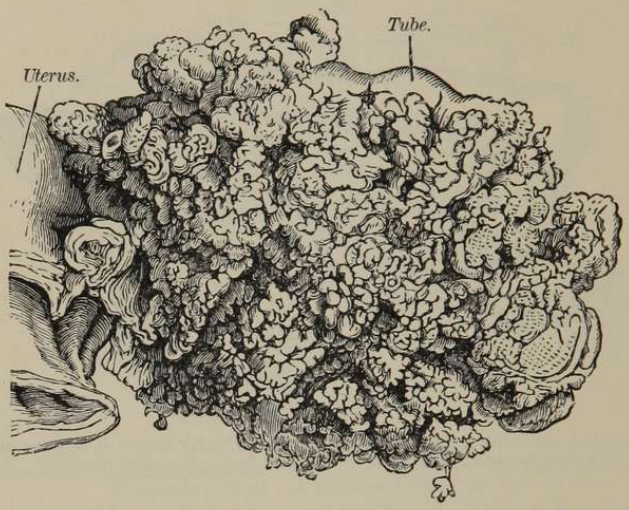
Paroöphoritic Cyst, showing its relations to tube, ovary, and meso-salpinx (Doran).

Tumors arising from the structure of the oöphoron occur at all periods of life. In the fœtus they are not infrequent. A large proportion of ovarian tumors occurring in infancy are dermoids.

Paroöphoritic cysts are, as a rule, unilocular, and differ from cysts of the oöphoron in the following particulars: 1. They do not affect the shape of the ovary until they have attained an important size. 2. They always burrow between the layers of the meso-salpinx, and when large between the layers of the broad ligament. 3. The interior is beset with warts (Figs. 382 and 383). The warts in such cysts vary greatly in number. They may cause a general papillomatous infec-

tion of the peritoneum. They are rare before the twenty-fifth year, and are most common between the twenty-fifth and fiftieth years.

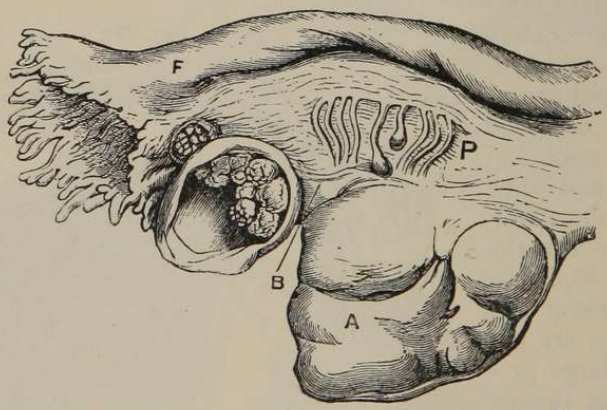
FIG. 383.



Ruptured Paroöphoritic Cyst, left half of specimen (Sutton).

PAPILLOMATOUS CYSTS have also been noted as arising within the oöphoron and within the layers of the meso-salpinx entirely independently of the ovary or parovarium. (See Figs. 384 and 385.)

FIG. 384.



Papillary Cyst growing between the layers of the broad ligament, near the tubo-ovarian ligament; *A*, ovary; *P*, parovarium; *B*, pedicle of the cyst; *F*, Fallopian tube (Sutton).

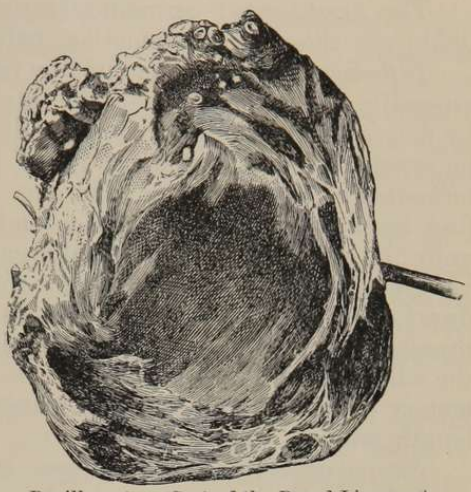
PAROVARIAN CYSTS.—Cystic dilatations of the parovarium burrow between the layers of the meso-salpinx; they are usually unilocular and filled with a clear fluid of low specific gravity. The ovary is generally found attached to one side of the cyst, and the Fallopian tube is stretched over the cyst. (See Fig. 386.) They do not often contract adhesions. They are almost unknown before puberty.

Ovarian cysts in general, in the great majority of instances, develop during the period of greatest sexual activity in women, although they are not rare in infancy and in old age. There are many observations of the occurrence of

the affection simultaneously in both ovaries. Their rate of growth is variable and uncertain.

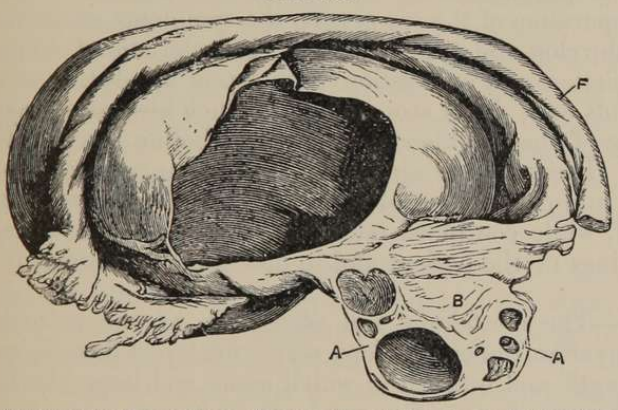
The **symptoms** which they provoke are due mainly to weight and pressure and to accidental complications which may develop. Their earlier history is often marked by the absence of noticeable symptoms, so that not infrequently they are first discovered by accident after they have attained some size. Only when the free development of the cyst toward the abdomen is hindered, as in some broad-ligament cysts, are symptoms referable to the bladder—*e. g.* irritation and tenesmus—likely to be provoked early. In some cases vague pelvic distress and sense of weight are soon experienced in a sufficient degree to invite examination and lead to detection of a growth. Menstrual disorders are comparatively rare, menorrhagia being the most frequently observed symptom referable to the uterus. When the cyst has emerged from the pelvis a spherical or irregular tumor causes a visible enlargement of the abdomen. This enlargement may become enormous, producing distention and thinning of the abdominal walls and protrusion of the umbilicus, while many dilated veins marble the cutaneous surface. This swelling is flat on percussion and is fluctuant; possibly at its sides solid masses can be felt, while about it a zone of resonance will indicate the presence of the displaced intestines. As the tumor becomes large enough to distend the abdomen, a train of pressure-symptoms is inaugurated, involving all the abdominal organs to a greater or less degree. The digestive apparatus is disordered; secretion and excretion are faulty; emaciation and debility result.

FIG. 385.



Papillomatous Cyst of the Broad Ligament (original).

FIG. 386.



A Cyst of the Parovarium, showing its relation to ovary and tube, two-thirds its natural size: *A*, oöphoron; *B*, paroöphoron; *F*, Fallopian tube (Sutton).

By compression of the ureters the ready flow of the urine into the bladder is interfered with, and various renal disorders are engendered, resulting finally in uremic and cardiac complications. Œdema of the lower limbs and varicose enlargements of the leg and hemorrhoidal veins may be produced.

When the abdominal distention is sufficient to embarrass the action of the diaphragm, dyspnea, and later cyanosis, result. Adhesions between the tumor and the viscera are prone to form, and by their traction to interfere with func-

tion and cause pain: with the gradual development of the conditions named discomfort and pain are added; sleep is interfered with; the emaciation and enfeeblement are progressive; a facial expression indicative of pain and malnutrition (*facies ovariana*) becomes well marked; and finally death occurs through exhaustion and uremia.

The accidental complications to which ovarian cysts are especially liable are those of inflammation, twisting of the pedicle, and rupture.

Inflammation may be excited by infection derived from adjacent structures, especially the Fallopian tube, the intestinal canal, and the urinary bladder, or by defective antiseptic precautions during tapping. This inflammation may be restricted to a limited portion of the cyst-wall, and result simply in the formation of circumscribed adhesions to neighboring structures, or it may diffuse itself over the whole surface and produce universal adhesions which may unite the sac to all the abdominal organs. In some instances the newly-formed vessels in these adhesions are very numerous, and attain so great a size as to dwarf those of the pedicle as a source of nutrition to the tumor. During the process of organization of these adhesions, if the surfaces remain in apposition, the adhesions will be close and sessile. But by movements while the inflammatory exudate is still soft this material may be stretched into bands of some length and of varying width.

Suppuration in an ovarian cyst is not an uncommon accident, occurring most frequently in smaller cysts lying low in the pelvis, especially dermoids. The symptoms that indicate inflammation of an ovarian tumor are those of acute circumscribed peritonitis, local pain and tenderness, possibly an initial chill, followed by fever and general disturbance. The violent symptoms gradually fading, a more or less prolonged local tenderness persists for a time, but ultimately disappears. Repeated attacks of this nature may mark the history of a case. When suppuration of the sac occurs, the symptoms are more severe and prolonged, and develop the type of hectic characteristic of deep-seated acute abscess. Emaciation and exhaustion from septic absorption are rapid, and, unless the pus finds exit, death soon follows. Such abscesses may burst spontaneously into any of the neighboring cavities or hollow viscera or upon the cutaneous surface. The resulting sinuses in rare instances are adequate to the full evacuation and obliteration of the cyst, with final cure, but more often fail of such relief, while continued retention of pus and septicemia remain to prolong the sufferings of the patient and to determine an ultimately fatal result.

Torsion of the Pedicle.—The stretching and elongation of the natural ovarian attachments as an ovarian tumor develops serve finally to provide it with a pedicle of varying length and breadth in which many and large blood-vessels run. Occasionally the cyst is caused to rotate upon its axis to such a degree as to cause torsion of this pedicle. This accident occurs with marked frequency when pregnancy has complicated the case, more especially after delivery. When the torsion is sudden and close, the veins becoming first compressed, a severe venous engorgement of the cyst is produced, with much exudation of serum, blood-extravasations, distention of the cyst, and ultimate necrosis of its tissue. When the torsion is more slowly effected its consequences may be limited to diminishing the blood-supply, and thus to atrophy of the tumor, unless new vascular connections through adhesions have been formed sufficient for its nutrition independently of the pedicle. The symptoms provoked by the occurrence of torsion of the pedicle of an ovarian cyst are sudden and violent pain in the abdomen and shock, with possibly a noticeable rapid increase in size of the tumor and alterations in its relative position in the

abdomen and in its pressure-symptoms. To these may be added the symptoms of internal hemorrhage when much effusion of blood into the cyst-cavity has taken place. The sudden development of these symptoms in a woman known to have an ovarian tumor is sufficient to establish a probable diagnosis and to call for immediate abdominal section for its relief.

Rupture of an ovarian cyst may be occasioned by a traumatism: it may result spontaneously, as from erosion produced by the pressure of intracystic papillary growths, or from necrosis owing to defective nutrition of a part of the cyst-wall, or follow from the inflammatory changes incident to suppuration. The rupture may be into the free peritoneal cavity, which is by far the most frequent occurrence, or into any of the hollow viscera with which adhesions have been formed.

When the ovarian fluid is clear and of low specific gravity, it is well tolerated by the peritoneum and is rapidly absorbed, provoking free diuresis. When the fluid is colloid in character, it is irritating and provokes peritonitis. Rupture of a cyst may result from the distention and necrosis caused by torsion of the pedicle, in which case free, possibly rapidly fatal, hemorrhage from ruptured vessels is likely to occur.

The **diagnosis** of ovarian cysts requires for its establishment a careful examination of the physical characters and relations of a growth, taken in connection with its history. In cases of doubt greater positiveness may be arrived at by taking advantage of the relaxation of the abdominal and perineal tissues to be secured by anesthesia, while careful palpation and percussion are made. In cases of great distention of the abdomen a preliminary tapping will facilitate examination.

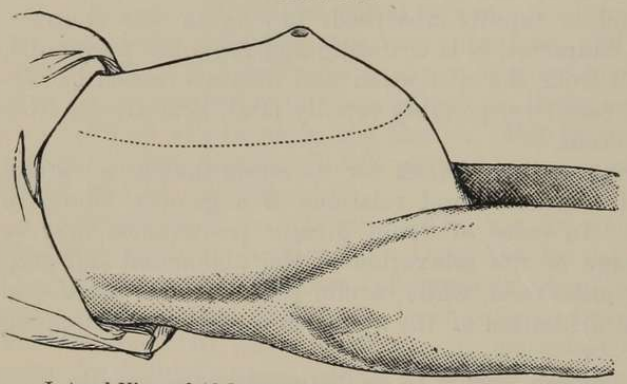
In its earliest stages an ovarian cyst is to be distinguished especially from small pedunculated subserous fibro-myomata, from inflammatory swellings of the appendages, and from tubal pregnancy. It is possible that these conditions may coexist with ovarian cyst and thus obscure the diagnosis, so that at times it may be difficult to make out positively the exact nature of an intrapelvic mass. The absence of the special symptoms that attend the various conditions named (for which see the sections descriptive thereof) will serve to indicate that a movable, clearly-outlined globular mass in the ovarian region, which is not especially tender to the touch and which is discernible by bimanual palpation, is an ovarian cyst.

When the tumor has risen from the pelvis into the abdominal cavity, special difficulties of diagnosis will present themselves, according as it still remains as a distinctly-outlined growth partially filling the abdominal cavity, or has attained a size sufficient to fill it to distention. In the first class of cases it is to be distinguished from a distended urinary bladder, from normal and from extra-uterine pregnancy, and from cystic degeneration of fibro-myomata. The distinction will usually not be difficult if the possibility of the existence of these conditions is borne in mind and their existence inquired into. A distended bladder collapses upon the introduction of a catheter: the common signs of pregnancy will usually reveal themselves if sought for. Pregnancy and ovarian cyst may coexist, and thus obscure, for a time, an exact appreciation of the condition present. Amniotic dropsy may cause the distended uterus to simulate for a time a fluctuating cyst, but careful examination will show the tumor to be the distended uterus. In any case of doubt as to the existence of pregnancy a delay of a few months at most will determine the question. The history of extra-uterine pregnancy and the character of the resulting tumor will declare its existence if a sufficiently careful examination be made. A fibro-cystic tumor of the uterus will reveal on examination the symptoms charac-

teristic of uterine fibro-myomata—enlargement of the uterus, elongated uterine canal, continuity of structure of tumor and uterus, and menorrhagia.

When the abdominal cavity is filled to distention, so as to obscure any tumor within, the question of ascites becomes important, and the differentiation from it of an ovarian cyst a matter requiring care. The history of the case may give information: the former existence of a laterally placed movable tumor indicates a cyst; the existence of chronic disease of heart, liver, kidneys, or peritoneum would account for an ascites. The shape of the abdomen is to be noted. If it is prominent, tending to protrude centrally, with its greatest circumference below the umbilicus, which is not prominent, a cyst is indicated; if it flattens in front, with bulging in the flanks as the patient lies on the back, with a prominent umbilicus, at the level of which the circumference is greatest, ascites is indicated. Figs. 387 and 388 illustrate the difference.

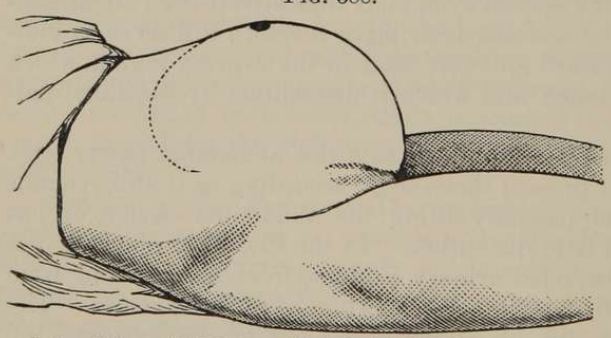
FIG. 387.



Lateral View of Abdomen affected with Ascites (Albert).

Upon palpation in ascites the abdominal wall is soft and lax unless the distention is very great, and the fluctuation is most distinct from flank to flank; in a cyst the abdominal wall is tense and the fluctuation is most distinct in front. The area of dulness on percussion is a very important differential indication. In ascites the abdomen is resonant in front, from the floating of the intestines on the fluid, and the flanks are dull; the area of dulness will vary with change of posture, the part lying uppermost being always resonant. In cystomata the area of dulness is in the front of the abdomen; changes of posture do not affect its position; its limits are sharply marked, and it is surrounded by an area of intestinal resonance; even when the cyst is of large size resonance can usually be detected in one or both flanks (Figs. 389 and 390).

FIG. 388.

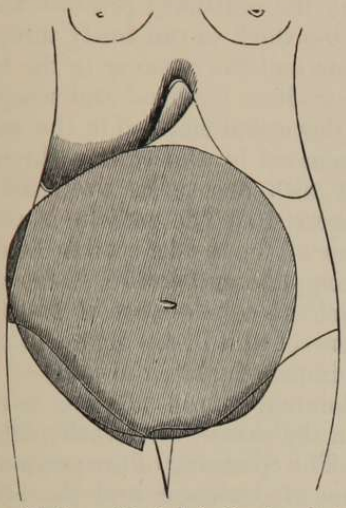


Lateral View of Abdomen affected with Ovarian Cyst (Albert).

The accumulation of dropsical effusions in cyst-like cavities formed by intra-peritoneal adhesions in the course of cancerous and tubercular peritonitis may form tumors that will simulate to some extent ovarian cystomata. The history of their development and the absence of the special signs which attend ovarian growths will indicate their nature. Obesity may give rise to suspicion of ovarian tumor, but careful examination will fail to elicit any signs confirmatory of the suspicion. Renal and liver cysts, when enlarged to such a degree as to extend down into the pelvis, may be confounded with ovarian cysts.

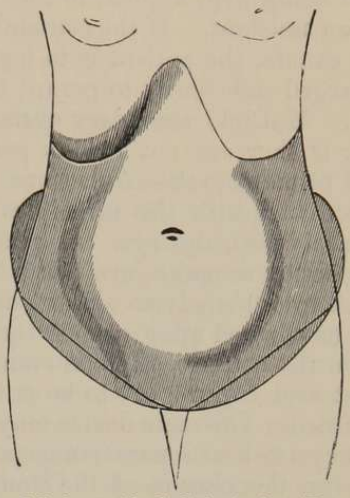
As long as a line of resonance exists between the tumor and the pubes, percussion will serve to differentiate them. The dulness of a liver cyst will also

FIG. 389.



Area of Dulness (shaded) in Ovarian Cystoma (Barnes).

FIG. 390.



Area of Dulness (shaded) in Ascites (Barnes).

usually be continuous with the ordinary liver dulness. That of a renal cyst will extend up under the ribs and into the flanks around to the spine, while downward over its center may be traced the resonant colon when distended with gas.

The **prognosis** of ovarian cystomata is almost wholly bad unless they are subjected to surgical interference. After they have attained sufficient size to affect the general health, but a brief period of life, rarely exceeding two years, is to be looked for. The tendency to death by malnutrition and uremia has been already mentioned. Peritonitis and embolism also are frequent causes of death. Papillomatous cysts are prone to malignant degeneration. In rare instances spontaneous cures take place; they follow rupture of the cyst, or atrophy caused by defective nutrition through a gradually effected twist of the pedicle.

The **treatment** required for ovarian cysts is, in all cases where possible, their extirpation by surgical means—ovariotomy: palliative tapping is to be resorted to only when symptoms of extreme pressure require present relief or for purposes of diagnosis. It should be done only under rigorous antiseptic precautions.

Ovariotomy was first done in 1809 in Danville, Ky., by Dr. Ephraim McDowell of that village. The patient recovered. It was not until fifty years later that the operation became at all common. Thanks to the knowledge of the principles of asepsis and antisepsis that has become general during the last quarter of the present century, early resort to the operation is now universal, and the ratio of successful results following it is very large.

Technique of Ovariotomy.—The preparation of the patient, the antiseptic precautions attending the operation, and the preliminary incision of the abdominal wall are to be conducted as described on page 985). The cyst having been exposed, a finger is swept over its anterior surface to note its immediate relations and to detach any soft adhesions that may be present; then, while the abdominal wound is made to gape and the tumor to project into it

by proper pressure, a large canula is thrust into it, either through a small opening made with a bistoury or by means of an attached trocar. As the fluid of the cyst is evacuated through the canula, the cyst-wall, seized by broad-bladed forceps, is drawn up and out through the incision, the abdominal wall being kept applied to the collapsing cyst by the continued pressure made by an assistant. If the contents of the cyst are too thick to run freely through the canula, the patient is to be turned on her side and the opening in the cyst enlarged sufficiently to permit the surgeon to introduce his hand and scoop it out. Multiple secondary cysts may be broken down and emptied in the same way if they are not readily penetrated and evacuated by the canula through the primary cyst. Adhesions as they are met with are to be overcome in accordance with the principles specified on page 1010. The pedicle is to be securely tied, the cyst cut away, and the stump of the pedicle, after careful inspection to make sure that the hemostasis is complete and secure, is dropped back into the pelvis. Broad-ligament cysts which are sessile must, if possible, be enucleated after proper incision of the layers of the broad ligament that form the capsule. If this enucleation is found impracticable, the edges of the cyst and capsule are to be stitched to the abdominal wound and the cavity drained. The same device may be resorted to in the case of universally adherent cysts whose separation seems impracticable. The cleansing of the peritoneal cavity, the closure of the wound, the use or not of drainage, and the after-treatment are in accordance with the general principles specified on page 987.

Results.—The removal of ovarian cysts uncomplicated by extensive or dense adhesions is quickly accomplished, ordinarily occupying less than thirty minutes in the hands of surgeons of average dexterity. The mortality in such cases is between 5 and 10 per cent. In complicated cases the operation is much graver in its prognosis, the death-rate rising to from 10 to 25 per cent., being influenced much by the dexterity of the operator. Shock, hemorrhage, and septic peritonitis are the chief causes of death. Intestinal obstruction from angulation of the bowel through adhesions is responsible for a mortality of about 1 per cent.

Solid Tumors of the Ovaries.—The ovaries may be the subjects of carcinoma, sarcoma, and fibroma, in relative frequency according to the order in which they are here named. The symptoms which they present are not characteristic at the onset. They are with difficulty distinguishable from pedunculated subserous solid growths from the uterus. They early provoke ascites. They should be extirpated without delay after recognition.

Tumors of the Broad Ligament.—Cysts of the broad ligaments have been studied with ovarian cysts, with which they are clinically closely associated.

Papillomata of the Fallopian Tubes and Fibro-myomata of the tubes and of the round ligaments, also Malignant Tumors arising primarily in these structures, have been met with. When recognized, they are, if possible, to be extirpated by abdominal section.

Hydrocele of the Round Ligament.—Small cysts, containing serum, are sometimes found within the peritoneal investment that ensheathes the round ligament for a varying distance within the inguinal canal. They present themselves as ovoid, tense sacs within the inguinal canal or at its external orifice. They are to be distinguished from herniæ, from glandular enlargements, and from lymphatic dilatations. They may be extirpated with the knife if they are the cause of any discomfort. If, as in some cases that have been described, they communicate with the general peritoneal cavity, they are practically hernial sacs, and require the same treatment of enucleation and tying off that would be suitable to the latter condition.

CHAPTER IX.

DISEASES AND INJURIES OF THE BREAST.

SURGICAL ANATOMY.—It behooves the surgeon to be acquainted with the minuter anatomy of the mamma, especially the distribution of its lymph-vessels, in order correctly to diagnosticate and treat its diseases. Owing to the age and the differing functional changes to which it is subject, the size, appearance, and consistence of the breast vary within wide limits, but the gland-structure retains its normal relations with the circumjacent tissues, except perhaps when the organ is unusually pendulous. The *boundaries* of the breast are often ill defined, portions of the gland-structure irregularly penetrating the surrounding adipose tissue, especially on the axillary side, and at times these glandular masses appear to be totally dissociated from the mamma proper. It is of importance to recall this when operating for carcinoma. The *gland proper*, however, is included within a firm fascial envelope, which, as a rule, strictly limits inflammatory infiltration; thus an interacinous abscess, even when deeply seated, very rarely becomes a post-mammary one, nor does the latter penetrate between the gland-lobules, and by the directions thus compulsorily pursued by the pus in neglected cases of these diseases the original seat of the trouble can often be determined. Posteriorly, the fascia of the pectoralis major, serratus magnus, and external oblique muscles is separated from the costal surface of the gland by a loose layer of areolar tissue, through which pass numerous blood-vessels surrounded by very distinct perivascular lymph-spaces—a fact to be borne in mind when dealing with mammary carcinoma. Reaching from the third rib above to the sixth or seventh below, the gland-tissue is thickest at its center and toward the axillary side, in which direction it extends farthest, making the long axis of the gland pass from the anterior axillary fold obliquely from above downward and inward. The overlying integument, the circumference of the fibrous gland-capsule, and the superficial fascia—which is also attached to the clavicle—are intimately connected with one another by fibrous bands, serving to hold the gland in place, and explaining the dimpling of the skin—not the depression of the nipple—over contracting neoplasms.

The *nipple* in some patients forms a well-marked conical projection; in others it is small and depressed, with a constricted base: it may lie in an umbilicus-like depression, or, again, it may be practically absent, being on a level with the skin. The skin is wrinkled, numerous sebaceous glands opening in the sulci thus formed; it is covered with papillæ, and varies in color from a light pink to a dark brown, according to the complexion of the individual, and to whether pregnancy has existed or is now present; in which event the nipple becomes much darker—sometimes a deep blackish-brown in brunettes. Uterine tumors, it is alleged, produce somewhat similar changes. The nipple is composed of numerous blood-vessels, areolar tissue, the milk-ducts, and considerable unstriped muscular tissue. The gland-structure is composed of numerous minute lobules aggregated into lobes, each lobule opening into a small duct, these small ducts in turn joining larger ones, until finally the secretion is emptied by fifteen or twenty milk-ducts opening upon the summit of the nipple, these large

ducts beneath the areola having first become dilated so as to form little sacs (*ampullæ*, *milk-sinuses*), but at the base of the nipple contracting into small canals whose orifices admit only a stout bristle. Glandular epithelium lines both the gland-vesicles and the ducts, continuous with that investing the nipple.

Arteries, Veins, Nerves, and Lymphatics of the Breast.—Blood reaches the gland chiefly through branches of the long and superior thoracic, internal mammary, and intercostal *arteries;* sometimes there is a special branch from the axillary trunk. In a virgin breast these vessels are small; during lactation they are much enlarged, as well as when the breast is the site of a rapidly-growing neoplasm. For the most part the arteries enter the upper and axillary borders of the gland, a point to be remembered when operating, since the organ can be rapidly excised with but little loss of blood by dissecting it up toward the axilla, the deeper attachments in this region being divided last. The blood is returned by *veins* generally pursuing a course similar to that of the arteries, and chiefly emptying into the internal mammary and axillary veins. The *nerves* are derived from the anterior and lateral cutaneous thoracic nerves, and communicate with the cutaneous branches of the lower cervical nerves.

Both the superficial and the deep *lymphatics* enter, in the main, the axillary glands, passing in two directions—one to the glands internal to the vessels, the other, more external, joining the lymphatics of the arm. Other routes must be remembered, since they account for systemic infection when no enlargement of the axillary glands has been detected. Thus the lymphatics of the nipple and sternal side pass through the second intercostal space with the artery and vein to the anterior mediastinum, there entering glands; others join the first in the anterior mediastinum by penetrating the space between the fourth and fifth costal cartilages; and, finally, the deep absorbents of the costal surface of the gland accompany the branches of the aortic intercostals on the axillary side, reaching the thoracic duct in the posterior mediastinum. It is by the passage of microscopic particles of the growth along these channels that carcinomatous disease enters the chest, often producing growths in the pleura, with consequent pleuritis, etc.; again, by this route the system may be contaminated, the axillary glands escaping infection entirely or at least for a long period, although the axillary route is the one almost always taken by the infecting fragments.

CONGENITAL MALFORMATIONS.

Supernumerary Nipples and Mammæ, while usually situated in close relation with the normal organs, sometimes occupy the axillary region, and rare instances have been reported of these organs having been located upon the back, over the acromion process, on the anterior abdominal wall, and on the outer aspect of the thigh. This abnormality is not confined to women, but occurs also in the male sex. The supernumerary nipple usually lies below and to the inner side of the normally situated one; it is sometimes well developed, but is more usually small or lacking in one or more of the following peculiarities: viz. the papillæ, areola, follicles, or hairs. This abnormality occurs most frequently upon the left side. These accessory glands are rarely functionally active.

Treatment.—Should they cause mental or physical inconvenience, they may be excised.

Absence of the Mammæ.—A few such cases are on record, the right gland being the one commonly absent; in addition, more or less of the muscular and bony walls of the corresponding portion of chest-wall is also lacking.

DISEASES OF THE NIPPLE.

Inflammation.—While this may result from any form of irritation, it is hardly ever met with except in connection with lactation. The trouble is rarely limited to the nipple, but extends to the surrounding skin, the red swollen organ itself becoming excoriated and fissured; ulcers form, these latter at times extending so deeply as to destroy the skin around the base more or less completely, leaving little else than the lacteal ducts as a connecting bond for what is left of the body of the organ: constitutional symptoms are sometimes present. Much smarting pain is felt, aggravated at each attempt at suckling, at which times fissures are reopened, the scabs are torn off, bleeding follows, and the pain is so severe that the woman often abandons the attempt; the engorged gland is not relieved, and either from this, or more commonly from septic lymphangitis spreading from the nipple, mammary abscess results. Sometimes the nipple is destroyed by ulceration, leading almost inevitably to extensive mastitis and recurring trouble at each succeeding delivery.

Treatment.—The effect of frequent applications of the infant to the breast should be guarded against as far as possible by properly-constructed shields, the nipple itself being always moistened before nursing and carefully dried afterward: these measures, combined with washing with a tolerably strong borax lotion, will suffice for the average case. Disinfection by non-poisonous antiseptics (if the breast is being nursed from), and stimulating and astringent applications, such as glycerole of tannin and sulphurous acid, equal parts, with double the bulk of water, tannic acid (grs. v to f℥j of glycerin), aided in extreme cases by touching the fissures or ulcers with a pointed stick of nitrate of silver, constitute the best means available; but mechanical protection by some form of shield is imperative in all severe cases. Sometimes the use of the breast has to be abandoned, in which case gentle centripetal frictions of the breast with hot camphorated oil, with occasional emptying of the gland by a breast-pump or firm compression with strips of belladonna plaster may be tried, both plans tending to suppress the secretion of milk.

Retracted Nipples.—This may be a congenital condition, or may be the result of cicatricial contraction from badly-ulcerated nipples, from inflammation of the gland, or from neoplasms.

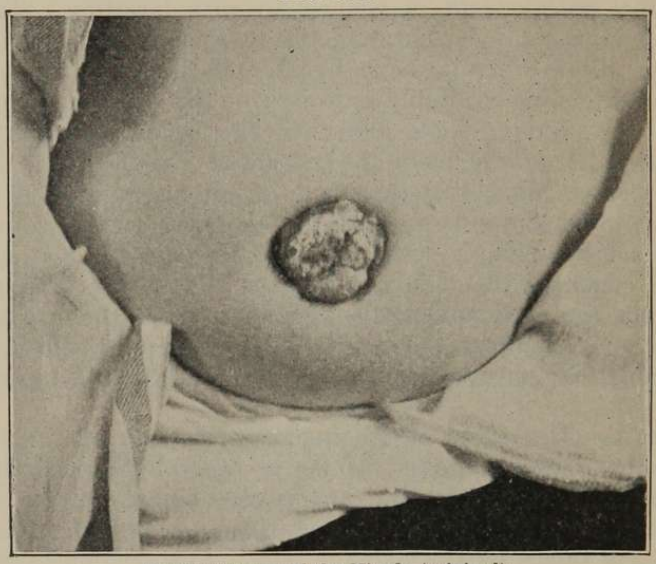
Treatment.—Sometimes this condition appears to be benefited by the application of suction by means of a breast-pump or a bottle with properly-formed neck, the contained air having been rarefied by heat. Many women with retracted nipples can nurse their children by the use of some one of the better forms of nipple-shield.

Paget's Disease.—This is a chronic destructive dermatitis of the papillary layer of the nipple and areola, most frequently attacking individuals between forty and sixty years of age, although in one patient the disease commenced at twenty-eight years.

Symptoms.—According to Bowlby, this disease is not simply eczema. First, a branny desquamation occurs, either on the nipple or areola, followed by a slight watery discharge, which may become very free, yellowish, and sticky. Next small scales and crusts form, which, becoming separated, leave raw or excoriated, intensely reddened surfaces. The process extends peripherally from the nipple as a center, with sharply defined margins, neither vesicles nor pustules forming, until sometimes much of the skin covering the breast is involved. The diseased surfaces are much redder than in eczema. During

the later stages the nipple becomes retracted, and in the more chronic cases is not infrequently destroyed by ulceration, which, extending to the areola, leaves

FIG. 391.



Paget's Disease of the Nipple (original).

a circular or ovoidal ulcer with a papillated, granular surface. Tingling, burning pain is complained of, but not severe itching.

Relation of Psorosperms to Paget's Disease.—Certain constantly-found rounded or oval bodies occupying the deeper layers of the epidermis have been described by Darier, Wickham, Bowlby, and others. These have never been seen in eczema, and have been considered by the above-mentioned authors, as well as others, to be psorosperms standing in a causative relation to Paget's disease. This claim seems more than doubtful, while none claim to have detected them in the mammary tumors following the majority of reported cases of Paget's disease—viz. 24 out of 35.

While some observations have been supposed to show that certain cases are really superficial epitheliomatous disease of the orifices of the lacteal ducts, the lesions have usually been of too long standing and yield too readily to simple treatment to be anything except a form of dermatitis. Nevertheless, this condition of constant irritation unquestionably predisposes to carcinoma mammæ, and if simple, soothing applications do not effect a cure, excision of the diseased tissues should be done, including the whole breast, if any suspicious indurations exist, with careful exploration of the axilla where the condition of the mammary glands has demanded excision.

DISEASES OF THE BREAST.

NEUROTIC CONDITIONS OF THE BREAST are of common occurrence in young unmarried women, but are never found in the aged. The most important as well as the most frequent is simple neuralgia, constant or periodic, severe lancinating pain being complained of in the armpit, and perhaps extending down the arm. The gland itself and the skin over it in many cases are exceedingly sensitive when even gently handled (hyperesthesia), although nothing abnormal can be detected. The patients are often greatly distressed by the fear of can-

cer. Ovarian disturbance frequently coexists, and probably stands in a causative relation to the local neurosis.

Diagnosis.—Where no tumor can be detected, the more severe the pain is and the greater the sensitiveness the less need the practitioner be alarmed, and the more confidently can he ascribe the trouble to its true cause.

Treatment.—As the mental and moral condition has much to do with the development of the trouble, all local treatment must be avoided, while regular hours for sleep, open-air exercise, tonics, cold bathing, and the avoidance of sensational novels, with provision for healthy mental occupation, must be insisted upon.

ATROPHY may occur in the unmarried as well as in the married, either from congenital defect inducing premature senescence or from ovarian disease, presumably always atrophy. Manifestly, no treatment can be of any avail.

HYPERTROPHY.—This is due to abnormal development of the constituents of the breast, usually commences at puberty, and commonly affects both breasts. The general health may or may not be impaired; the catamenia are in all cases established, but are apt to be scanty or irregular. Occurring in adults (usually before thirty years of age), the single and the married, the prolific and the sterile woman, alike may be attacked. The course is slow throughout, or rapid for a time and then perhaps stationary for life or for long periods, but usually one breast outstrips the other in growth. Pain is rarely complained of even upon handling, but the inconvenience from the weight (tumors having been reported of even sixty-four pounds) is often excessive. The breasts may be symmetrically enlarged or may be pendulous, and are covered with normal skin. They feel soft throughout or as if each lobule was uniformly enlarged, rendering the mass somewhat irregular, but no circumscribed induration is detectable. When occurring later in life, while both breasts are apt to be attacked, one may commence to enlarge before the other.

Diagnosis.—This depends upon the uniform, gradual, excessive enlargement—often commencing at puberty—without cutaneous or glandular involvement, and the normal feel of the gland, which when compressed between the *opened hand* and the chest-wall gives no sensation of localized induration: when both breasts are enlarged the condition can hardly be mistaken.

Treatment.—Attention to the general health and to the ovarian and uterine functions is important, compression and support of the glands may be tried. The excitation of lactation has proved successful in two cases, while the removal of one breast has in one or two reported cases caused diminution in the size of the other. When the weight becomes unendurable, amputation must be done.

MAMMITIS, MASTITIS, OR INFLAMMATION OF THE BREAST.—Of course from traumatisms or other causes inflammation may attack the tissues over and in the immediate neighborhood of the breast, and this may terminate by resolution or suppuration: absence of the characteristic induration of the gland will serve to distinguish this from mammitis, and the treatment must be conducted upon general principles.

Mammitis may occur at any age and in either sex. Infants not uncommonly present evidences of mammitis within a few days after birth, especially if the nurse has tried to "break the strings of the breast" or "to rub away the milk:" a milky or serous discharge sometimes exudes from the nipple. Either spontaneously in those in somewhat feeble health, or from a blow, inflammation is not uncommon at or about puberty in boys as well as in girls, although it is more common in females: resolution or suppuration may take place. Between sixteen and twenty years of age a chronic enlargement of the

breast in a girl—although often a fibroma—is exceedingly apt to be either a localized mammitis or a chronic abscess the result of such a condition.

Acute mammitis, however, more often attacks nursing women during the first week to a month after delivery, then being usually due to infective lymphangitis from "cracked nipples," especially when these organs are retracted or the ducts are obstructed by recent or old inflammatory conditions, but is often attributable solely to inability of the child to empty the breast, combined with exposure to cold. Both these conditions favor congestion, and therefore predispose to mammitis, but the **exciting cause** is the entrance of germs, either through an open surface or after lodgment in the deeper portions of the milk-ducts, by their penetration into the periacinous connective tissue: during the later stages of lactation, if the individual becomes run down in health, trivial causes will induce mammitis.

Symptoms.—At first only uneasiness and stiffness of the whole or part of the breast are complained of; next a chill or slight rigor occurs, which is followed by fever, with a tense, hot, swollen, painful condition of the breast, one or all of the lobes being indurated and the overlying skin reddened. The inflammation may terminate by resolution or suppuration, or may leave chronic thickening of the gland. When pus forms, it may be situated, first, superficial to the gland; secondly, in its substance, or rather between the lobes (intramammary, interlobular); and, thirdly, between the gland and the chest-wall (post-mammary). The first variety differs neither in symptoms nor in treatment from any other superficial abscess, but often preludes the second form. The interlobular form usually occurring during lactation may be single or multiple, and presents the usual signs of deep-seated glandular abscess. The post-mammary abscess may originate in the costal portion of the gland, but it usually starts in the cellular tissue between the breast and the chest-wall, being then probably due to tuberculosis of the latter, is not preceded by mammitis, as are the preceding forms—except in those rare instances where the costal portion of the breast is the primary seat—and pushes forward the breast, which, with the large inflammatory base, forms a peculiar conical projection: deep-seated, throbbing pain is complained of, increased by motion of the arm, while œdema and mottling of the skin are present. If left to nature, the pus, when of purely post-mammary origin, opens at the inferior and external border of the breast; but when its primary seat is the costal surface of the breast, the pus may burrow between the lobes, opening anteriorly, often leaving fistulæ which are hard to heal.

Treatment.—This should be directed against the formation of pus, and must consist in the measures advised for fissured nipple, cessation of nursing with the affected breast, the cautious use of the breast-pump, in robust individuals a saline purge, sometimes leeching, and attempts to arrest the secretion of milk by extract of belladonna reduced to a plasma by glycerin, frequent *hot* fomentations, and poulticing if pus is forming, while the moment this is detected free antiseptic incision and drainage must be employed, the cut or cuts passing in a radiating manner from the nipple to avoid division of the lacteal ducts. Support must be afforded to the breast by a proper sling or bandage, and the arm kept in a sling or bound to the side. The post-mammary form requires free incision, preferably at the lower, outer part of the swelling. Neglected cases require free incisions, freshening of the sinuses with the Volkmann sharp spoon, disinfection, and free drainage. More rarely, the gland must be partially dissected back from the chest-wall, and the suppurating surfaces freshened, after which the breast must be sutured in position with catgut, carefully effacing all cavities by means of buried animal sutures. Proper attention to diet, with

quinine, ferruginous tonics, and stimulants, is indicated if the patient's health is deteriorated.

Milk Fistulæ.—These result either from abscesses opening up the milk-ducts or from the surgeon's knife, the secretion of milk serving to keep the orifices patent, so that the abscesses degenerate into fistulous tracks.

Treatment.—Stimulating injections, as of iodoform, iodine, or chloride of zinc, may be employed, with compression along the sinus tracks and general support of the breast. Should these measures fail, the sinuses must be dilated, curetted, antiseptically irrigated, and a drainage-tube inserted through their whole extent, the tube being gradually shortened and compression applied in its track as it is withdrawn.

Chronic Inflammation; Chronic Abscess.—As a sequence of the acute process or from certain constitutional causes (struma?) in an otherwise healthy breast, one or more portions may become the seat of chronic inflammation, evidenced by thickening and perhaps tenderness on pressure. This condition may remain stationary, may gradually diminish, or may terminate in the formation of pus, which is very slow to reach the surface.

Treatment.—Attention to the general health, support of the breast amounting to pressure if it can be borne, counter-irritation from time to time, and covering the part with a belladonna plaster or applying equal parts of extract of belladonna and compound ointment of iodine, will generally hasten resolution. If pus is suspected, the exploring needle or the aspirator must be used, as it is of the utmost importance that these collections should be opened at the earliest possible moment. The incisions should be made as directed for acute abscess, but careful curetting of the cavity, thorough antiseptic irrigation or irrigation with weak iodine-water, followed by light packing with iodoform gauze around a drainage-tube if the cavity be of any size—the gauze to be withdrawn in a day or two—will facilitate the healing process.

Chronic Lobular Inflammation (Irritable Mamma).—Pathologically, this is a chronic interstitial mammitis resulting in a small-celled infiltration of the interlobular connective tissue, with some epithelial proliferation. The newly-formed connective tissue, contracting, obliterates the ducts and acini, resulting in fatty degeneration of the epithelium. Some of the acini, by having only their ducts compressed, may dilate, forming small cysts. The importance of this affection resides in its liability to be mistaken for carcinoma when occurring about the menopause.

Symptoms.—Either the whole or more commonly a part of the mamma becomes indurated and tender—possibly even the latter, with but little of the former—in young unmarried or in sterile married women, in these latter perhaps more often about or after the menopause. Disturbances of the uterus, of the ovaries, of digestion, with mental excitement or depression, are not uncommon.

Diagnosis.—This must depend upon the following facts: The growth does not steadily increase as in neoplasms; the pain and tenderness are greater; the benign tumor is more circumscribed, while scirrhus is much harder, the density appearing less—instead of greater, as would be true of scirrhus—if the mass be examined by rolling the breast over the chest-wall with the flat of the hand; the swelling is wedge-shaped, with the apex toward the nipple; the pain is referred to the distribution of one or more nerves, which, as Mr. Birkett long ago pointed out, if pressed upon at their exit from the thorax, will give rise to severe pain, "sometimes confined to the branch distributed to the indurated part, while the rest are unaffected;" the axillary glands if enlarged—a rare event—are not *indurated*. In an exceptionally doubtful case a fragment can be removed by antiseptic incision and subjected to microscopic examination.

Treatment.—This should be directed to the removal of the functional disturbances mentioned: assurance should be given that the disease is not malignant and is curable, and a belladonna plaster should be applied, chiefly to prevent the patient's handling the part, while small doses of iodide of potassium should be given internally. If these measures fail, counter-irritation and compression, or in severe cases free antiseptic incision, may be tried. Should the induration persist or increase, with severe pain, despite appropriate treatment, in middle-aged or older women, amputation is indicated, because continued irritation may result in the development of genuine carcinoma.

Tubercular Affections.—Secondary involvement of the breast, causing induration or abscess and ulceration, may take place when the neighboring cellular tissue, lymphatic glands, or bones are the seat of primary tuberculosis. Velpeau, however, has described certain instances where at numerous points of the breast there were isolated masses whose centers had undergone caseous change. This condition is found in pale, delicate females, and coincident strumous enlargement of the axillary and cervical glands is quite common. The small masses are difficult to detect, because not sharply defined, and tend slowly to enlarge, break down, and open externally by ulceration, leaving the gland riddled with sinuses.

Treatment.—Early extirpation, including in the removal, as a rule, the entire breast, is probably the best practice. Curetting, irrigation with weak iodine-water, and packing with iodoform gauze may be successful. Tubercular infection of the neighboring glands is common: if any enlarged glands are detected at the time of operation on the breast, they should be removed then.

Syphilitic Affections.—As in tuberculosis, so in syphilis, secondary trouble may result from specific disease in the contiguous cutaneous, cellular, and osseous tissues. A primary affection of the gland, producing a more or less uniform indurated enlargement of the organ, has been described as occurring in syphilitics in the late secondary or early tertiary period. Either one or both breasts may be attacked, producing a not very painful, hard, smooth enlargement readily yielding to antisyphilitic treatment.

Treatment.—Iodide of potassium, either alone or combined with mercury, aided perhaps by counter-irritation and pressure, is all that is requisite.

TUMORS OF THE BREAST.

Tumors composed of nothing but pure fibrous, fatty, myxomatous, cartilaginous, vascular, or nervous tissues are so rare that they will not be separately considered here, the student being referred to the general chapter on Tumors.

For clinical purposes mammary tumors may be classed under the following heads:

1. Those tumors resembling **fully-formed connective tissue** and derived from it. Tumors belonging to this class are *non-malignant*, and it comprises the fibromata (fibrous tumors), the lipomata (fatty tumors), the myxomata (mucous tumors), and the chondromata (cartilaginous tumors).

2. Those tumors resembling **embryonic** or transitional **connective tissue,** derived from that of the gland: these neoplasms are *malignant.* To this class the term sarcoma is applied.

3. Those tumors which more or less closely resemble **glandular tissue** and are derived from the glandular epithelium. They are *non-malignant,* except when occurring in connection with sarcomatous elements. This class comprises adenoma pure, or adenomatous tissue combined with fibrous tissue (adeno-fibroma), with cysts (adeno-cystoma), or with atypical cells of the connective-tissue type, round, spindle, or giant cells (adeno-sarcoma).

4. Those tumors composed of **atypical epithelial cells**, atypically related to the fibrous stroma of the gland. These tumors are *malignant.* The term applied to this class is carcinoma.

5. Those tumors resulting from hypertrophy of such highly **specialized tissues** as blood-vessels, etc. They are *non-malignant.* This class embraces angeioma (vascular tumor) and neuroma (nervous tumor).

About 83 per cent. of all mammary tumors are carcinomata, while the remaining 17 per cent. are sarcomata, adenomata—including its varieties—and cysts.

ADENOMA.—In its pure form this is one of the rarest of mammary neoplasms. Closely resembling the mammary tissue in the pregnant woman, the epithelial elements are arranged in a purposeless way, as it were, a confused mass of acini and ducts being seen microscopically. The cubical epithelial elements may line with a single or double layer the newly-formed acini, but are more apt entirely to fill their lumen, only a mass of cells being discernible; but, unlike carcinoma—which presents a very similar picture—the cells are separated from the surrounding connective tissue by a distinct basement membrane; *i. e.* they do not infiltrate the connective tissue.

Diagnosis.—This must depend upon the detection of a tumor in the breast of a woman—usually married and prolific—from thirty to thirty-five years of age; of slow growth, requiring many years to reach a size productive of annoyance; movable, and bosselated on the surface. Neither retraction of the nipple nor involvement of the axillary glands occurs, but where any portion of the mamma is left there is sometimes a tendency to local "reproduction."

Treatment.—Free excision, or occasionally amputation.

ADENO-FIBROMA.—These are the commonest of all the benign mammary neoplasms. They consist of hypertrophied connective tissue, mingled with small portions of normal or altered glandular tissue. They occur as freely-movable, circumscribed, rounded, slightly nodular, usually painless growths. When no secondary cystic changes have taken place, they are firm and elastic: when they have undergone cystic degeneration, over the more prominent bosses they feel soft or even fluctuating, while dense elsewhere. Pain is sometimes complained of by neurotic individuals. These neoplasms are completely encapsulated, and their cut surfaces are dry, white, opaque, compact, creak under the knife, and in some specimens the bundles of fibrous tissue are concentrically disposed around numerous central points which project above the surface. In slowly-formed tumors dense adult fibrous tissue is the main constituent: in more rapidly developing neoplasms interlacing bands of young, wavy connective tissue form the bulk of the tumor, producing a more succulent growth, which is glistening white or even rosaceous on section. In those of most rapid growth abundant cellular elements are present. Inflammation or suppuration of fibromata is very rare, and in consequence fungous protrusion through ulceration of the skin is almost unheard of. Should this occur, the skin immediately around the opening is normal, non-adherent, and of course not infiltrated. Cystic degeneration from fatty or mucous change of the epithelium or myxomatous degeneration of the interacinous tissue takes place in about 4 per cent. of all cases, and even blood- or extravasation-cysts have been observed, while telangiectatic change occasionally attacks the cystic variety, indicated in one-half the cases by a bloody discharge from the nipple: such tumors are of rapid growth.

Diagnosis.—Sometimes a small solitary adeno-fibroma so closely resembles a cyst that only a resort to the hypodermatic syringe can decide the point. The age of the patient, and the defined, circumscribed outline of the tumor, serve to distinguish it from both carcinoma and chronic lobular inflam-

mation, while the absence of adhesion to the skin and deeper parts, with the freedom of the axillary glands, still further distinguishes it from carcinoma. While usually single, they are occasionally multiple.

Prognosis.—If removed they do not recur.

Adeno-cystoma.—Since any adenoma consists of acini and ducts possessing no normal outlet, cysts form either from accumulation of their secretion or from being drawn asunder by the contraction of the periacinous and pericanalicular tissue of the new growth. This condition is apt to obtain when there is primarily but little hyperplasia of the connective-tissue elements of the neoplasm, which would of course result in the hard form or ordinary adeno-fibroma described in the last section, often called, from its excess of fibrous tissue, a fibroma. The cysts are lined with round, cubical, or cylindrical glandular epithelium. In many instances the pericanalicular interstitial tissue projects as ingrowths into the cavities of the cysts—which they sometimes completely fill—forming many-shaped papillary, cauliflower, dendritic, or perhaps pedunculated masses covered by epithelium. This variety of adenoma is called "the proliferous mammary cyst," "endocanalicular" or "intracanalicular mammary tumor," and comprises 86 per cent. of the cystic tumors of the breast. Upon section they present a white or cream-colored, lobulated surface, with numerous cysts, some small, some large—some have been reported even containing a quart—but usually of medium size, filled with a serous, mucous, lactescent fluid, or one variously tinted by blood, rendering it brownish or sanguinolent. A distinct capsule envelops the growth, which, it has been alleged, is always attached by a pedicle to the gland tissue, and never infiltrates it.

Diagnosis.—This tumor is distinguished from an adeno-fibroma by occurring later in life, from thirty to thirty-five years of age, and from carcinoma by the fact that this disease, as a rule, appears later. While it is hard, it is movable, somewhat nodulated, of slow growth, and in advanced cases from the large cysts it is of unequal consistence, giving here and there, over the most prominent bosses, a sensation of elasticity, perhaps of indistinct fluctuation. Sometimes, after growing slowly for many years, it will suddenly enlarge, when it may produce ulceration of the skin, a fungating, bleeding mass protruding, but the skin-opening is supple, with sharp-cut edges—hence not infiltrated with the growth—and the axillary glands are not involved. Possibly from the inflammation the glands may be, in rare instances, somewhat enlarged and tender in these ulcerating cases, but they never present the characteristic steady increase in size, with matting together of all the axillary tissues, terminating in œdema of the arm from pressure on the veins.

Prognosis.—Visceral involvement never occurs, nor does local recurrence take place after thorough removal.

Adeno-sarcoma.—In the preceding forms of adenoma the periacinous and peritubular connective tissue, becoming hyperplastic, develops into a permanent tissue more or less perfectly approximating the type of normal fibrous tissue, but in adeno-sarcoma the proliferating elements tend to form, not adult, but some variety of embryonic connective tissue. Thus it may consist chiefly of small spindle-cells, mingled with a varying amount of mature connective tissue, of large spindle-cells, of imperfectly organized fibrous tissue infiltrated by numerous round cells, of stellate and fiber cells with anastomosing processes, between which lies a mucoid substance; or, finally, all these varieties may be found in the same tumor, each in a different portion of the growth or variously combined: scattered cysts are also frequently found. Growths of this nature are believed to remain quiescent for long periods when commencing in early life, but it is more probable in such cases that an origin-

ally benign growth has undergone a secondary malignant (sarcomatous) change. Originating in middle life, adeno-sarcomata always grow rapidly.

Diagnosis.—A tumor commencing in the breast of a woman from thirty to forty years of age (perhaps older), covered by non-adherent skin, which is heavy, movable, slightly nodulated, elastic, but of unequal consistence at its more prominent points, and which grows with great rapidity without involvement of the axillary glands, is probably an adeno-sarcoma: moreover, a tumor which has presented for years the symptoms given for adeno-cystoma, which suddenly begins to enlarge, provided the enlargement is not due to one or more cysts becoming distended, is probably a benign adeno-cystoma undergoing sarcomatous change.

Prognosis.—The microscope alone can determine the degree of malignancy of any given growth, the appearances varying from those of a tumor essentially benign up to those characterizing one whose interacinous tissue is extensively infiltrated with round cells or composed chiefly of spindle-cells, when the growth is practically a round- or spindle-celled sarcoma, which is liable to recur both locally and in distant parts.

SARCOMA.—For the specific histological appearances of the solid sarcomata the reader is referred to the section on Tumors, p. 198. The round-, spindle-, and giant-celled forms all occur, mingled with more or less adenomatous tissue, but the large spindle-celled is by far the commonest. Sarcomata are liable to become inflamed or to suppurate, and may undergo myxomatous, fatty, cystoid, calcareous, and telangiectatic metamorphoses, the two former being the most frequent cause of those large interstitial hemorrhages of such common occurrence in mammary sarcomata, sometimes converting them in whole or in part into a grumous, semifluid material. More than half of all mammary sarcomata undergo cystic changes, and in about one case in seven discharge from the nipple takes place. Sarcomata usually appear between the ages of twenty and thirty-five years—one has been reported so early as the eighteenth year—and when of very rapid growth there may be considerable local elevation of temperature. They usually thrust aside, compress, and cause atrophy of the gland, but in rare instances are only attached to it, and then merely by a pedicle. Their usual position is beneath or near the nipple or in the upper inner segment of the gland.

Diagnosis.—Possessing a distinct capsule, they form rounded or ovoidal, somewhat lobulated, usually single, firm, or soft and elastic, rapidly-growing tumors. They are in consistence sometimes so diffluent that they feel fluctuant, so that surgeons have incised them, believing them to be chronic abscesses. The veins of the overlying skin enlarge early, but the tumor does not become adherent to it nor to the contiguous tissues (Plate XXIII, Fig. 1). Later there is a distinct tendency to ulceration, but this is due to inflammation and gangrene from pressure rather than to infiltration with sarcomatous elements, and, as a rule, the surrounding skin is at first neither discolored nor attached to the fungous protrusion which almost invariably forms after the skin has given way. The ulcer is apt to be circular, and sometimes several exist, with intervening bridges of sound skin. The discharge from the fungus is fetid and bloody, but may be purulent from inflammation.

Sarcomata usually develop with great rapidity, and the viscera, especially the lungs, may become involved early, but the axillary glands do not enlarge except in very rare instances, and then only from inflammatory irritation, not from the lodgment of sarcomatous elements. The distinction between solid and cystic sarcomata may perhaps be made by noting that the latter appear earlier—before the thirty-third year; that they are more apt to be located

near the nipple; that they grow more rapidly; that they suddenly increase after quiescence or slow growth for long periods; that they are more lobulated and their consistence is more unequal; that discharge from the nipple is quite frequent; and that pain, usually harassing, is experienced in more than three-fourths of all cases. They must be differentiated from carcinoma by the earlier age at which they occur, by their mobility, by their unequal density, by the absence of retraction of the nipple, of invasion of the skin, of induration of the lymphatic glands, and of fixation to the chest-wall, and, when ulceration exists, by the fact that in sarcoma fungous protrusion is apt to occur *without infiltration of the skin*, the characteristic thickened, infiltrated, everted margins of the carcinomatous ulcer being absent.

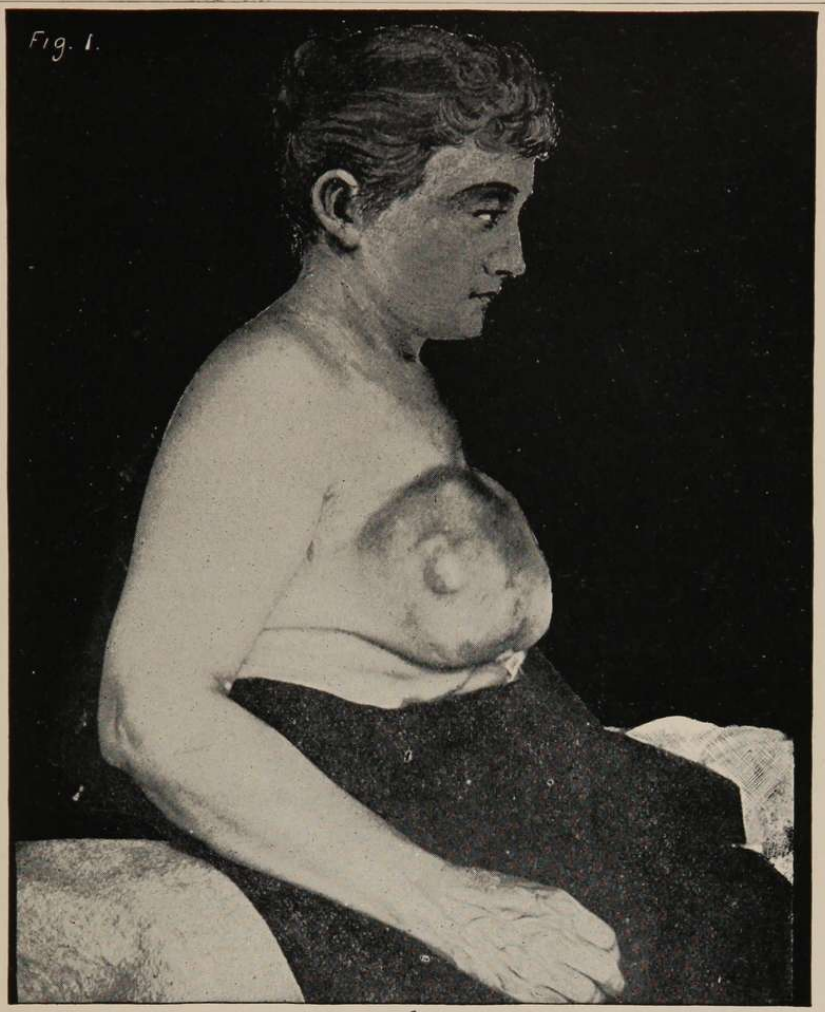
Prognosis.—Many of the sarcomata, especially those of the round-celled form, which possess but little intercellular substance, are exceedingly malignant. Both local recurrence and visceral implication are the rule, the former being the commoner because the disease, although apparently remaining encapsulated, progresses along the adventitia of the blood-vessels external to the capsule, which serve as points of departure for both the local recurrence and the visceral contamination.

Treatment of Adenoma, Adeno-fibromata, and Sarcomata.—Grasping the mass firmly so as to render the skin tense, an incision should be made down to and through the capsule of an **adenoma** or a **fibroma**, when it can readily be enucleated, requiring perhaps a few touches of the knife. **Adeno-cystomata**, when involving much of the gland, require amputation of the entire breast; and the same treatment is indicated for cases of **cysto-sarcomata** and pure **sarcomata**, with free removal of the superjacent skin.

CARCINOMA.—**Predisposing and Exciting Causes.**—Heredity has some but not a great influence, but traumatism and such lowering in grade and vitality of the tissues as results from the chronic thickening and induration left after acute mammitis or abscess seem not uncommonly to stand in causative relation to carcinoma. As has already been pointed out, the chronic dermatitis of the nipple called Paget's disease sometimes precedes and unquestionably favors the development of carcinoma. Any slight, prolonged irritation, increasing the vascular supply to the epithelial tissues in a gland which is senescent or old—which for the mamma means from thirty-five to fifty years—may excite the disease in one predisposed to it, probably by some inherited peculiarity of tissue. As a rule, the patient when attacked is in good or even robust health.

The pathological anatomy of carcinoma has been so fully described elsewhere that only a few general remarks will be made here. Carcinoma is an atypical epithelial growth consisting of a stroma whose intercommunicating spaces are occupied by polymorphous, spherical, or cubical epithelial cells, no genuine intercellular cement substance being apparently present, and the intercommunicating columns of cells—seen in cross-section they resemble *alveoli*, and are hence so called—are not surrounded by a basement membrane, but are in direct relation with the fibrous stroma, thus differing from adenoma, in which a limiting membrane encloses the cell-masses, and which moreover are often not solid, but possess a central space, exactly simulating a normal acinus.

Varieties of Carcinoma.—According to the relative proportions of the fibrous and the epithelial elements, a given carcinoma is classed as hard or soft. At one extreme is the **fibrous, hard,** or **scirrhous** carcinoma, in which the fibrous tissue is in excess; at the other, the epithelial elements form the bulk of the tumor, resulting in the soft, cellular, medullary, or **encephaloid** carcinoma.



1

2

1. Sarcoma of the breast. 2. Scirrhus of the breast.

Course, Symptoms, and Termination of Hard Carcinoma.—Scirrhus forms an irregular, nodulated, somewhat rounded, stony-hard, heavy mass, inseparable from the glandular tissue, possessing no defined outline, but gradually merging into the healthy mammary tissue, with which it freely moves (Plate XXIII, Fig. 2). Soon it adheres to the skin, which becomes dimpled, and later to the pectoral muscle; thus at first being partially, then immovably, fixed to the chest-wall. At the outset the tumor grows slowly; the nipple gradually becomes retracted, but the growth never attains a great size, as does the soft carcinoma. As a rule, the upper, outer (axillary) segment is attacked, but scirrhus may originate close to the nipple or to the inner side of the breast. Studying in detail certain symptoms, it will be seen that while the skin may adhere to subjacent inflamed tissues or benign growths, it is then glazed, thinned, and stretched by mechanical pressure; but in carcinoma the conditions are different, for the fibrous septa connecting the skin and mammary fascia being infiltrated with young cells, new fibrous tissue forms, which, contracting, pulls in isolated *unthinned* portions of normal skin, producing the characteristic delicately-pitted "pig-skin" appearance.

Retraction of the nipple due to carcinoma differs from that seen occasionally in benign growths, in that the nipple is actually drawn in, and not buried, by the projection of the tumor-mass; and by pressing this back in the case of an innocent growth, the nipple will be seen to be normal, having only been buried, not retracted. Genuine retraction of the nipple results from the contraction of the milk-ducts, the walls of which have been infiltrated with young cells which have developed into fibrous tissue (Fig. 392). In proportion to the propinquity of the growth to the nipple is its retraction: a growth occupying only the upper outer segment of the gland will not produce this symptom. When present it is valuable corroborative evidence of the existence of a hard carcinoma, but its absence under some circumstances proves nothing. Very rarely a small amount of thin discharge exudes from the nipple when the growth is near it, but this discharge differs from that characteristic of some forms of cystic adenomata.

FIG. 392.

Retraction of the Nipple in Mammary Carcinoma (Bryant).

Pain, usually believed to be characteristic of carcinoma, is absent in the earlier stages, and becomes prominent only when the tumor is of some size. Sometimes slight stinging pains attract attention to the growth, but it is more often accidentally discovered: it is not tender. When fixed to the chest-wall and the axillary nerves are compressed by the secondary lymphatic glandular tumors, the pain is severe and almost ceaseless. Its character is lancinating, darting, or cutting.

Cachexia is present when ulceration has taken place and when mental anxiety, prolonged pain, or profuse discharge has exhausted the patient; but in nearly every instance the patient is in robust health when first attacked. Moreover, if under the former circumstances the tumor is removed, and with it worry, pain, and discharge, the patient promptly regains color and flesh. Age is an important point, since most hard carcinomata appear between the ages of forty and fifty years. A very few cases have been reported before the thirtieth year, yet this is such a rarity that a tumor simulating scirrhus at this period of life can be confidently decided, as a rule, not to be a hard carcinoma.

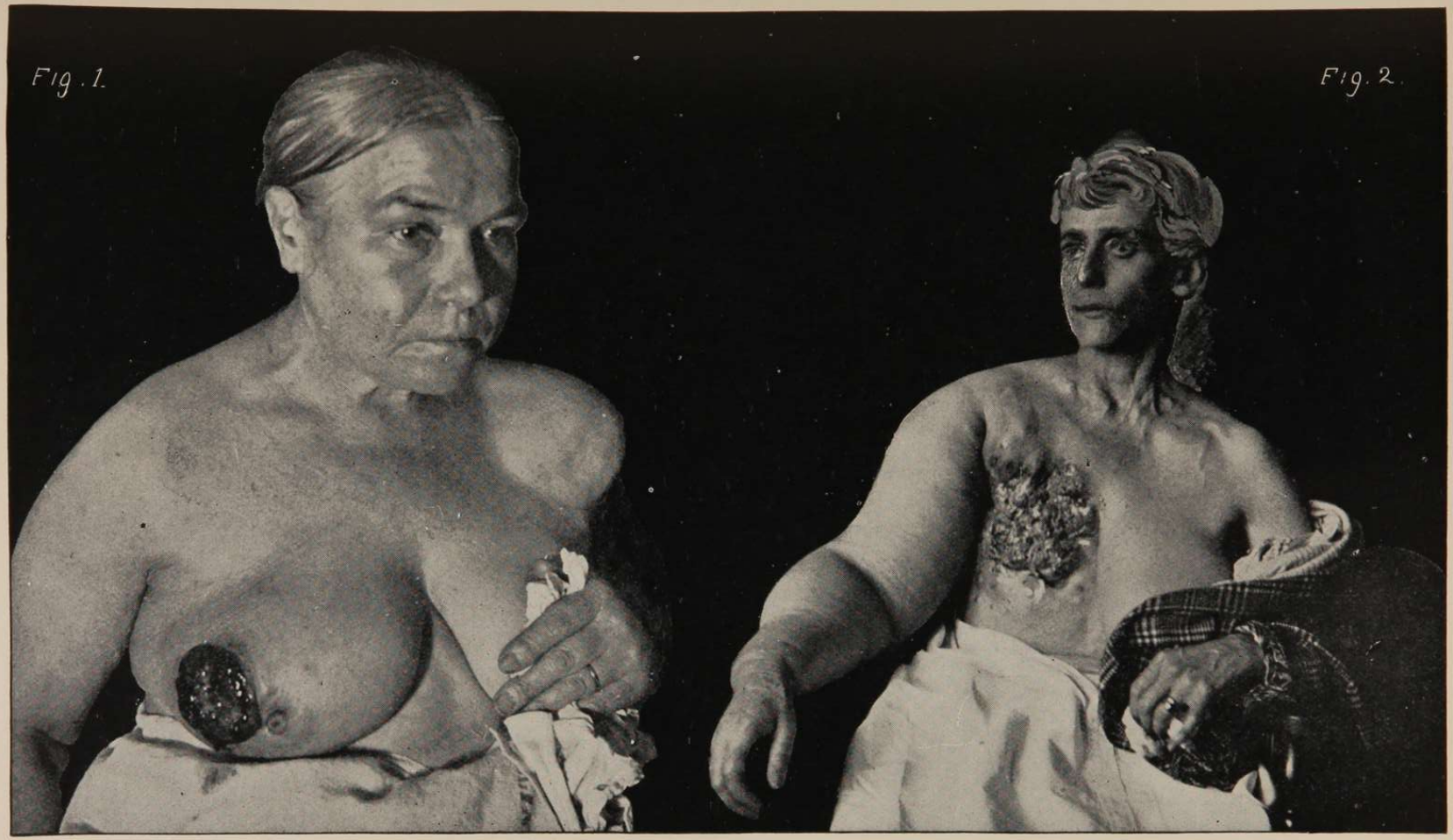
Scirrhus, left to itself, will involve the whole mamma, converting it, with

the overlying skin and subjacent muscular parietes of the chest, into one nodular, stony-hard mass with retracted, buried nipple. The cancer-cells find entrance into the perivascular lymph-spaces of the cutaneous blood-vessels, forming here and there smaller or larger nodules. When this condition involves a large portion of the chest-wall, it is called cancer "*en cuirasse.*" Owing to the contraction of the widely-spread and rigid neoplasm, the movements of the chest are sometimes sufficiently embarrassed to produce distinct difficulty in breathing. Usually the skin over the affected area is decidedly reddened. Ulceration may occur (Plate XXIV, Fig. 1), either superficial or deep, more commonly the latter, producing deep, crater-like cavities with hard, tuberous, irregular, and everted margins, the base being formed of unhealthy, sloughing granulations or cancer-tissue covered with thin, ichorous, sanious, offensive discharge: no fungus ever forms. Severe and repeated hemorrhages, readily controllable, however, by pressure, are not uncommon. Early in the disease, although often incapable of detection by the touch, the axillary lymphatic glands become involved in fully 85 per cent. of cases supposed before operation to be free from this complication: when the axillary fascia has been divided, the glands are found to be carcinomatous. These, forming masses behind and in front of the brachial plexus and vessels, finally fuse together, steadily contracting until the return circulation is markedly interfered with, as evinced by œdema of the whole upper extremity, and most distressing neuralgic pain is produced. From the axillary glands the disease spreads to the supraclavicular glands. By recalling the other routes by which the lymph is normally returned, as described on page 1022, the surgeon will recognize that the anterior mediastinal glands, the pleura, and the viscera may all be involved, even although secondary disease of the axillary lymphatics does not occur. Plate XXIV, Fig. 2, shows the appearances in local recurrence after extirpation. After the lymphatic glands the viscera become diseased, in order of frequency as follows: liver, lungs, pleura, and bones. Cysts, usually from retention produced by obstruction of acini or ducts, are occasionally observed.

The Atrophic or Withering Scirrhus, from the fatty degeneration and absorption of the epithelial cells (Fig. 393)—perhaps induced by the unusually abundant development of the fibrous stroma contracting so as to diminish the blood-supply to the cells—leaves little more than a mass of fibrous tissue, with here and there a few cells surrounded by granular débris. Although the tumor is slower in its progress and rather diminishes in size than increases, the malignancy is not thereby lost, the ultimate result being the same.

Diagnosis.—This depends upon the detection of a tumor most frequently in the upper, outer segment of the breast of a woman over forty years old, heavy, stony-hard, without definite outlines, covered by adherent "pig-skin" integument, at first moving *with* the breast, and later adherent to the pectoralis major muscle, with enlargement of the axillary glands and retraction of the nipple as the growth reaches its neighborhood: if originating beneath or near the nipple, retraction of that organ will be an early sign; if the neoplasm is examined when only one border of the gland is involved, this symptom will be entirely absent. From sarcoma it is to be distinguished, in addition to the difference in feel and absence of mobility, by the adherent and peculiar-looking skin and the glandular involvement.

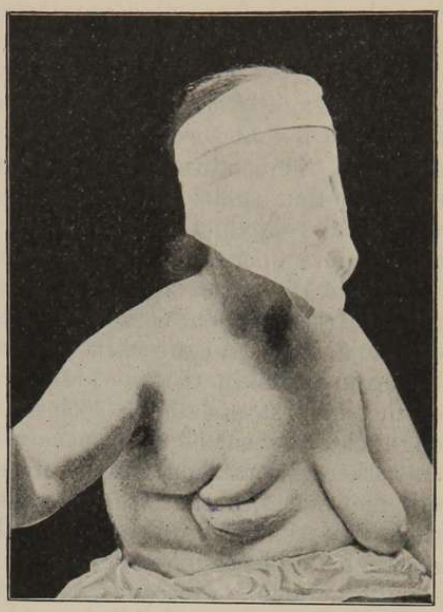
Soft Carcinoma.—This is a disease of earlier life, runs a more rapid course, and its capability of contaminating the system is much more pronounced than that of scirrhus. Usually more deep-seated than scirrhus, it forms at the outset a rounded, nodular, movable tumor, at points elastic or pseudo-fluctuant, growing with such rapidity that it may sometimes reach the



1. Ulcerated scirrhus of breast, and a fatty tumor on the left shoulder. 2. Recurrent scirrhus of breast, with œdema of the right arm from extension of the disease to the axillary glands and pressure on the vein.

size of a child's head in a couple of months. Soon the skin adheres, reddens, becomes glazed, and, the appearances closely simulating those of abscess, the integument gives way by ulceration. By this process and sloughing of masses of the tumor large excavated sores are formed. Pain is a late symptom, but cachexia sets in early, as well as lymphatic and visceral metastases. Cysts are also formed occasionally, as described when speaking of scirrhus, while abscesses have been observed, especially in rapidly-growing tumors developing during pregnancy. Colloid change likewise *very* rarely attacks some of the firmer forms of soft carcinoma.

FIG. 393.



Atrophic Scirrhus (original).

Diagnosis.—The resemblance to round-celled sarcoma is great, the cardinal point of distinction being that sarcoma is an encapsulated, and therefore a distinctly circumscribed growth, while soft carcinoma is a non-circumscribed, infiltrating neoplasm. The rapidity with which it attains a great size, the relative softness of the mass, the late appearance of pain, and the early constitutional involvement distinguish it from hard carcinoma. Colloid carcinoma cannot be diagnosticated before removal, but is of slow growth, and glandular infection occurs late.

Prognosis.—Without operation carcinoma of both kinds terminates by death; the attending operation will be referred to later.

The average *duration of life* in the fibrous form is about thirty months, in the soft about twelve months, although life may be greatly prolonged in the former, while it may be much curtailed in the latter, especially if the disease commences during pregnancy, when a few weeks sometimes comprise the whole course of the affection.

Treatment.—Experience having proved that no internal remedy is of the slightest benefit, the question resolves itself into allowing the disease to pursue its course, relieving pain and making the patient as comfortable as possible,—the so-called palliative method; or resorting to the radical plan, meaning by this the prompt extirpation of all the diseased tissues.

Palliative Treatment.—This is often necessitated by the disease having reached so advanced a stage when first seen that all opportunity for the successful employment of the radical method has been lost. The parts must be put to rest by carrying the arm in a sling; corsets and tight clothing must be interdicted, but at the same time the diseased organ must be carefully supported. Local applications of extract of belladonna with opium or conium at first give relief, but the free use of morphia with small doses of atropia soon becomes requisite. The constant application of acetate of lead in the proportion of grs. xv @ ℥j will sometimes afford relief when a rapidly-growing tumor becomes reddened, hot, and tense, or ice-bags may be employed. When ulceration has taken place, deodorizing, unirritating dressings should be employed, such as chloral, grs. v @ ℥j of vaseline, balsam of Peru, etc. The use of Esmarch's powder under these circumstances will often relieve the pain, check the

rapidity of growth, and decidedly diminish fetor. Its composition is arsenious acid and muriate of morphia, each 0.25 part, powdered gum arabic 12.0 parts. Half a teaspoonful of this should be daily sprinkled over the surface of the sore until a yellowish crust forms, which after separation leaves a healthy granulating surface: this powder can be repeated when necessary. Hemorrhage can be stopped by pressure or by the local application of styptic cotton.

Operative Treatment.—The first question to be answered is, Can the disease be totally eradicated? If not, no operation should be attempted, unless to remove a foul sore purely as a palliative measure. When contemplating even this, the conditions must be carefully scrutinized to determine with great certainty that sufficient skin can be saved to ensure prompt healing; otherwise local reproduction will ensue, leaving the patient in a worse condition than before operation.

While each case must be a rule for itself, the following conditions are positive *contraindications* to a radical operation: enlargement of the supraclavicular glands, cancer *en cuirasse*, such a dissemination of small shot-like bodies in the skin that a wide margin of healthy skin cannot be left outside of the smallest nodule, or such extensive axillary involvement that the thorough clearing out of that space will be impossible. Again, the liver, lungs, and other viscera should be carefully examined to eliminate the probability of any metastases, because the discovery of any such is an absolute bar to operation. To reiterate, unless all local and glandular disease can be thoroughly eradicated and presumptive proof exists that the viscera are free, no operation should be done. Moreover, in very advanced life the disease often progresses so slowly that the probabilities of prolonged life are sometimes greater without than with operation.

In the case of an otherwise healthy woman of middle age, without any such infiltration of the skin and subjacent muscles as will clearly prevent complete extirpation, yet where extensive axillary involvement exists, what is the proper course to pursue? Examine the axilla carefully under anesthesia, and if still in doubt make an exploratory incision, when, if this cavity can be successfully cleared, do this, afterward removing the breast with all doubtful cutaneous and muscular structures; but if it appear that the axilla cannot be cleared, close the wound and abandon further interference.

When the skin is merely adherent and the tumor freely movable on the deeper parts, with simple enlargement of the axillary glands, the surgeon should *urge* the promptest and freest possible operative measures. It is the surgeon's duty to endeavor to educate the public up to the recognition of the necessity for early operation before extensive local and glandular infection has taken place.

The results of early radical operations performed by König, Küster, Gross, Barks, Estlander, and Gussenbauer show from 16.7 per cent. to 22.5 per cent. of permanent cures, the average being 20.08 per cent. According to Curtis, Dennis, Weir, and Bull, the average of permanent cures is 20.87 per cent.

The mortality from the operation, which is a much more severe procedure than was formerly adopted, has fallen, according to Williams, from 17.35 to 9.4 per cent. This latter percentage unquestionably represents a much higher death-rate than prevails in this country, which is only about 5 per cent., and in 464 cases reported by Bull, Dennis, Weir, Halsted, and Keen is only 0.86 per cent. Williams conclusively shows that where a cure is not effected life is prolonged, those operated upon living upon an average 60.3 months, as compared with those not operated upon, who survive for only 44.8 months. From the data given by Halsted, recurrence in the practice of Czerney, Fischer, Gussenbauer, König, Lücke, Volkmann, and Halsted reaches 62.55 per cent.,

but in his own practice, with a still bolder use of the knife, only 3 recurrences were observed in 46 cases.

Method of Operating.—While no rules can be given applicable to every case, in general every particle of diseased tissue must be removed, no regard being paid to retaining enough skin to cover in the wound if this essential indication will be thereby interfered with. The knife should sweep wide of the apparent limit of infiltrated skin, making, if necessary, a cut encircling the whole base of the gland. If it appears right to save any of the covering skin, the outline of the incisions should include an ellipse embracing the central portions of the growth, the long axis of the ellipse extending from just below the anterior axillary fold downward, forward, and inward. The incisions should be boldly made through the skin and paramammary fat down to the pectoral aponeurosis, and the gland rapidly dissected off from below upward, cutting the attachments toward the axilla, and with them the larger vessels last. Let an assistant compress each spurting vessel by the finger-tips until the gland is removed, when hemostatic forceps should be applied. The pectoral fascia, and any remaining portions of infiltrated muscles or outlying gland tissue, must then be freely removed and the vessels tied.

A complex network of lymphatic vessels lies on the outer surface of the muscles and the upper surface of the fasciæ. These vessels intercommunicate, and the lymph-current is from the muscle toward the fascia, as demonstrated by injections. The presence of these lymphatic networks shows the necessity of removing the pectoral fascia with the underlying fat in all operations for carcinoma, and also explains the possibility of a carcinoma being actually adherent to the fascia, while the muscle itself may remain free.

The axilla is to be opened by an incision parallel to and one inch below the anterior axillary fold, and this space cleared of *all* glands, lymphatic vessels, and fat by dry dissection, when possible. Careful use of the knife, with double ligature of any tissues that may contain large vessels before dividing them—even to the axillary vein if endangered—will render this a safe procedure. It is safer to clear the vein first, and then proceed with what further dissection may be requisite. Having determined by careful search both in front of and behind the axillary vessels and nerves that every gland, however minute, has been removed, the skin should be freely loosened by the scalpel handle or its edge around the wound until the margins can be approximated. To secure this without tension, either completely or partially, relaxation buttons and sutures are sometimes requisite, which can be removed from the fifth to the seventh day. Finally, provide for drainage by passing a perforated glass or rubber drainage-tube through the posterior axillary fold by an especial incision, thus draining the most dependent portion of the wound. The skin should then be accurately apposed by superficial silk sutures, either interrupted or, preferably, continuous. If relaxation sutures will not enable the surgeon to coaptate the whole wound, the angles should be closed, leaving the central portion to heal by granulation. Skin-grafting may be immediately adopted, provided the operation have been done aseptically—*i. e.* without the use of antiseptics; or after granulations have formed this procedure may be employed to close the whole gap at one sitting. Antiseptic towels should surround the field of operation, and when a prolonged axillary dissection is requisite, the breast-wound should be temporarily covered with sublimate gauze to prevent shock and perhaps pneumonia: antiseptic sponges or mops of sublimate gauze should also be employed, avoiding as far as possible all wetting of the patient. The ordinary aseptic preliminaries and some one of the forms of antiseptic dressings must be employed, and the arm confined to the side by a snugly-pinned binder. Shock,

which is often very pronounced, must be combated by appropriate measures. The mortality by this method of operating, although small, considering the magnitude of the operation, is higher than by the older plan, but more cures will result, hence more lives will in the end be saved.

Halsted has recently insisted that all the pectoralis major muscle, excepting possibly its clavicular portion, should be excised with the breast in one piece, including the axillary contents. Thus: Carry the incisions at once through the fat, fully reflect the triangular skin-flap, and, dividing the costal insertions of the pectoralis major, split the muscle between its costo-sternal and clavicular portions up to about opposite the scalene tubercle on the first rib; divide the clavicular portions of the muscle with the overlying skin close up to the clavicle, exposing the apex of the axilla; draw upward the cut clavicular portion of the muscle with a broad, sharp retractor and dissect all loose tissue from it; split the muscle out to the humerus, and cut it through close to its attachment, making tension by means of traction upon the loosened breast muscles, etc.; strip everything away from the chest-wall, including, when possible, the sheath of the pectoralis minor, clearing the external border of the muscle, cut it transversely through its middle, dividing it as far externally as possible, and then reflecting inward the cellular tissue overlying the coracoid extremity of this muscle, which then draw upward with a broad, sharp retractor; dissect out and carefully ligate close to the axillary trunks all the small vessels, chiefly veins, lying beneath and near to the muscular insertion; complete the extirpation of the axillary contents by dissecting the vein, artery, and nerves clean of any loose tissue; making traction upward and outward, divide with the knife the fascia which binds the axillary fat to the chest-wall; an assistant renders the triangular skin-flaps tense; dissect the tissues away from the subscapular, teres major, and latissimus dorsi muscles, exposing and securing before dividing the subscapular vessels, but sparing the subscapular nerves if possible; having cleared these, turn the mass inward and remove it by a cut along the base of the triangle; approximate the wound by a buried purse-string suture, including only the base of the triangular flap, whose apex is to be shifted to a lower portion, so as to secure a loose lining for the axilla, maintaining contact between the flap and subjacent tissues by carefully-applied dressings. No axillary drain need be employed, the uncovered portion of wound healing either by so-called organization of blood-clot or by granulation. Little or no disability is said to be noticeable after this operation, and what results comes from loss of skin, not loss of muscle, and can sometimes be rectified by skin-grafting.

Cysts.—The distinction must be made between these and *cystic tumors*—*i. e.* cystic degenerations of solid tumors—since all forms of mammary tumors may undergo such changes, even the carcinomata; but the adenomata and the sarcomata more frequently show these alterations.

Hydatid Cysts.—This is the only parasitic disease of the breast, and is of very rare occurrence. Only one cyst has ever been found at a time, but it may contain from one to four daughter cysts. Hydatid cysts grow slowly, attain a moderate size, are painless, forming smooth, round, firm, elastic, sometimes fluctuating, movable tumors, adherent neither to the skin nor to the chest-wall. They generally occur in the upper outer segment of the gland, but are never found near the nipple. From secondary changes the skin may become adherent or the axillary glands enlarged.

Diagnosis.—From other forms of cysts it will generally be impossible to distinguish a hydatid cyst except by the use of the exploring needle or trocar, thereby evacuating the characteristic watery fluid and perhaps daughter cysts

and hooklets. From a lacteal cyst it can readily be distinguished, because the latter appears *near* the nipple *during lactation*, and is prominent, and of rapid formation.

Galactoceles, or Milk Cysts.—These are rare, result from obstruction and dilatation of the milk-sinuses or ducts, and in consequence are situated close to the nipple or beneath the areola. Nearly always single, they appear suddenly during lactation, increase rapidly and form soft, fluctuating, painless swellings, sometimes pendulous, covered with unchanged skin containing enlarged veins: sometimes milk can be expressed from the nipple by pressure on the cysts. The contents may be unchanged milk, be like cream, or consist of a semi-solid, cheesy material, in which case the history generally shows that fluctuation was noted at the beginning, and that the tumor gradually became solid to the feel, and smaller; sometimes it can be indented by the finger.

Glandular Cysts.—While these may be single, they are commonly multiple, sometimes being disseminated throughout the gland. They originate in the smaller rather than in the larger ducts, and in the acini, from their partial or complete occlusion, the former being rather common, when their sero-sanguinolent contents may escape quite copiously from the nipple. The cysts vary in size from that of a pin's head to cavities which may contain many ounces, but are oftenest about an inch in diameter. Their interior is covered with a layer of epithelial cells, papillomatous ingrowths from which, at times, completely fill up the cyst-cavity. The contents may be yellowish serum or may be variously tinted red or brown from admixture of old or more recent blood.

Diagnosis.—They are prone to occur in patients from thirty-five to fifty years of age, are smooth in outline, and are somewhat elastic, but fluctuation is rarely detectable, the cysts when tensely filled being often mistaken for solid growths. This must be remembered in any case of suspected carcinoma when neither involvement of the skin nor adhesion to the deeper parts has taken place, since cysts occur at the same age, so that when in doubt the exploring needle or an incision should be resorted to before sacrificing the breast: the above points, with the absence of lymphatic glandular involvement and the slow, benign course, distinguish doubtful cases of cysts from malignant disease.

Cysts resulting from Degenerative Changes (Involution Cysts).—These mostly occur in women past the menopause, and are usually numerous, and so small as to escape detection. Occasionally one or more may enlarge, causing much embarrassment in diagnosticating them from carcinoma. No involvement of the skin, deeper structures, or lymphatics, however, is found: they pursue a slow, benign course, and exploratory incision will determine their nature.

Lymphatic Cysts.—Certain serous cysts which do not differ materially in their symptoms, course, and treatment from the glandular cysts have been ascribed by Birkett and others to accumulation of fluid in the connective-tissue lymph-spaces, and have therefore been termed "connective-tissue cysts" or "lymph-space cysts:" they are lined with endothelial plates instead of epithelial cells, and resemble—except for their contents—adventitious bursæ.

Diagnosis.—This has been sufficiently indicated in the description of each variety.

Treatment.—When thin-walled, incision, with antiseptic packing after wiping out the cavity with iodine tincture or deliquesced carbolic acid, will usually suffice. If thick-walled or numerous, excision of the diseased portion is indicated, and if the disseminated form exists, nothing short of amputation is worth considering.

Contusions of the Breast.—When the relation which traumatism bears

to the development of tumors in the female breast is considered, it will be recognized that these injuries should be carefully treated by rest, confining the arm to the chest or in a sling, and by evaporating anodyne applications, while any induration should be removed, if possible, by the frequent prolonged use of equal parts of compound iodine and belladonna ointments or mercurial ointment in combination with belladonna.

WOUNDS.—These require the treatment which would be adapted to similar injuries of other glands, remembering that if suppuration occurs it may extend throughout the cellular framework of the gland, producing widespread damage, so that antisepsis, proper drainage, and fixation of the mamma by properly applied bandages, and of the arm by confining it to the chest, are advisable.

DISEASES OF THE MALE BREAST.

Occasionally the gland becomes HYPERTROPHIED and functionally active, the result of frequent applications of a nursing child to the breast.

INFLAMMATION OF THE MALE BREAST.—This may result from injury, with any of the usual consequences of inflammation, but sometimes the glands at puberty become enlarged and tender irrespective of traumatism, these attacks perhaps recurring from time to time.

Treatment.—Anodyne applications and protection of the parts from friction, with such treatment as has been indicated for the inflamed female breast, should be instituted if suppuration is threatened or is present.

TUMORS.—These may be either benign or malignant, examples of nearly every variety of each having been observed. Of the former variety, cysts—even galactoceles—and fibromata are the most common. Spindle-celled sarcomata and scirrhous carcinomata are the usual varieties of malignant growths, carcinomata occurring in the proportion of about one male to forty-two females. These neoplasms pursue the same local and constitutional course as in the female.

Treatment.—This is precisely that recommended for the same affections occurring in women.

CHAPTER X.

SURGERY OF THE EYE.

IN a brief article on the surgery of the eye it will be impossible to include its anatomy, physiology, pathology, therapeutics, and the means of examination by instruments or glasses, or to do more than mention the causes that render a resort to surgical procedure necessary, and describe the various operations themselves. All reference to the diseases of the choroid and retina are omitted, as they belong rather to ophthalmic medicine than to surgery.

In clinical work eye cases may be briefly classified into (1) those due to constitutional disease, needing therapeutic treatment; (2) surgical, requiring operations; and (3) errors of refraction and accommodation, which necessitate the mechanical use of glasses of various kinds. We must limit ourselves here to the surgery alone, without reference to those diseases and refractive defects which exceptionally demand surgical interference.

A glance at the interesting and instructive table of Cohn,[1] compiled from the observation of 300,000 cases treated in 67 institutions, enables the student to grasp the relative frequency of the various diseases of the eye as they appeared in actual practice up to 1875. It may be well to observe, however, that the proportional number of errors of refraction and accommodation treated in our clinics and in private practice since then has greatly increased.

The frequency of constitutional disease as a cause is shown by the table of Magnus,[2] who found from a total of 2275 cases treated in his clinic that nearly 21 per cent. were dependent upon constitutional affections. This 21 per cent. is the field chiefly of the therapeutist, whilst to the correction of errors of refraction might be assigned perhaps 60 per cent. more, leaving 19 per cent. to the domain of surgery proper. The name and character of the operative procedures in this domain may be learned from the following table, abbreviated from reports of 54 institutions of Europe and America in the year 1884, showing a grand total of 48,324 major operations:

Table of 48,324 Operations on the Eye.

Operations for cataract, of all kinds	19,794	Operations on orbit	103
Iridectomies, iridotomies	13,617	Neurectomies	42
Cornea	1666	Sclerotomies	200
Conjunctiva	681—2,347	Extraction of foreign bodies from globe	40
Eyelids	4,606	Puncture of retina	66
Muscles	3,627	Extraction of cysticercus	14
Lachrymal apparatus	2,535		48,324
Enucleation	1,323		

We therefore find that 69 per cent. of the total number of operations were for the relief of cataract and affections of the iris. Corneal operations yield nearly 5 per cent.; operations on the lids, nearly 10 per cent.; those on the muscles, over 7 per cent.; those on the lachrymal apparatus, 5 per cent.; and enucleation of the ball, 2.5 per cent. This table gives the best possible idea of the relative frequency of these operations, and is a basis for the space given them here.

This division into three classes—namely, medical, surgical, and mechanical or refractive—and their relative importance are confirmed by the following report of 1000 consecutive cases recently treated at the Jefferson College Hospital:

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[1] *Cohn's Table of 300,000 Cases.*

Diseases of	Per cent.	Diseases of	Per cent.
Conjunctiva	30.	Corpus vitreum	0.7
Cornea	21.—51.	Globe	2.
Sclera	0.4	Refraction and accommodation	12.
Iris	6.	Muscles	3.
Choroid	1.	Fifth nerve	0.2
Glaucoma	1.	Lids	9.
Retina, optic nerve, amblyopia, amaurosis	5.	Unclassified	1.5
Lens	6.		100.00

[2] *Magnus's Table of 2275 Cases.*

Eye diseases arising from	Per cent.	Eye diseases arising from	Per cent.
Scrofula	16.79	Pregnancy and puerperal fever	.21
Measles	1.32	Diphtheria	.13
Syphilis	.61	Hysteria	.13
Cerebral disease	.52	Scarlet fever	.08
Tabes	.39	Typhoid fever	.04
Albuminuria	.21	Erysipelas	.04
Anemia	.21	Basedow's disease	.04
Tuberculosis	.21		20.93

1. Surgical	111, about 10 per cent.
2. Mechanical or refractive	590, about 60 per cent.
3. Medical	299, about 30 per cent.

It may aid the student's understanding of the subject to add that all defects of sight may be assigned to one of three main causes: (1) defects of transparency, (2) errors of refraction, or (3) lesions of the retina and of the optic nerve. And to remedy these defects we have to resort to surgical interference, to the correcting lens, or to therapeutic measures.

Disease of the appendages of the eye requires treatment, as does the attainment of binocular vision under certain conditions, but the divisions here given are of practical value for rapid diagnosis in teaching and in practice.

Owing to the limited space assigned, we must refer the student to standard works on the eye for information as to the medical and refractive portions of the subject, including a description of the instruments, materials, and apparatus needed for their diagnosis and treatment.

Operations on the eye and its appendages are undertaken to improve the personal appearance, to remove deformities which threaten the integrity of the eye, to relieve pain, to improve vision or prevent its loss, to restore sight, or even to save life itself.

A few general remarks, applicable to all operations, before proceeding to detailed description may prevent useless and confusing repetition. To this end it may be stated that the ophthalmic surgeon should see that the instruments in use are absolutely free from foreign and deleterious matter—that they are rendered aseptic by chemical agents which neither injure the steel nor irritate the delicate structures of the eye. Boiling water, absolute alcohol, a 5 per cent. solution of carbolic acid, a solution (1 : 5000) of corrosive sublimate, and a saturated solution of boric acid are practically useful for this purpose. Knives and needles should be sharp, and may be tested by piercing and cutting a piece of thin white kid held in the hand or in the drum found in most instrument-cases. Scissors should be sharp, and carefully adjusted to cut smoothly to their points.

A good light, natural or artificial, must be secured, from one side only, and care should be taken that no object is interposed between it and the part illuminated during the necessary manipulations. The head of the patient must be securely fixed on the chair, bed, or table by mechanical means or by the hands of an assistant.

General anesthesia is infrequently required, except in the young, in very nervous patients, or in cases where severe or long-continued operations are necessary. Cocaïne, in solution of from 2 to 5 per cent., placed in the conjunctival sac, has come into general use as a local anesthetic, and is usually effective for that purpose. It renders the conjunctiva and cornea entirely insensitive, and enables us to perform even an enucleation without suffering to the patient. It is very perishable in water, and should be dissolved in a solution of bichloride of mercury, 1 : 5000, to render it aseptic. There can be no discussion as to the necessity of antiseptics: the bichloride, in the strength of 1 : 5000, which can be quickly made by adding $\frac{1}{10}$ gr. to one ounce of water, is perhaps the best, and is well borne. The solution of the biniodide of mercury, with excess of iodide of potassium in water, from 1 : 5000 or 10,000, has been largely used with good results, but it is decomposed by a solution of cocaïne, and gives a white precipitate in the eye. It has the advantage, however, of being non-irritant, and may be used in a much stronger solution than the bichloride. The peroxide of hydrogen may supersede the bichloride solution, being efficient and non-irritating. It must be remembered that although the asepsis of the conjunctival sac may be secured, the inflam-

matory products of the eye or conjunctiva, particularly in cases of suppuration of the lachrymal apparatus, give good cause for anxiety, and may account for the occasional failures to get beneficial results. Many use a saturated solution of boric acid, which is entirely free from danger and can be used without fear of inducing local irritation. Before an operation is undertaken the conjunctival sac and surrounding tissues should be repeatedly cleansed with an antiseptic. If it is deemed requisite, the boric solution can be injected into the anterior chamber to wash it out completely in cataract extractions. If the pupil is to be dilated or the accommodation kept at rest, a solution of atropine or hyoscyamine, of the strength of 2 grains to the ounce, with a 1 : 5000 solution of the bichloride, may be dropped into the eye.

Dressings for the eye should be cool, light, and aseptic, applied over the lids, upon which a piece of linen dipped in cosmoline is first laid in such a manner as to prevent the entrance of light and to secure the eyes in a position of rest and immobility. A mild narcotic may be necessary to allay pain and secure sleep and to rest the ocular muscles. All operations on the eyeball requiring special skill and delicacy of touch should be practised on the eyes of pigs placed in an opthalmo-phantom or held in a towel by an assistant before undertaking them on the human subject.

PART I.—DISEASES AND INJURIES.

I.—DISEASES AND INJURIES OF THE EYELIDS.

Wounds, burns, inflammation, abscesses, erysipelas, eczema, herpes, warts, nævi, chancre, and other injuries and growths of various kinds, are met with in the lids, as elsewhere, and demand the same general treatment; but in operations upon the lids special care must be used to guard against the formation of cicatricial bands, which might leave deformities, limit the movements of the ball, and produce malposition of the lashes that would later on endanger the eye itself.

Blepharitis Marginalis (*Tinea Tarsi*) is a chronic pustular inflammation of the edges of the lids, commonly found in strumous children, extending into the hair-bulbs, causing loss of the lashes or turning them inward upon the cornea. In adults it is often the expression of an uncorrected ametropia, and needs careful adjustment of glasses. The lids should be thoroughly washed with an alkaline solution of borate of sodium, five grains to the ounce of water, then dried and anointed with a salve composed of two grains of the yellow oxide of mercury to a dram of vaseline. In severe cases a solution of nitrate of silver, five grains to the ounce, may be applied with a brush to the roots of the lashes. Tonics and nutrients to improve any existing dyscrasia may be given, and glasses to remove any eye-strain should be prescribed.

Hordeolum (*Stye*) is a circumscribed inflammation of the connective tissue near the edge of the lid, ending in suppuration. The inflammatory process is accompanied by general œdema of the lid, pain, and localized conjunctivitis.

Treatment.—Hot fomentations or poultices, with frequent washes of borax or boric acid in solution, and when suppuration has taken place a free incision and pressure to evacuate the sac. When a succession of styes occur, the general system should be built up by tonics, and the ametropia which is nearly always found in these aggravated cases should be relieved by correcting lenses.

Chalazion (*Tarsal Cyst*) is caused by obstruction in the duct of a Meibomian follicle, which produces an indolent tumor about the size of a pea near

the tarsal border. The tumor is not red nor painful unless suppuration occurs. Chalazia are single or multiple, and remain indefinitely if not removed.

Treatment.—Evert the lid, cocainize it, and search for a grayish-red spot which forms the base of the tumor. Incise the tumor through its base and press out the gray gelatinous material with the fingers or the handle of a knife. The wall of the empty sac should be cauterized with a solution of nitrate of silver, with a view to the obliteration of the cavity by adhesive inflammation. If preferred, the incision may be made through the skin, and the sac emptied and curetted. This simple operation is followed by a radical cure of the affection.

TRICHIASIS is an inversion of the lashes against the cornea, which is clouded and inflamed by their constant rubbing. DISTICHIASIS is the same condition, except that there appear to be two rows of lashes.

ENTROPION is a turning in against the ball of the free margin of the lid.

ECTROPION is an eversion of the lid. This condition causes an exposure of the conjunctival surface.

All these are ugly deformities, and are generally the result of long-continued, neglected inflammation of the conjunctiva or of adjoining tissues which cause a spasmodic contraction of the orbicularis muscle. They are most frequently met with in the upper lid. Ectropion also results from burns and wounds followed by cicatricial contraction. When local applications fail to give relief, the hairs may be removed with forceps for temporary relief, and if this fails the scalping of the lid to remove the hair-bulbs, or plastic operations to cause or correct eversion, must be employed; all of which will be more fully described under Operations.

ANKYLOBLEPHARON is the partial adhesion of the margins of the upper and lower lids, resulting in a partial or complete closure of the palpebral fissure.

SYMBLEPHARON is the partial or complete union of the conjunctiva of the lids and eyeball, and is generally of traumatic origin. This union of the conjunctival surfaces is by cicatricial bands left after burns by hot metal, quicklime, caustics, acids, etc. When the deformity is great, impaired movements of the ball and partial or entire loss of sight from insufficient separation of the lids may result. Either of these conditions would require division of the cicatricial bands by operation. To prevent the tendency of the divided bands to reunion, glass or metal shields should separate the divided surfaces during the process of healing. In extensive adhesions the lids should be dissected from the ball and the gap be filled in by the conjunctiva of a rabbit.

BLEPHAROSPASM is a tonic contraction or spasm of the orbicularis muscle which prevents the voluntary separation of the lids, and may continue for seconds, days, or weeks. It may be a manifestation of hysteria, or a reflex from far-distant organs, or be caused by irritation of the fifth nerve or of one of its branches; but it is most frequently caused by inflammation of the conjunctiva or cornea, in which photophobia is a marked symptom, by foreign bodies, by hyperesthesia of the retina, or by errors of refraction. Frequent twitching of the lids characterizes the affection when due to ametropia.

Treatment is directed to removal of the cause. Cocaïne, in 2 per cent. solution, frequently applied, will cause local anesthesia of the conjunctiva and thus relieve peripheral irritability. Mydriatics, atropine or hyoscyamine, will paralyze the ciliary muscle and suspend the power of accommodation, and for a temporary effect for the purpose of making an examination, particularly in children, the face may be momentarily immersed in cold water. When the disease is clearly dependent on neuralgia or pressure upon a branch of the fifth nerve, stretching or excision of the suspected nerve should be considered.

PTOSIS is a partial or complete inability to lift the upper lid, caused by swelling and increased weight of the lid, injury of the levator muscle, or paralysis of a branch of the third nerve or of its entire trunk: in this condition we must expect to find a divergent cast of the eyeball, a dilated pupil, and a want of accommodation, which would dispose us to look for some central lesion of, or pressure upon, the nerve innervating the part.

The **treatment** will be suggested by the discovery of the cause, and when it has been ascertained to be congenital or central, and there is no further hope of improvement from therapeutic agents, an operation becomes necessary. This consists in the removal of a portion of the palpebral integument or in bringing the lid under the control of the frontalis muscle by causing a subcutaneous cicatrix. Such a cicatrix is formed by passing a suture under the skin from the free margin of the lid to the edge of the frontalis muscle, and allowing it to cut its way out gradually.

COLOBOMA (Fig. 257) is a congenital fissure of the lid analogous to, and sometimes associated with, coloboma of the iris and choroid, hare-lip, cleft palate, etc.

EPICANTHUS is a congenital redundancy of the skin over the bridge of the nose, causing deformity by its concentric folds overlapping and concealing, more or less, the inner canthi. It is congenital, and usually disappears as the nose develops. It is removed by excision of the superfluous skin from the bridge of the nose.

ECCHYMOSIS ("black eye") is the effusion of blood into the loose cellular tissues of the orbital cavity, following a contused wound. The temporary and harmless disfigurement is lessened by the prompt use of ice compresses, evaporating lotions, and massage, all of which promote absorption.

INCISED, LACERATED, OR PUNCTURED WOUNDS, BURNS, etc. should be carefully cleansed of all foreign matter and dressed aseptically. The parts, when practicable, should be placed and held in their relative positions. Consequent deformities of the lids, cartilages, and lashes should be guarded against as far as possible.

PARALYSIS OF THE ORBICULARIS MUSCLE is the result of disease or of injury to the portio dura, or seventh nerve. This affection leaves the lids incompletely closed, and the eye is consequently exposed to external irritation. Tears escape over the cheek, and the patient has a staring look, called *lagophthalmos*, or *hare's eye*.

Treatment.—Electricity, antiseptic and sedative lotions, boric-acid and cocaïne solutions, bland ointments to the lids, and, if necessary, a light dressing to keep the lids in apposition and to exclude dust.

II.—DISEASES AND INJURIES OF THE LACHRYMAL APPARATUS.

EPIPHORA is the accumulation and overflow of tears from the inner canthus. This condition may arise from excessive secretion from the lachrymal gland itself, due to irritation or disease, or from reflex irritation in consequence of hyperemia or inflammation of the conjunctiva, resulting from ametropia. It is generally caused, however, by eversion of the puncta, so that the tears cannot enter them, or by obstruction in the canaliculi, sac, or duct through which the tears normally flow into the nose. The accumulation of the tears in the inner canthus and their overflow on the cheek cause constant irritation of the eye. The patient first observes this as an occasional symptom when exposed to the wind, but as the obstruction increases the overflow may become constant, and demand operation for its relief. This consists in open-

ing and probing the canaliculi and nasal ducts, and will be described under Operations.

Dacryo-cystitis (*Acute Inflammation of the Lachrymal Sac*) is one of the serious results of neglected epiphora in chronic disease of the ducts, in nasal catarrh, and in exposure to cold or injury. It is marked by tenderness, pain, and swelling and redness over the sac, the swelling extending to the lids. Unless relieved, the skin becomes thinner and the abscess bursts through it, leaving a fistulous opening into the sac. Warm fomentations should be used, the canals should be opened to give exit to any pus, and, if this is not enough, a free incision through the skin should be made into the sac, which should be kept open until the abscess has been completely drained. The canals should be slit open, and probes passed to restore the proper drainage into the nasal cavity, allowing the external incision to heal. A chronic fistula, if not relieved by early treatment, will ultimately demand the destruction of the lining membrane of the sac by free incisions and the application of caustics, the wound being allowed to heal by granulation from the bottom.

Chronic Inflammation of the Sac, or Mucocele.—This is the usual result of obstructions in the tear-passages from swelling of the mucous membrane or thickening of the submucous tissues or of the periosteum lining the bony canals below the sac. There are constant epiphora and irritation of the eye, swelling over the region of the sac, and an escape from the canals of a viscid mucus into the conjunctival sac upon pressure by the finger below the inner canthus. Unless relieved, the discharge becomes muco-purulent, and may give rise to severe conjunctivitis or result in acute suppuration of the sac. The drainage must be restored by opening the canals, passing probes, and freely injecting antiseptic and astringent washes. The treatment is often unsatisfactory and always prolonged, and in the end obliteration of the sac may become necessary. Should the epiphora continue in spite of these measures, the lachrymal gland should be extirpated.

III.—DISEASES AND INJURIES OF THE CONJUNCTIVA.

Hyperemia, or congestion of the mucous membrane, is recognized by these symptoms: a sandy, scratchy feeling, pain, increased lachrymation, photophobia, and spasmodic closure of the lids. There is redness of the membrane covering the lids and ball. It is caused by prolonged near use of the eyes in ametropia, or by exposure to excessive light, to wind, dust, smoke, or other external irritation. It will yield to applications of a solution of borax, gr. v to ℥j, or to a solution of boric acid, gr. v to ℥j. A 1 per cent. solution of cocaïne hydrochlorate may be frequently instilled, and the use of vaseline to the edges of the lids aids the treatment. Errors of refraction and muscular defects should be corrected when they are present.

Foreign Bodies on or in the conjunctiva give rise to severe irritations, and must be searched for by oblique illumination with the aid of a magnifying glass, and removed by the proper instruments. Anesthesia by cocaïne should be induced when the cornea is involved.

Burns with metal, hot water, irritant gases, lime, or acids demand the above remedies, aided by oil or vaseline and by one of the mydriatics. Care should be taken to prevent adhesions during the healing process.

Ecchymosis, from the rupture of one or more blood-vessels, may occur as a result of sneezing, or in whooping cough, or may be due to scurvy or to Bright's disease, and in the aged occurs without apparent cause. It requires little treatment, disappearing in a few days.

ŒDEMA of the conjunctiva is observed in Bright's disease, in debility from other chronic diseases, and in old age. It is a symptom of diagnostic value.

EMPHYSEMA of the conjunctiva may occur in injuries of the lachrymal sac or in fractures of the nasal bones. Simple washes and a pressure bandage constitute the treatment.

CONJUNCTIVITIS may, for convenience of description, be studied under several divisions which are not fixed, but run into one another in many cases: they are catarrhal, purulent (idiopathic and gonorrheal), croupous, diphtheritic, granular, follicular, and phlyctenular. The discharges are usually contagious, and must not be transferred to others by the patient or surgeon.

Catarrhal Conjunctivitis, the mildest form, often becomes epidemic and is known as "pink eye." It follows exposure to cold, injuries, and exanthematous diseases. Both eyes are generally affected. The pain and photophobia are not severe, but the patient complains of a sandy feeling, itching, a smarting sensation, and increased lachrymation. In severe cases there is a mucopurulent discharge which causes the lids to adhere in the morning. The conjunctiva of the ball is œdematous, and in severe cases rises above the level of the cornea, constituting the condition called *chemosis*. The blood-vessels are numerous and distended, and present a characteristic area of redness that is most marked at the junction of the palpebral and scleral conjunctivæ. The redness gradually shades off toward the cornea. If not treated by poultices, tea-leaves in water, and other domestic remedies, it runs its course in a few days.

The **treatment** is rest to the eyes without bandage, and the frequent instillation of a solution of borax or boric acid. A solution of the bichloride of mercury, 1 : 5000, or applications of a 1 per cent. solution of nitrate of silver to the everted lids, are indicated in severe cases. Some bland ointment should be freely applied to the lids at bedtime. The solution of silver should never reach the cornea, and it is best applied with a brush or with absorbent cotton on a match, the upper lid being everted and the lower depressed and held so that the two lids shall be in contact over the cornea. The solution is then applied slowly, and the lids held in position until the silver has been neutralized by its action upon the tissues and fluids of the lids. The application is then wiped off with a piece of absorbent cotton saturated by a weak solution of boric acid. Should the condition become, as it often does, chronic, the refraction must be tested and glasses given when required. A smooth crystal of alum passed over the inflamed surface every day is very effective in some cases. Solutions of sulphate of zinc, one or two grains to the ounce, are useful, or, if a vegetable astringent is needed, one to two drams of tannic acid to the ounce of glycerin may be employed.

Purulent Conjunctivitis is recognized by the appearance of a free purulent discharge with great swelling of the lids and chemosis. It is generally the result of infection from gonorrheal or other contagious matter. Its dangers cannot be over-estimated, and every precaution should be employed to confine it to the eye primarily affected and to prevent its transmission to others. In gonorrheal ophthalmia one or both eyes are frequently lost, and the blind from ophthalmia neonatorum are said to furnish in some countries 40 per cent. of the inmates of blind asylums. The gonorrheal variety is the most severe. Blindness results from extensive ulceration of the cornea due to interference with its nutrition by chemosis and inflammatory new formations at its juncture with the conjunctiva. Its progress is rapid: a perforating ulcer, involving the entire cornea, may develop in a few days.

The **diagnosis** is generally easily made from the history, the swelling of the lids and conjunctiva, and the profuse discharge of pus.

Treatment.—When one eye alone is affected the greatest care should be taken to close hermetically the other. Ice in a rubber bag should be kept on the lids, and hot-water applications should be used every hour or two. A 2 per cent. solution of nitrate of silver should be carefully applied once a day to the entire conjunctival surface. Cleanliness must be attained by the introduction every hour of an antiseptic wash, such as boric acid, biborate of sodium, or a solution of bichloride of mercury, 1 : 5000. A pipette may be employed for this purpose. Great relief from pain is obtained by freely pouring vaseline, pure or medicated with boric acid, between the lids. The patient should remain in bed, should take some saline cathartic, and if depressed full doses of quinine and iron should be given. Narcotics may be required to secure sleep and freedom from pain. The cornea must be carefully watched from day to day: atropine is employed to paralyze the ciliary muscle, and leeches are applied to diminish localized congestion. The surgeon's care should be unremitting throughout the attack. When the case is not properly treated at the early period or is treated without due comprehension of its gravity, sloughing or a perforating ulcer of the cornea is inevitable, with prolapse of the iris. Anterior synechia, anterior staphyloma, and hopeless blindness are among the probable consequences of the disease.

Ophthalmia Neonatorum is due to the infection of the eyes at birth by the purulent discharges from the mother's vagina. It is generally binocular, and is recognized by swelling and redness of the lids, which are closed, and by the escape of purulent matter when they are opened. It is often lightly regarded and inefficiently treated, with the result, in the gonorrheal variety, of perforation of the cornea and entire loss of vision. The treatment, as far as possible, is the same as that employed in the form just described. The application of a silver solution should be carefully made with the aid of lid-retractors, and frequent antiseptic washings insisted upon. Prophylaxis is of supreme importance. Credé was the first to endeavor to prevent a disease thus dangerous to sight. He has reduced the proportion of cases in his lying-in hospital from 9 to 0.5 per cent. by using vaginal injections before birth, by washing the lids and eyes of the new-born child with a 1 : 5000 solution of the bichloride, and by dropping into the conjunctival sac a 2 per cent. solution of the nitrate of silver. Silver in this strength is a most efficient germicide, and probably acts by destroying the superficial layer of the epithelium of the conjunctiva and the gonococci contained in it. Were these precautions observed in all cases of confinement, this disease would be rarely encountered.

Croupous Conjunctivitis is purulent in character, a grayish and slightly adherent exudation forming on the mucous surface of the lids. Bleeding occurs when the croupous membrane is removed, and this procedure, together with frequent hot-water bathing, constitutes the treatment.

Diphtheritic Conjunctivitis presents a firm, fibrinous exudation not easily detached from the conjunctiva, with brawny, stiffened, and swollen lids. It is generally destructive to sight from perforation and destruction of the cornea. It requires the same vigorous local treatment as the other forms of purulent conjunctivitis. Hot applications are, however, specially indicated, and the treatment proper to its dyscrasia should not be ignored.

Trachoma (*Granular or Follicular Conjunctivitis*) is an inflammation of the palpebral conjunctiva, characterized by the appearance at the retrotarsal folds of translucent granular masses beneath the conjunctiva, with vascularity and thickening. In appearance they resemble boiled sago-grains, but are not

to be confounded with the swelling of the papillæ usually called "granular lids," nor with the large papillary granulations left after a neglected purulent conjunctivitis. The disease is infectious, and may be transmitted by towels or other means of contact. It is, moreover, pre-eminently a disease of the poor. It spreads among people who are crowded together, eat poor food, breathe vitiated air, and are insufficiently clad. Its tendency is not to a cure. The cornea does not slough or perforate, but sight is partially or entirely destroyed by cloudiness or pannus induced by a rubbing of the cornea by the granular lids. The individual granules should be crushed with forceps made for the purpose, or they may be treated by electrolysis, by the galvanic cautery, or by incision and pressure to extrude their contents. They require also the daily application of astringents—namely, solutions of silver nitrate, glycerole of tannin, zinc sulphate—or they may be touched with crystals of copper sulphate or alum. A solution of mercuric chloride, 1 : 5000, may be used three times daily to cleanse the sac, and an ointment of vaseline with calomel, or yellow oxide of mercury 2 per cent., may be used in the sac at night. Trachoma is a very chronic affection, and may demand continuous treatment for weeks, months, or years.

Pannus is a sequel of trachoma caused by the friction of the cornea by granular lids, roughened by cicatricial contractions and sometimes by inversions of the lashes. It is essentially a keratitis from irritation, and is recognized by extension over the cornea of fine blood-vessels from the limbus toward its center. It may disappear with proper treatment. If not, the operation of peritomy, or exsection of a narrow band of conjunctiva with its vessels, just outside of the limbus, may be tried. These corneal vessels are obliterated by a severe purulent inflammation, and to induce this it was formerly the custom of some ophthalmic surgeons to drop into the eye the pus of ophthalmia neonatorum or to bathe the eyes with an infusion of jequirity beans for a few days. This treatment has been abandoned.

Phlyctenular Conjunctivitis, or *Strumous Ophthalmia* as it is sometimes called, is recognized by the appearance of one or more small grayish-red elevations, surmounted by a serous vesicle which bursts and leaves a small ulcer, which becomes the center of a congeries of blood-vessels. They are usually found at the limbus of the cornea, and sometimes encircle it. They frequently appear on the cornea, giving rise to phlyctenular keratitis and corneal ulcer, causing severe pain, photophobia, and lachrymation. Sight is impaired only when the ulcer is near the center of the cornea. It is the most frequently observed form of conjunctivitis in our public clinics and in children who live in badly-ventilated houses and are deprived of proper food. When on the conjunctiva these vesicles run their course in about a week; they last much longer on the cornea. Frequent relapses are the rule. Extreme dread of light, lachrymation, and a burning pain in the part are the chief attendant symptoms.

One of the names, strumous ophthalmia, suggests the **treatment** most urgently needed, without which local applications do little good. Tonics, such as cod-liver oil, the phosphates, iron, nutritious aliment, salt baths, friction of the skin, exposure to the sun and air, and free ventilation of the sleeping-room, will tend to remove the dyscrasia. The use of a mydriatic and cocaïne will alleviate the photophobia and aid in arresting the spasmodic closure of the lids. A wash of mercuric chloride, 1 : 5000, may be used with the mydriatic several times a day. Dusting the everted lids with finely-levigated calomel or introducing the yellow oxide of mercury in an ointment made with vaseline is almost a specific for the local manifestations. Atropine 1 part, calomel 20

parts, vaseline 200 parts, may be introduced into the opening of the lids with a brush several times daily.

Pterygium (Fig. 398) is an hypertrophied condition of the conjunctiva, usually found at the inner corner of the palpebral fissure, sometimes at the outer. It is vascular, with a base toward the periphery of the eye, and its apex points and grows toward the center of the cornea. It is found most frequently in persons habitually exposed to wind and cold, such as sailors and farmers, or it may be one of the expressions of an error of refraction. It is of slow growth, gives little trouble, and requires no treatment until its apex has so encroached upon the clear cornea as to impair vision. Operation is then needed, which will be described under the proper head.

Pinguecula is a small yellowish tumor of fatty appearance seated in the conjunctiva near the corneal margin, consisting of hypertrophied conjunctiva and epithelium. It is rounded, circumscribed, and harmless, but may be excised if desired.

Lupus of the conjunctiva occurs as an extension of this disease from the skin of the lids, and appears as an ulceration of the conjunctiva, covered with small red granulations which bleed upon the slightest touch. The patch may heal spontaneously in one place while it extends in another. We now know that lupus is really a tubercular disease, that its diagnosis may and ought to be determined by finding in the discharges from the ulcer the peculiar bacillus of phthisis, and that energetic treatment is required to prevent its extension to other parts of the body. The treatment is to scrape the ulcer with a sharp spoon and to apply the actual cautery.

Dermoid Tumors are small growths, like skin in structure, yellowish in color, seated at the margin of the cornea, and supporting a growth of fine hairs. They require excision.

Epitheliomata and Syphilitic Ulcers may occur in the conjunctiva, and require the same careful diagnosis and treatment here as elsewhere.

IV.—DISEASES AND INJURIES OF THE CORNEA.

Injuries and Wounds are to be carefully studied, on account of their great frequency and variety, and because they tend to leave permanent traces in the form of cicatrices and opacities, and in altered curvature of the cornea, causing astigmatism with more or less loss of vision. Wounds from chemical agents, burns, etc. have been described under Conjunctivitis, and their treatment indicated.

Contused, lacerated, or punctured wounds are dangerous in proportion to their extent and to the probability of the introduction of pyogenic matter with the agents which cause them. Even so slight an injury as the scratch of a finger-nail may give rise to severe purulent keratitis from the introduction of pyogenic micro-organisms into the epithelial lesion. They therefore demand thorough antiseptic dressing. Solution of blue pyoktanin has been used with good results in these cases. It is non-irritating, and by its staining qualities enables the observer to judge how far it has penetrated the tissues. Rest to the iris and ciliary muscles must then be obtained by a mydriatic: the lids should be kept quiet by a knitted compress of black yarn, which will restrain motion and exclude light, placed over sufficient antiseptic cotton to fill the orbit, the lids having been freely anointed with vaseline to prevent adhesion of the dressing.

Foreign Bodies are frequent complications of these wounds, and must be sought for by oblique illumination with a lens or mirror, the vision of the

surgeon being aided by a convex lens. The part should be anesthetized by cocaine, the lids everted, and the foreign body removed. It may be necessary to separate the lids with a speculum, and, in removing foreign bodies from the globe, to control the movements of the eye with fixation forceps. The condition of the patient is of importance, and the presence of constitutional disease may seriously complicate these wounds. A small cinder from a locomotive has been known to cause in the cornea of a syphilitic patient a serious and protracted suppurative keratitis that required prolonged and local constitutional treatment, and left behind a scar, with astigmatism to impair vision. Pyogenic organisms may find their way into the eye in an injury of this kind not properly treated, and start a purulent keratitis and iritis which may eventuate in a panophthalmitis and entire loss of vision in the eye primarily affected, and in the other eye through sympathetic ophthalmia.

NEBULA, MACULA, LEUCOMA, are terms used to indicate varying degrees of corneal opacity following local injury or constitutional dyscrasia. The first term is used for very slight opacities discoverable only by oblique illumination. Macula is a more decided opacity, recognizable by daylight, and leucoma is a densely white opacity, the result of deep-seated and destructive inflammation of the cornea. In the early stages irritation by levigated calomel, massage, and applications of hot water may do some good, but later on treatment is unavailing. Nebulous patients are often myopic, which may be due to the strain to which such eyes are subjected in prolonged near use. Special glasses, with astigmatic and stenopaic corrections, are often of great service in clearing up the vision and in giving the power to read or to do other kinds of near work.

Tattooing has been found of much value in leucoma to reduce the color of the entire scar or to blacken a central portion to resemble the pupil. It is done with a grooved needle carried well into the tissue, a paste of fine India ink being used. The part is previously rendered insensitive by cocaine. These cases often admit of good vision through an artificial pupil where a portion of the cornea remains transparent. Where the entire cornea is opaque, hopes have been entertained of restoring sight by the transplantation, by the aid of a trephine, of a piece of the cornea of a rabbit: Von Hippel has labored for years at this problem, but with incomplete success, since the portion of rabbit's cornea, although becoming adherent, often loses its transparency in a few days, and is then as densely opaque as the leucoma itself. The consideration here given to the various forms of traumatic keratitis and their sequelæ will apply to much that follows in the treatment of keratitis of idiopathic origin.

KERATITIS, or INFLAMMATION OF THE CORNEA, is distinguished from conjunctivitis by the situation and degree of the redness. The cornea gets its nutrition from vessels not in its own substance, but which lie in the conjunctiva at its border, and which are usually invisible. During an attack of keratitis these vessels become enlarged and constitute the "circumcorneal zone," pink in color, shading off toward the equator of the ball, and most intense at or near the corneal edge. This zone is composed of small vessels not movable with the conjunctiva, and not much changed in hue by pressure with the tip of the finger. This zone of redness is found in cases of iritis and cyclitis, and should always be recognized, and distinguished from the brighter redness of the conjunctival vessels, which are movable, larger, and more numerous as they recede from the cornea in conjunctivitis. The patient complains of a deep-seated pain in the affected eye, and dreads exposure to light and air. Spasm of the lids and profuse lachrymation are prominent symptoms. The corneal surface may be dulled from infiltration and give imperfect reflections. It has a grayish look by oblique light, and may be enough wanting in trans-

parency to veil the details of the iris or of the fundus in the ophthalmoscopic examination. Parts or the whole of the cornea may become turbid and swollen by cellular infiltration of its tissue, caused, as we now believe, by the presence of certain known or unknown micro-organisms, among them gonococcus, the staphylococcus pyogenes, and other forms yet undescribed. The infiltration is recognized by its opacity and the dulness of the tissue about it. The layers of the cornea break down, the epithelium comes away, and an ulcer forms, with or without suppuration. In some cases the ulcer has a tendency to spread, in others to go deeply inward. Some of these ulcers are easily controlled, others are intractable and almost incurable; in fact, they present great variety in their pathological aspects. Irritants and local stimulants are contraindicated, and would be as harmful here as they are useful in conjunctivitis. Rest, a light compress to keep the lids closed, atropine, cold applications, or, if it is found more grateful, frequent bathing with hot water, may be substituted; leeching and such constitutional treatment as the case may require must be resorted to.

Phlyctenular Keratitis has been partly described under the head of Strumous Ophthalmia, and is recognized by the appearance of minute vesicles on the corneal surface, singly or in groups, which burst and leave small ulcers. The pain and photophobia are out of all proportion to the amount of diseased tissue; the discharges irritate and excoriate the parts over which they flow, and the general health, the predisposing cause of the disorder, is still further reduced by the pain, loss of sleep, and confinement. The treatment is fully described under Phlyctenular Conjunctivitis.

Simple or Non-suppurating Ulcer may be due to injury, to conjunctivitis, to disease or injury involving the ophthalmic branch of the fifth nerve, to impaired nutrition, to old age, to starvation, to exhausting fevers, and to malarial poisoning. In these cases it often follows a neglected inflammation of the lachrymal sac. It may be recognized at once by inspection. The edges of the growing ulcer may be transparent, but in healing considerable opacity is observed. This lessens as the material with which the ulcer is filled up becomes more or less similar to true corneal tissue.

Ulcer from Herpes Zoster is found during or after an attack of ophthalmic or frontal herpes which may have been confounded with erysipelas, and is more likely to follow when the skin of the nose is affected. A group of vesicles occurs on the cornea, but is seldom observed until discovered by the surgeon. There may be some anesthesia of the cornea, as in neuro-paralytic disease.

The **treatment** demanded is cocaïne, disinfection, dusting the eye with calomel, brushing it with a camel's-hair pencil wet with a solution of boric acid, and the use of atropine and warm fomentations. Herpes of the cornea can be confounded only with phlyctenular keratitis. In the latter the cornea may become vascular—in herpes, never. The first is seldom seen before puberty, the latter is a disease of childhood.

Neuro-paralytic Keratitis is seen in cases of paralysis of the ophthalmic branch of the fifth nerve as a purulent infiltration and ulceration of the cornea. It is recognized by the complete absence of sensation in the eyeball and parts supplied by this nerve. Formerly supposed to be due to the lesion of the nerve-trunk, it is now known to be caused by the want of sensation and the resulting irritation of dust and other foreign bodies which remain in the eye and are not removed by reflex motions of the lids.

The **treatment** consists in protective dressings to close the lids or in the use of sutures to keep them closed.

Any of these ulcers may be complicated with *onyx*, which is a collection

of pus in the layers of the cornea at its lower border, or with *hypopyon*, which is the name given to a collection of pus in the anterior chamber, indicating not only that pus has found its way thither from the cornea, but also that the iris has become involved and has given rise to this product of inflammation. The ulcer may also penetrate deeply and perforate the cornea, cause a *prolapse of the iris*, and eventuate in a partial or complete *staphyloma* of the cornea (p. 1054). In these cases nature should be forestalled, and a paracentesis made through the floor of the ulcer with a broad needle, narrow knife, or keratome without delay. Through this linear cut the aqueous humor escapes, the tension is diminished, and the iris does not prolapse, as it would through the extensive perforation that would otherwise occur. If it is desired, this opening can be re-established each day with a probe. Atropine or eserine may be instilled to dilate or contract the pupil, according as the perforation in the cornea is central or peripheral, in order to prevent the adhesion between the iris and the cornea that would otherwise take place. If adhesion has already occurred and the iris prolapses, it should be excised at the bottom of the ulcer by scissors or knife, and the excision repeated as often as may be required to preserve that portion of the cornea not involved in the ulcer from damage by an increase of the staphyloma. Atropine, bandages, and hot fomentations are the main resources in corneal ulcers. The iris is so generally involved that we must remember the value of atropine in keeping the pupil dilated and the accommodation paralyzed. The bandage is imperative, and must be applied so as to exert an equable pressure over the eyeball sufficient to restrain the involuntary contractions of the lids. Hot fomentations stimulate the tissue-changes in the cornea and promote the healing processes. They may be applied by placing a compress of lint dipped in water of 120° F. over the eye, frequently renewed, for half an hour at a time, and repeated every three hours. As an antiseptic finely-powdered iodoform may be dusted on the floor of the ulcer.

Ulcus Serpens, or Saemisch's Ulcer, is a suppurating ulcer with gray infiltrated margin and base. It may originate from a simple ulcer, from an abscess, or as a point of pyogenic infection. It has a strong tendency to perforation, suppuration of the deeper tissues, and destruction of the eyeball. Saemisch advises incision through the base of the ulcer with a Graefe knife, entered two millimeters from its margin and brought out at the same distance from its base on the other side, the cut then being made complete from within outward. This gives exit to any pus in the anterior chamber. The actual cautery or the galvano-cautery may be applied to the diseased surface with a view to its complete disinfection, or the softened tissue should be carefully scraped away with a corneal spud, and the ulcer then thoroughly washed with a solution of bichloride daily until the tendency to suppuration has disappeared. At short intervals a 1 : 5000 solution of mercuric chloride, with atropine, hot fomentations, and, if necessary, a retentive bandage, should be used.

Abscess of the Cornea is a collection of pus within the cornea tending to great destruction of tissue. It may undergo a partial caseation and give rise to permanent opacity. It should be treated by incisions, crucial, if need be, and free evacuation of the pus, the after-treatment being the same as for a suppurating ulcer.

Interstitial Keratitis is a chronic, non-suppurating inflammation of the substance of the cornea, with exudation enough to cause an opacity similar to that of ground glass. It begins at the margin, extends to the center, and clears up first at the margin. Its course is very slow. It may exist for years. The cornea may become vascular and iritis develop as a complication. It may be due to malnutrition, but is usually the expression of *inherited syphilis*, and

is accompanied in that case by deformities of the teeth described by Hutchinson. It is a disease of the young, attacking persons between the ages of five and fifteen years, and most frequently girls. The treatment must be addressed to a cure of the inherited condition. Locally, hot fomentations to the eyes, the use of atropine, massage, and the ointment of yellow oxide of mercury to stimulate the absorbents and carry off the exudation, are serviceable. A tonic and invigorating routine of life should be instituted, and iron, cod-liver oil, and specific inunctions of mercury continued for weeks or months. Under this treatment the cornea may be restored to normal transparency and the sight regained.

Conical Cornea is a staphylomatous protrusion of the cornea, without inflammation or want of transparency, coming on very slowly, and when not congenital probably caused by prolonged near use of the eyes. The sight is impaired by the high myopia and astigmatism thus induced. Spherical concave glasses do little good. Stenopaic slits are occasionally found to improve vision. Sometimes the best results are attained by high convex cylinders. The operative treatment comprises iridectomy, iridodesis, trephining the cornea, and Graefe's operation, which consists in cutting a flap from the apex of the cone and cauterizing the divided edges of the cornea with silver nitrate. By this operation a shrinking cicatrix is produced and the refraction of the eye is lessened.

V.—DISEASES AND INJURIES OF THE SCLEROTIC.

Wounds of the sclerotic are serious in proportion to the implication of other tissue. Small, clean cuts heal readily when closed with fine sutures. Where the choroid, retina, and vitreous tumor protrude, the presenting hernia should be cleanly divided by scissors, the wound closed by sutures, and antiseptic applications made.

Scleritis or Episcleritis is an inflammation of the sclera characterized by patches of dark-red hyperemia, generally near the corneal border. It is usually seen in women whose health has been impaired by nursing or who have a marked rheumatic diathesis. There is no tendency to suppuration, but the disease is very chronic, is prone to recur, and may cause attenuation of the sclera and bulging of it and of the choroid.

The treatment should be directed to the general system and to a cure of the probable rheumatic taint. Syphilis is a possible cause of the disease, and should be considered in the treatment. All irritants must be avoided, atropine must be used twice a day, and the eyeball should be bathed frequently with hot water and subjected to massage.

VI.—DISEASES AND INJURIES OF THE UVEAL TRACT, IRIS, CILIARY BODY, AND CHOROID.

The iris, ciliary body, and choroid are histologically one tissue; their blood-supply and nerve-innervation the same; they form one of the continuous coats of the eyeball, and their pathology is so similar that injuries and wounds of one are likely to inflame the others. Constitutional diseases, such as rheumatism, syphilis, septicemia, typhoid fever, pneumonia, and the recurrent fevers, are often predisposing causes in destructive inflammation of this tract. Inflammation of these parts goes on to suppuration, and sympathetic transference to the other eye is not an uncommon occurrence—a fact it is well to keep in mind. Their histological classification as one tissue aids us in their study and treatment, whether local or constitutional, and enables us to anticipate the changes in this situation—namely, lesions of transparency from adhesions of the iris to

the lens capsule, opacities in the vitreous, separation of the retina, atrophy of the optic nerve, atrophy of the choroid, and the destructive suppuration of the ball called panophthalmitis. For systematic consideration we shall describe the lesions of each part separately.

IRIS.—A simple wound of the iris will usually heal readily unless complicated by infection from some penetrating body, when iritis may follow. If the foreign body be lodged in the iris, it should be removed by means of an iridectomy. If the iris prolapse through the wound, it should be excised, the eye placed under the influence of a mydriatic, and a bandage applied.

IRITIS.—Inflammation of the iris is caused by injuries, exposure to cold, rheumatism, gonorrhea, syphilis, and extension of disease from other parts. The objective symptoms are the pericorneal zone of vascularity, changes in color and structure of its texture, and the sluggish reaction to light of the iris. The subjective symptoms are the neuralgic pain over the brow and down the nose, following the distribution of the supra- and infraorbital branches of the fifth nerve, usually worse at night; occasional photophobia and lachrymation, since the conjunctiva is usually involved; and impaired vision from the clouding of the media by exudation. The danger to vision is from adhesions between the margin of the pupil and the anterior capsule of the lens, and the formation of opacities of various degrees of density in the pupil itself.

These well-recognized and incidental results will suggest the most important feature of the treatment *imperative in all cases of iritis*, and that is the use of mydriatics (atropine, hyoscyamine, duboisine, etc.) in strong and repeated doses until the pupil has been dilated, and thus removed from its dangerous contact with the convex surface of the lens capsule. This result is aided by hot-water applications. To neglect these drugs, or to fail to distinguish between a plastic iritis and conjunctivitis, is to pave the way for a recurrence of the inflammation with all its dangers, and to leave the eye exposed to an attack of secondary glaucoma at some future period. The implication of the iris is suspected by the sluggish reaction of the pupil to light, but a mydriatic alone gives us a positive diagnosis, and its use generally reveals one or more adhesions at the border of the pupil which cause it to present an oval or distorted appearance. Not only is the diagnosis thus confirmed, but the necessity for further mydriasis is clearly indicated. The atropine is used in a 1 per cent. solution, one drop of which should be instilled into the eye every fifteen minutes until six drops have been used, taking care by pressure over the tear-ducts to avoid as far as possible the passage of the drug into the nose, from which it would be absorbed, producing constitutional symptoms. A dry mouth and perhaps slight narcosis or delirium may result. If the full opening of the pupil can be restored and maintained by several applications of the mydriatic daily, there need be little apprehension felt for the future of the case. But grave anxiety must be felt when the adhesion has been found complete and the pupil remains unchanged under repeated instillations of the mydriatic. Hot fomentations are indicated. Leeches also are of great value.

Swanzy says that more than 50 per cent. of cases of iritis depend upon syphilis, and a large portion of the remainder upon rheumatism. And this vital truth guides us in the removal of the cause. Mercurial inunctions or proper doses of this specific internally, followed by or combined with potassium iodide, and in the rheumatic cases with salicylate of sodium, 20 grains every two hours, until tinnitus aurium has been produced or the neuralgic pain of the iritis abated, are the agencies used. The main stay is the mydriatic. One drop of a 1 per cent. solution contains $\frac{1}{100}$ of a grain. This may be placed in the eye and repeated six times at short intervals. The endeavor to tear away adhesions

by these doses may easily cause fulness of the head, headache, deep sleep, delirium, and coma, in which case the physiological antidote, morphia, in sufficient doses should be given. This treatment should be employed first, and if it succeeds in partly or fully freeing the pupil the instillations may be continued twice daily until the inflammation subsides and the eye is free from pain.

The general practitioner must be cautioned against the use of atropine in this and all other affections of the eye in persons beyond forty years of age, since it has a tendency to increase the tension and cause glaucomatous hardness and consequent loss of sight. Ophthalmic surgeons know very well that atropine is ordered in almost all eye-washes by the general practitioner, and its power to convert a mild conjunctivitis into a furious fulminating glaucoma, demanding immediate iridectomy and often resulting in loss of sight, should be pointed out with clearness. If great increase of tension follows the use of atropine and continues for two or three days, paracentesis of the cornea, done by passing a Graefe knife or broad needle obliquely through the cornea and allowing the aqueous humor to escape slowly, is legitimate. Eserine may be used previous to the operation to counteract the effects of atropine and reduce tension. In rheumatic and syphilitic iritis the disease generally attacks both eyes simultaneously, and thus aids in the diagnosis, while increasing, of course, the danger. The duration of the disease may be from ten days to many months, with relapses where the dyscrasia has not been removed or where synechiæ have occurred, and where errors of refraction remain unrecognized and uncorrected.

Should the whole uveal tract become involved, we have what is called an *irido-cyclitis*, indicated by great tenderness upon pressure over the ciliary region; and *irido-choroiditis*, when the symptoms already described are aggravated by a clouding of the vitreous and a contraction of the visual field. When the cornea is also implicated, we have *kerato-iritis*, with further loss of vision caused by exudation into the corneal tissue.

The **treatment** is the same: rest, hot-water fomentations, mydriatics, cocaïne, leeches, and dry warmth, with frequent antiseptic washes to the conjunctival sac and anodynes to secure rest. Mercury to the border of salivation should be given, irrespective of syphilis, and followed or accompanied by iodide of potassium. If the eye recovers without being lost by suppuration or by panophthalmitis, the vision may be much reduced from partial or total occlusion of the pupil. After the active stage has passed there is hope of great improvement by an operation for artificial pupil, which will be described under Operations.

The CHOROID, when involved with the rest of the uveal tract, is prone to suppurate, and to give the final blow to all hope of recovery by causing finally the condition known as *panophthalmitis*. It then becomes necessary for the surgeon to enucleate the ball or what remains of it, in order to avert extension of septic material into the sound eye and its loss by sympathetic inflammation. Before the days of antisepsis this condition used to be a too frequent result of cataract operations, and it often followed cuts and penetrating wounds with or without foreign bodies. Disease of the choroid is often met with as a metastasis of typhus fever, cerebro-spinal meningitis, pneumonia, and puerperal and other septic fevers. The pathological appearances are unmistakable: the lids are swollen and closed; the conjunctiva is red and œdematous; the cornea is cloudy; the anterior chamber is shallow, with pus in it; the pupil is occluded with lymph; the ball is tender and painful; and the tension is much increased. Atropine and hot poultices to favor suppuration, paracentesis, and a free opening to give exit to pus, constitute the treatment.

TUMORS OF THE CHOROID are not infrequent; they are usually sarcomatous and pigmented, and are recognized in their early period by the resulting scotoma and by the ophthalmoscope. They warrant early enucleation of the ball to avoid otherwise certain death from transmission of the disease to the brain or other internal organs.

SYMPATHETIC OPHTHALMITIS is a possible and too frequent sequel to suppurative or septic inflammations in the uveal tract. It is an inflammation of one eye induced by incised, punctured, or gunshot wound in the other eye. The suppuration of the uveal tract in this, the *exciting eye*, causes in the other, the *sympathizing eye*, a plastic, purulent irido-cyclitis and choroiditis, insidious in its early stages and terminating usually in entire blindness. Formerly it was thought that this was due to a reflex irritation carried from one ball to the other by the ciliary nerves, but the present view is that it is due to septic matter and micro-organisms capable of exciting destructive inflammation, as the staphylococcus pyogenes aureus or albus, which find their way from the diseased ball by its lymph-channels to the optic commissure, and thence to the other ball. Thomson has had an opportunity to confirm this view in a recent case of irido-choroiditis in the exciting eye. The first sign of disease in the eye secondarily affected was a papillitis, or inflammation of the optic nerve, which was well recognized by the ophthalmoscope, and which gradually extended to the choroid, ciliary body, and iris, and eventually destroyed the sight. This is one of the grave results of cataract extraction when inflammation has caused a loss of the eyeball operated upon; later on, sympathetic inflammation, with entire loss of sight, may occur in the other eye. All surgeons of large experience witness these cases, and to avert them use the most thorough antiseptic precautions in operations, and carefully avoid injury of the ciliary region in making their incisions. It must be remembered that frank cases of purulent ophthalmitis, with extensive suppuration, disorganization of the ball, and free discharge, seldom cause sympathetic inflammation. The conditions necessary for its production seem to be perforation of the ball, entrance of septic matter, chronic, long-continued inflammation without free egress of its products, and retention of foreign bodies. Tenderness on pressure over the ciliary body of the *exciting eye* should suggest the possibility of sympathetic inflammation. The possible period of appearance of irido-cyclitis in the *sympathizing eye* is from two weeks to twenty years; the usual one is six weeks. The prognosis is most grave, the sympathizing eye seldom retaining any useful vision after an attack.

Treatment.—All wounds or perforations must be treated by careful and repeated use of the proper antiseptics, and by the removal of foreign bodies whenever possible. Abadie advises injection into the globe of the injured eye, if inflammation becomes severe, of a few drops of the solution of bichloride, 1 : 1000, and, where the second eye has become affected, of the same solution into the vitreous humor, which he affirms checks the process and ameliorates the course of the sympathetic ophthalmitis. The only measure now generally admitted to be competent as a prophylaxis, when done early enough, is the removal of the injured or exciting eyeball or its entire evisceration; and the question as to the proper time for enucleation requires the nicest judgment on the part of the surgeon. It is, moreover, not easy to gain the patient's consent to the loss of an eye in which the vision may be fairly good. But enucleation should be done at once upon an eyeball that has been so injured as to render loss of sight almost certain, more particularly if irido-cyclitis has commenced, and without hesitation when a foreign body is lodged in the eye and cannot be extracted. An eyeball with irido-cyclitis is tender on pressure, painful, and dangerous to its fellow. It should be enucleated at

once if vision is lost. When the sympathizing eye is affected, the exciting eye should be removed unless it retains a fair amount of vision, for in such cases the exciting eye sometimes proves to be the better in the end. When inflammation has unmistakably appeared in the second eye, all the means to combat the plastic iritis and other complications must be used, such as rest for days in a darkened room, leeches, hot fomentations, atropine, and a tonic but non-stimulating regimen. Mercury internally is indicated, but, as above stated, all these measures may fail to arrest the destructive process. After the eye has become quiet an iridectomy may be considered, but should be delayed for a year or more for fear of rekindling the inflammation.

Sympathetic irritation must be distinguished from inflammation, and is marked by lachrymation, pain on near use, photophobia, and injection of the conjunctiva of the good eye. These symptoms should lead us to look for and correct any latent error of refraction that may exist, and to treat the eye by rest, atropine, and cocaïne washes before proceeding to the severe measures required for sympathetic inflammation.

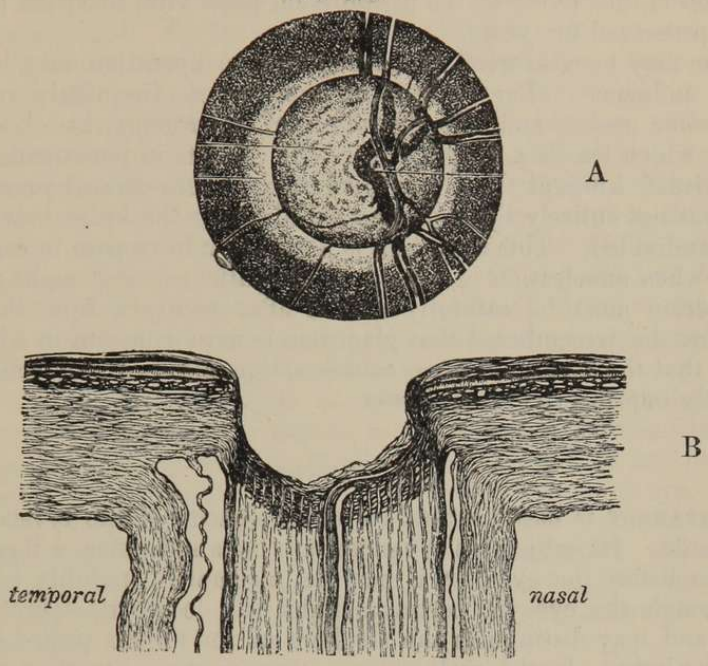
VII.—GLAUCOMA.

Glaucoma is a disease dangerous to vision, occurring usually after middle life, especially in the hypermetropic, causing sudden or gradual loss of the field of vision, commencing at the nasal side, having no tendency to recover spontaneously, and ending in complete blindness unless recognized and treated. Its etiology is yet under discussion, but its chief symptom is an abnormal hardness of the globe from increase of the normal tension, to be detected by the palpation of the ball by the index fingers of each hand pressed alternately upon the eyeball through the upper lids, the patient closing the eyelids. Perhaps from hardness of the sclerotic coat or interference with the lymph-passages at the periphery of the anterior chamber, or increased density of aqueous humor, the ball becomes over-distended and hard to the touch, and this pressure upon the ciliary nerves between the choroid and sclerotic produces impaired sensibility and even anesthesia of the cornea. At the sclerotic ring we may find with the ophthalmoscope the characteristic *cupping* or depression of the papilla below its proper level (Fig. 394), due to long-continued intraocular pressure and the giving way of the entire optic nerve at this the weakest part of the ball.

There are three forms: the acute (glaucoma fulminans), the chronic, and the simple. In the first there may be violent and agonizing pain in the ball, often ascribed to a severe sick headache, with vomiting. The nature of the attack is often not diagnosticated until valuable time has been lost. The patient generally remains in bed, avoids the light, and does not complain of defective sight. There is usually hyperemia or inflammation of the conjunctiva, with a circumcorneal zone of redness, and these cases are often treated as violent attacks of rheumatic iritis, although in the latter case the pupil is smaller than usual, while in the former it may be dilated and little sensitive to light. The disease may continue unrecognized for days or weeks until vision has been lost. The incautious and unnecessary use of atropine may induce this form of glaucoma when the drug is used to combat a supposed iritis. The testing of the vision, central and peripheral, should clear up the diagnosis at once, and if it is much impaired or limited, the dangerous condition is revealed. The cornea should be lightly touched with a shred of cotton, and its sensibility ascertained, the state of the pupil noted, the cornea examined by a good light and by the ophthalmoscope, and the condition of the optic

nerve at the disk ascertained and pulsation of its vessels looked for. It may not be cupped in acute cases, but the details of the eye-ground may be dimly

FIG. 394.



Glaucomatous Excavation of the Optic Papilla.
A, as seen by the ophthalmoscope from in front; B, as seen in section after removal of the ball (Fuchs).

seen from the hazy condition of the cornea and vitreous humor. An iridectomy gives the only chance of relief, and no time should be lost in performing it, although 1 per cent. solutions of eserine frequently dropped into the eye may diminish the tension, clear up the vision, and give relief in the milder cases. One eye is usually first attacked, the other following later; vision may be completely destroyed in a few hours, or the eye may partly recover, but will be more or less damaged. The eye may remain irritable until the attack recurs again and again, the globe growing harder, the anterior chamber becoming shallower, the pupil remaining dilated and insensible to light, the sight growing worse, and the lens becoming opaque. The case then is to be classified as glaucoma absolutum, and demands at any time the enucleation of the eye to gain relief from agonizing pain. The chronic cases resemble the acute, but with less violent symptoms and longer intervals between the attacks.

Simple Glaucoma proceeds to the same result more slowly and insidiously, the field gradually contracting until only the center of it may remain; the optic nerve becomes deeply cupped, with its blood-vessels falling into the cup at the sclerotic ring, and its veins pulsating violently or upon slight pressure upon the ball. This form may become acute at any time, and if one eye only is affected the patient should be informed that an outbreak of glaucoma may occur in the other eye during treatment. To Graefe is due the honor of finding a remedy for this formerly intractable form of certain and painful blindness. He first used it in 1856, and it is now employed throughout the civilized world. It consists in a full iridectomy through a large cut at the periphery of the anterior chamber. The section of the iris alone has perhaps little effect on

the disease, but must be done to prevent its prolapse whilst the slow healing of the extensive cut into the sclero-corneal margin goes on. No doubt a leaking cicatrix is formed through which the over-abundant fluids of the eye find exit. The tension is thus reduced, the pressure on parts vital to vision relieved, and the sight preserved for years.

Eserine may be also tried, and sometimes an operation may be postponed under its influence. Paracentesis of the cornea, frequently repeated, has relieved some cases, and the operation of sclerotomy has been proposed (Wecker), which leaves a weeping scar. It consists in puncturing the eyeball with the Graefe knife at the upper third of the sclero-corneal junction, cutting upward, but not entirely through, and withdrawing the knife, leaving a bridge of tissue undivided. This operation is useful to relieve pain in cases of entire blindness when enucleation is refused by the patient or is thought unadvisable. The refraction must be carefully studied after recovery from the operation, since it must be remembered that glaucoma is most common in hypermetropic eyes, and that the operation often causes astigmatism, the correction of which may greatly improve the visual power.

VIII.—CATARACT.

By CATARACT is meant a total or partial opacity of the crystalline lens or of its capsule. Its subjective symptoms are impaired vision, a foggy or smoky appearance before the eyes, or, it may be, a complete inability to distinguish form, although the eye yet perceives light, can locate its source, natural or artificial, and may distinguish the shadows of the fingers passed between the eye and the light. In the early stages, owing to the contraction of the pupil, the fog is greatest in a bright light, and the patient may yet see well in a dull light, which enables the pupil to dilate: this arises, of course, from the fact that the early opacity is usually greatest at the nucleus or centre of the lens, or its capsule at the anterior or posterior pole.

The **causes** are malnutrition of the lens from gouty or rheumatic diatheses, renal disease, diabetes, old age, with its general, calcareous, and atheromatous degenerations, traumatism, high myopia, and glaucoma. The varieties are (1) congenital, (2) acquired, (3) traumatic, (4) senile. They are also divided, according to their locality, into nuclear or central, cortical or peripheral, and capsular. Nuclear cataract begins in the center of the lens as a whitish or amber-colored cloud; cortical, as striæ affecting the periphery and extending toward the center of the lens; and capsular, involving the anterior or posterior surface of the lens, not as yet affecting its body. Congenital cataract is occasionally seen, and must be treated by discission or by iridectomy. A traumatic cataract occurs from contusions or penetrating wounds which cause a rupture or fissure of the capsule, permitting the aqueous humor to invade the lens substance.

Cataracts are soft or hard: the first occurs, usually, in persons under forty; the latter, as a senile change, in older persons. They are said to be ripe when the lens substance has become uniformly clouded without visible sectors, since it is then less adhesive and separates readily from the capsule when pressed upon in operations for its removal. When unripe, portions of the lens matter are stripped off, remain behind in the anterior chamber, and cause delay in obtaining a good result. The remaining cortical substance undergoes tedious absorption. By Förster's operation for artificially ripening the cataract the time required to render the lens fit for operation may be reduced to six or eight weeks. The color by reflected light may be white, yellow, or gray, or white with a yellow reflex in its lower part, due to a softening of its cortical

portions, and a subsidence of the hard nucleus to the lowest part of the capsule, as in Morgagnian cataract.

The **diagnosis** is attained by a study of the objective symptoms after full dilatation of the pupil by a mydriatic, by means of oblique illumination, and by the ophthalmoscope. By the latter we can detect the earliest striæ in incipient cases. At a more advanced stage of the affection the opacity may be so dense as to cut off any red reflex from the fundus. By oblique or focal illumination we can distinguish the large brown or yellow nucleus with fine striæ of the hard form from soft cataract with its smaller nucleus and larger striæ and with the mother-of-pearl reflex from its anterior surface. When ripe and in a favorable condition for removal the lens substance next to the capsule is opaque, and the shadow cast upon it by the edge of the iris is very narrow, whilst if any clear lens matter remains between the capsule and the nucleus the shadow is broader and more marked. The natural course of the disease is to remediable blindness, but care must be exercised in giving an opinion as to the period of time required to produce blindness.

Patient efforts should be made to determine by the ophthalmoscope the absence or presence of disease or defects in parts of the eye behind the opacity, in testing light and color-perception in all portions of the field, and the patient's power to locate the position of a candle-flame placed before the eye. By these precautions we escape the error of submitting the patient to a serious operation and prolonged treatment for the removal of a cataract which will not restore vision to an eye blind from atrophy of the optic nerve, glaucoma, separated retina, choroidal atrophies, retinitis pigmentosa, or other destructive lesion of the fundus oculi.

No specific **treatment** has any marked value, and we are finally led to surgical procedures for the removal of the opaque lens substance. These may be grouped under three heads: *discission*, *suction*, and *extraction*. The first and second are applicable only to soft cataract. Hard cataract, senile, is removed by extraction. (See Operations.)

Secondary Cataract is an opacity that remains in the capsule after the removal of the lens, the result of inflammation and deposit in the capsule, degeneration of its inner surface, or of its folding or wrinkling in the healing process. It requires to be torn at its center by one or two needles introduced through the cornea, or by incisions with a small knife.

IX.—STRABISMUS, OR SQUINT.

Strabismus is a deviation (squint) of one eye in looking at an object, or an inability to exercise binocular vision. The deviating eye may turn inward, convergent strabismus; outward, divergent strabismus; upward or downward, vertical strabismus. The vision is double (diplopia), unless there is unconscious suppression of the image in the squinting eye, and the expression of the face is bizarre and sometimes malign. It is of diagnostic value to ascertain whether the squint is recent or of long standing, and whether it came on without apparent cause or as the result of injury. It is usually the result, in childhood, of ametropia, or, in adult life, of central nervous disease. It is concomitant when the movements of the eyes are free and associated; monolateral when the squinting eye is fixed. The latter condition is due to paralysis of one or more ocular muscles, and may point to grave cerebral disease or to the presence of some constitutional dyscrasia. The full treatment of this complicated subject, in which the neurologist and the ophthalmic surgeon meet, cannot be given here, but it may be practically sufficient to enumerate the causes

and symptoms of these casts or squints in order to prevent errors of diagnosis and of treatment. The reader is referred to special text-books for fuller information.

Paralytic squint is recognized by the fact that if a candle or the finger of the surgeon is carried from right to left before the face of the patient, the deviating eye fails to follow to its proper limit, and leads us to look for lesions of the sixth nerve in failure of the external rectus, of the third nerve in failure of the internal rectus of either side, of the fourth nerve in impairment of the superior oblique muscles. In adults this is usually due to syphilitic disease involving the nerve-centers or trunks, or to rheumatism. The treatment in each case is thus indicated. Locally, we may resort to the use of electricity and to operations, undertaken, however, with great discrimination. Blows and falls upon the head sometimes cause squint, and are usually accompanied by marked and annoying diplopia or double vision, which may not be relieved by treatment. Mechanical means are required under these circumstances to occlude the squinting eye. Opaque or ground glasses are used for this purpose.

Concomitant Squint is *unilateral*, when the same eye always deviates; *alternating*, when either deviates, the other being fixed; *constant*, when the squint remains permanent; *periodic*, when the eyes are occasionally free from it. Macula may lead to a squint, but the prime factor is found in errors of refraction, in hypermetropia, or in myopia with or without astigmatism. A full discussion of the subject does not come within the scope of this work, but we may broadly assume that in the strain upon the ciliary muscle requisite to high visual power in the hypermetropic eye the excessive innervation of the internal rectus which accompanies the effort of accommodation is the cause of the convergent squint so common when this defect is marked. The forced accommodation required for prolonged near sharp sight, then, is attended by the periodical squint of one, usually the weaker, eye, and this is first noticed, clinically, in children about five years of age—an age when they begin to amuse themselves with pictures or other objects viewed from a short distance. In myopic refraction the accommodation is not used relatively with the convergence, the tendency in high myopia being to suppress this function; and with this defective innervation of the ciliary muscle there is an apparent weakening of the internal rectus and a divergent squint, which becomes habitual. These are cardinal rules, but the subject is large, and there are other causes: for general surgical guidance it may be stated that cases of convergent squint are frequently relieved by convex glasses whilst they are habitually worn, and that concave lenses have a tendency to avert physiologically the divergence of myopia. At all events, no operation should ever be done in strabismus until the refraction has been carefully estimated under the influence of a mydriatic. Glasses should be regarded as essential aids in correcting and preventing returns of squint, even when it has been removed by an apparently successful operation. These views lead us to decline operations on very young children or to delay them until the patient has at least reached the age of seven years. The surgeon may wonder why the adult with suddenly-acquired strabismus makes so much complaint of his diplopia, and why it is seldom mentioned by those patients in whom it is dependent on optical defects. In the latter cases there are either congenital or acquired conditions of poor sight in the retina which lead to the suppression of the images by the deviating eye, known as *amblyopia ex anopsia*. No hope of improved vision should be given as the result of operation. The use of a red glass over the fixing eye, the test-object being a candle- or gas-flame at the distance of twenty feet, will enable the patient to

recognize the diplopia, and the surgeon to determine or estimate the distance between the two images, and to bring them together with a prism which is the measure of the cast.

X.—DISEASES OF THE ORBIT.

Orbital Cellulitis is an inflammation of the connective tissue of the orbit, accompanied by swelling and redness of the lids, especially the upper; pain, which is increased by pressure on the ball; and severe neuralgia in branches of the fifth nerve. There are impaired motion of the eyeball, marked exophthalmos, and usually high fever. Suppuration is to be expected. The location of the abscess should be determined by careful palpation, and the exit of pus hastened by incisions through the skin or mucous membrane. Recovery may be hoped for, but complete atrophy of the optic nerve, with blindness, sometimes follows. It may occur idiopathically or from exposure to cold, from traumatism, from extension of inflammation from neighboring parts, from metastasis, in pyemia, or as a sequel of fever, such as purulent meningitis, typhoid, scarlatina, etc. It should be treated by hot applications, by incisions which allow free escape of pus, and by remedies addressed to the general constitution.

Periostitis may present all the symptoms just described, generally less severe, but it may have a more chronic course and be complicated by necrosis of the bones or by communication with neighboring cavities. Syphilis and rheumatism may be suspected, and demand appropriate constitutional treatment, together with hot fomentations, an early incision to evacuate pus, and antiseptic injections. The results may be serious in all cases of orbital disease, including such disasters as atrophy of the optic nerve from pressure or extension of inflammation, paralysis of the muscles and nerves of the orbit, or even death from inflammation transmitted to the meninges of the brain.

Injuries and Wounds in this situation are also dangerous, since they may cause phlegmonous cellulitis, with all its accompanying symptoms, dangers, and sequelæ. Punctured wounds of the orbit are especially dangerous, as they may involve the brain by piercing the orbital plate. This possibility should always be investigated. Foreign bodies should be sought for and removed when found. Antiseptics should be used with skill and diligence, and great care should be taken to prevent the onset of inflammation.

Tumors of the orbit and globe, such as warts, dermoid cysts, epithelioma, exostosis, carcinoma, sarcoma, and aneurysmal pulsating exophthalmos, may be dismissed with the brief statement that they occur in this region, and that their diagnosis and treatment belong to the domain of general surgery.

PART II.—SURGICAL OPERATIONS.

EYELIDS.

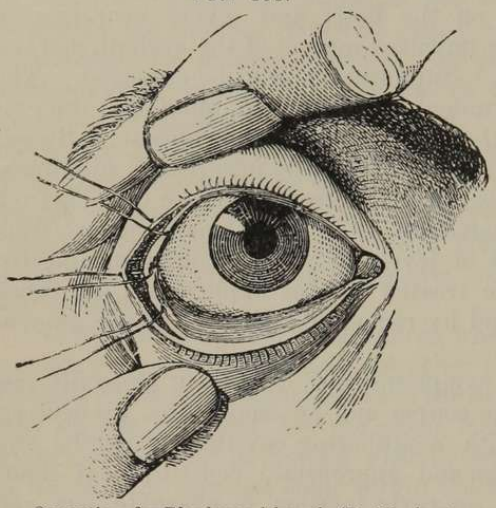
But one method under each head of the numerous and ingenious operations on the lids can be given, owing to the limit of space.

Ptosis may require surgical interference in order to remove deformity or to improve vision. The patient gains some power to keep the pupil from being covered by strongly contracting the occipito-frontalis, thus giving a disagreeable expression to that part of the face. With a view to increase the control of the frontalis muscle we may employ a method proposed by Pagenstecher, which creates a cicatricial band of union between the frontalis and the integument of the lid. A needle armed with a strong ligature is introduced into the skin half an inch above the eyebrow, and, passing downward beneath it, is

brought out near the margin of the lid in its middle line. The ends are then loosely tied, and tightened every few days until the thread cuts its way out. This is a simple procedure and yields good results.

Canthoplasty is required in some acute inflammations of the eye to relieve spasmodic closure of the lids. It is of great value also in narrowing of the commissure when there is friction of the cornea by mucous membrane roughened by long-continued inflammation. It is performed by passing one blade of a strong pair of blunt-pointed scissors laterally as far as possible beneath the skin of the outer commissure, and dividing the intervening tissues by a firm outward cut. The lids are widely separated. A suture is passed from the center of the cut conjunctival margin to that of the skin, and tied. Two more sutures, one above and one below, unite the mucous membrane and skin so as to oppose mucous membranes to each other and thus prevent a reunion of the divided tissues.

FIG. 395.



Operation for Blepharophimosis (De Wecker).

Symblepharon. — Any small bands of adhesions between the lid and the ball may be incised. When they are larger, divide the band from the eyeball sufficiently to turn it down into the raw surface, and secure it by sutures, having in mind the main indication to oppose to each other only mucous surfaces protected from union by their epithelium. Complicated plastic operations, transplantation of mucous membrane from the lip, from the vagina, or from the rabbit's eye, are described in special works on the eye.

Distichiasis, Trichiasis, Entropion, are conditions demanding operations ingenious, numerous, and complicated, all having the same object in view—namely, to rectify the position of the lashes. The simplest one is known as *epilation*, which consists in pulling out with the proper cilia forceps the harmful hairs. This gives immediate if temporary relief, and may even be of permanent value, as the constant removal of the hairs has a tendency to destroy their bulbs.

Repositio Ciliorum consists in passing a needle threaded with both ends of a silk suture through the skin close to the root of the lash it is desired to control. The displaced lash is then caught in the loop of the silk and pulled gently through the track of the needle into its proper line.

Electrolysis is employed to destroy the hair-bulb. This method is of much value where but a few lashes are in faulty position. The *actual cautery* is also an efficient means of destroying the bulbs. *Excision*, where a limited number of bulbs are in fault, consists in removing them by a V-shaped incision, bringing the base of the wound together by a stitch.

The *Arlt-Jaesche* operation consists in splitting the lid throughout its extent to a depth of 5 mm., leaving the tarsus and conjunctiva in the posterior part; a second incision through the integument 7 mm. from its free margin is made through its entire length, and from one end of this to the other a third curved incision is made, with its highest part 7 mm. above the second one,

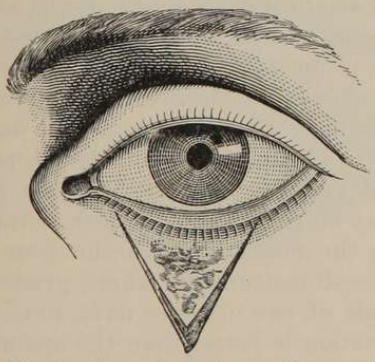
and the semilunar area of skin included between these two last cuts is dissected off without disturbing the underlying muscle. After this gap has been closed by sutures, which should be passed into the margins of the skin and tied, the lower portion, containing the hairs and their bulbs, is everted and the hairs drawn away from contact with the cornea.

Burow's Operation gives very great relief in cases where there is a moderate degree of inversion. The skin is not touched externally, but the object is to divide the tarsal cartilage from the inner surface of the lid and secure an eversion equal to the gaping of the cut in the cartilage. The lid is to be everted and stretched upon a spatula: 3 mm. from its free border and at its central part the mucous membrane and cartilage are punctured with a knife sufficiently to permit the introduction of one blade of the scissors, with which the conjunctiva and half of the cartilage are divided; the blade is then passed in the opposite direction and the same free division is made, both incisions being parallel to the ciliary border of the lid.

Ectropion, or **Eversion of the Eyelid,** occurs in two forms: the first is caused by a spastic contraction of the orbicularis muscle or by the paralysis of senile weakness; the second is due to cicatricial changes. In the first form, the conjunctiva having become œdematous, the edge of the lid is everted, and by the pressure of the muscle a swollen condition is induced, called *palpebral paraphimosis.* It should be treated by remedies applied to the conjunctiva and by a properly-applied bandage; in chronic cases by Snellen's operation. In senile ectropion, caused by atrophy of the muscle, or in cases of paralysis of the muscle, the deformity is complicated by the eversion of the inferior punctum and a flow of tears over the cheek, giving rise to excoriation of the skin. Here mild astringents to the conjunctiva are demanded, and an ointment of vaseline and boric acid applied to the integument of the lid is serviceable. Slitting the canaliculus may answer every purpose, or, that failing, Snellen's operation should be performed.

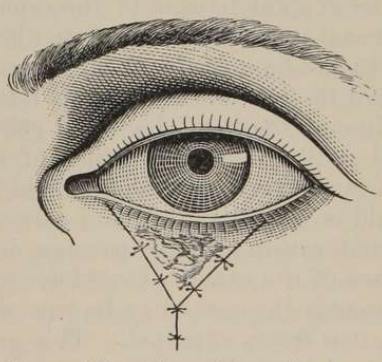
Snellen's Operation requires a single suture armed with a needle at both ends. One needle is passed into the most prominent point of the conjunctiva, turned downward, and brought out 2 cm. below the edge of the lower lid. The second needle is entered 5 mm. from the first, and its point of exit is 2 cm. below the margin and 1 cm. from the point of exit of the first needle. The loop thus made includes a quantity of the swollen conjunctiva, and when

FIG. 396.



Wharton Jones' Operation for Ectropion.

FIG. 397.



Edges of Wound brought together in a Y.

traction is made below and the lid pressed into position with the finger, the ectropion disappears. The lid is retained in position by tying the ends of the

suture over a roll of plaster placed on the cheek. Two or more such sutures may be required.

Cicatricial Ectropion is usually the result of injuries, and demands operation, the simplest form of which is known as the *Wharton Jones' Operation* (Fig. 396). The object is to convert a V-shaped incision, including the cicatrix, by properly-applied sutures into one shaped like the letter Y (Fig. 397). More serious cases are frequently seen, as in burns or other accidents or in lupus, in which the entire lid has been destroyed, usually the upper one. Enucleation is advised for such cases by good authorities, but in making a new lid enough success has been attained to warrant the effort. All adhesions which keep the tarsal border away from its proper place should be divided, and the large raw surface thus made should be filled in by grafts of skin from the arm, one-third larger in size to permit of shrinking, and held in position by fine sutures. These proceedings have been described fully by Wolfe and Lefort.

OPERATIONS ON THE LACHRYMAL APPARATUS.

The **malposition,** or partial or complete **stenosis** or closure, of the **punctum** requires that it should be opened and the canaliculus converted into a slit. Weber's knife, a small cutting instrument with a probe point, is required. Its probe end is carried, forcibly if the closure is nearly or quite complete, into the punctum; the handle is then dropped, the lid rendered tense by the surgeon's fingers, and the blade passed as far as the case demands, the edge turned inward toward the ball, and the canal opened by a swift upward movement of the handle. The canal may be pervious beyond the punctum, in which case only a small incision is required. The entire canal may be contracted or only partially closed, and fine probes may then be used for diagnosis and treatment. Should the stricture be at the neck of the sac, it must be divided by a small cutting instrument and probes passed daily to keep the passage open.

Stricture of the Nasal Duct may be caused by inflammation of its mucous membrane from catarrh of the nasal passages. It may be acute or chronic in character. The membranous or cicatricial contraction causing the stricture may be the result of injury to the bones of the nose from violence, or of syphilis, acquired or hereditary. Bony stricture of the canal is nearly incurable. Obstructions of the mucous or submucous membranes are best treated by the method proposed by Sir William Bowman; that is, by gradual dilatation with probes. There are six sizes of such probes in a set, and after the partial or total division of the canaliculus the smallest one may be passed along the canal in the direction of the lachrymal bone, and when that is touched the hand must be raised and the direction of the probe altered until it is pointed toward the sulcus between the nose and the cheek. It now corresponds with the line of the nasal duct, and gentle pressure should be used to pass it downward until it reaches the floor of the nostril. The probe should be properly bent, and every movement should be guarded and gentle. Little or no pain should be caused. Skill and perseverance may be required to gain an entrance without causing a false passage or stripping the mucous membrane from the surface of the canal. Once having passed a small instrument, others, gradually increasing the size, may be passed at intervals of two or three days until the largest is freely admitted. This gradual dilatation is better than the operation proposed by Stilling—viz. cutting the seat of stricture and introducing large probes.

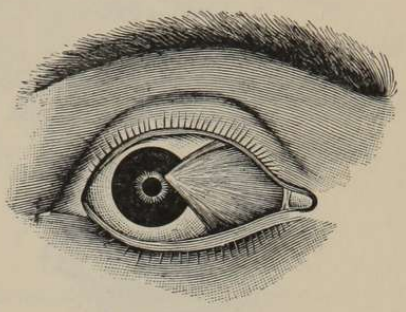
Extirpation of the Lachrymal Gland may be a necessary consequence of disease, or may be advisable in order to reduce the flow of tears in cases where

the tear-passages cannot be opened. It is accomplished by an incision through the skin at the outer third of the orbital margin. The gland is here easily reached. After the incision it is drawn out with a hook and dissected from its detachments.

OPERATIONS ON THE CONJUNCTIVA.

Pterygium (Fig. 398).—The redundant tissue is seized by forceps a short distance from the corneal border, transfixed with a Beer's knife, and its apex shaved from the cornea; or a strabismus hook may be used after the transfixion and the apex torn from the cornea by a rapid movement of the hook. The sides of the pyramid may be then incised toward the base. The freed apex should be tucked under the conjunctiva above or below the incision, and retained there by sutures. Simple division of the entire pterygium at its base is frequently followed by a recurrence of the growth.

Fig. 398.



Pterygium (Meyer).

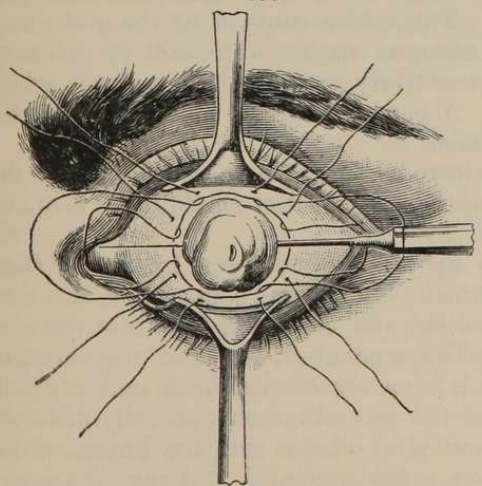
OPERATIONS ON THE CORNEA.

Staphyloma, involving a large part of the cornea, may require an iridectomy to reduce the tension as well as to aid vision. When the cornea has been destroyed by ulceration, and the protruding mass is large enough to separate the lids and keep up a constant irritation of the eyeball, enucleation or evisceration of the ball or abscission of the mass becomes necessary.

Abscission is a simple and effective operation. It is done by transfixing the staphyloma at its base by a Beer's knife and dividing two-thirds of it by a cut upward, and removing the other third with scissors. The lens is then extracted, antiseptics are freely employed, and the large opening thus made is left to heal by granulation.

In *De Wecker's method* sutures are used and the wound is closed at once. He divides the conjunctiva from the margin of the cornea, and dissects it from the ball nearly as far backward as its equator; he then passes through the conjunctiva, 2 or 3 mm. from its cut edge, four sutures of silk in the position indicated in Fig. 399. The sutures are of different colors, to facilitate ligation. The staphyloma is then cut away and the sutures are tied. De Wecker further suggests that after healing the center of the scar can be tattooed, so as to imitate the natural parts, and thus do away with one of the reasons for wearing an artificial eye.

Fig. 399.

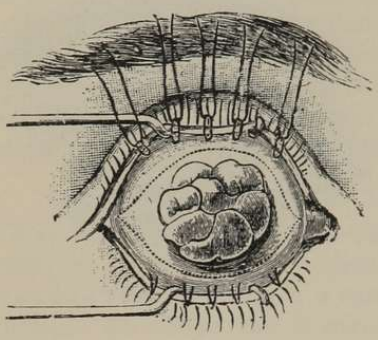


Operation for Staphyloma Corneæ (De Wecker).

Critchett's Operation has long been a favorite method, and consists in passing four or five long curved needles, armed with silk sutures, through

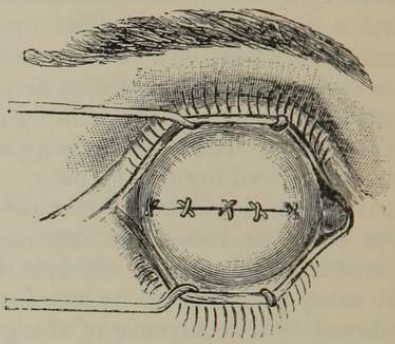
the sclerotic, the points of entrance being midway between the base of the staphyloma and the insertions of the recti muscles (Fig. 400). A sharp knife is then passed through the center of the mass from the insertion of the outer to that of the inner rectus muscle, and a horizontal cut made; the upper and lower flaps are then cut off with scissors about 2 mm. distance from the needles. The needles are next drawn through, the edges brought into perfect apposition, and the sutures tied. This leaves an excellent stump for an artificial eye (Fig. 401);

Fig. 400.



Critchett's Operation for Staphyloma.

Fig. 401.



Stump after Critchett's Operation for Staphyloma.

and but one objection has been made to it—namely, the danger of exciting a destructive inflammation which might cause "sympathetic inflammation" in the other eye, the wounds being in or near the ciliary region. These procedures are efficient when there is no increase of tension, but when the tension is high and the ball inflamed and painful, most surgeons would prefer the enucleation of the globe or its evisceration by Mules's operation.

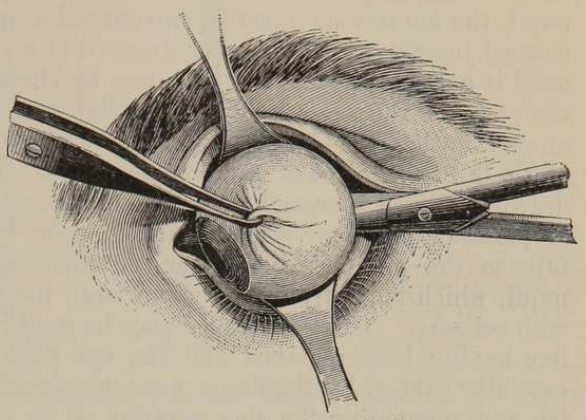
Evisceration is used as a substitute for enucleation in suppurating disease of the globes to prevent meningitis or when sympathetic inflammation is feared. A Graefe knife is passed through the ball at the sclero-corneal junction, and one-half of the cornea is removed, the rest being cut away with scissors. All the contents of the globe are then removed, using, if possible, the scoop introduced by Mr. Mules, with which the choroid can be separated from the sclerotic back to the sclerotic ring, preserving the choroid unbroken until it is adherent only at the lamina cribrosa. The entire contents of the globe may then be lifted out with the scoop. Antiseptic washes—1 : 5000 of corrosive sublimate is the best—must be injected freely into the ball, and the edges brought together with a few sutures. A good and freely movable stump for an artificial eye is obtained by this method.

Mules's Operation consists in the introduction of a glass sphere into the empty eyeball, with a view to rendering the stump better suited to an artificial eye.

Enucleation of the Eyeball is by two methods—one known as Bonnet's, and the other as the Vienna, method. In Bonnet's operation the conjunctiva is divided at the corneal border, and separated for some distance backward from the ball by scissors. The tendons of the four recti muscles are then in turn brought within reach by a strabismus hook and divided. Pressure backward upon the margin of the lids will then generally dislocate the ball forward, and the surgeon is enabled to seize it with the fingers of his left hand or with forceps, while he passes a probe-pointed and curved scissors deeply into the orbit, feeling for and dividing the optic nerve close to the ball. The oblique muscles and other remaining tissues are then quickly and

easily divided with the scissors (Fig. 402). A 1 : 5000 solution of corrosive sublimate should be used freely, the entire cavity of the orbit being irrigated for some minutes. Finely-powdered iodoform may be freely sprinkled upon the interior of the orbit; a piece of drainage-tube may be placed in the cavity to promote discharges, and a pad of antiseptic material may be kept in position to increase pressure and arrest hemorrhage. This rather serious operation gives the surgeon no anxiety since the general enforcement of antiseptic precautions. The patients are seldom confined to bed for more than one or two days, and are usually able to leave the house or hospital within a week. Some cases, however, terminate fatally by meningitis, and this possible sequel should be kept in mind. After a fortnight the parts are usually so healed that an artificial eye may be selected and worn, but it is well not to use it constantly until a month or more has elapsed.

Fig. 402.



Enucleation of an Eyeball (Meyer).

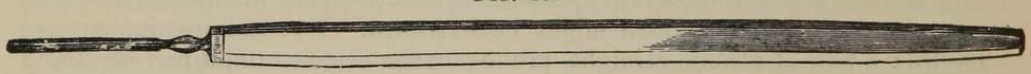
The *Vienna Method* is more brilliant and rapid, but it is not well suited for the removal of those globes which have been weakened by ulceration or injury, inasmuch as considerable pressure is needed in the manipulation. The contents of a weakened globe might be extruded. But two instruments are needed: a pair of strong, straight, probe-pointed scissors and a pair of strong toothed forceps. The tendon of the internal rectus muscle, after division of the overlying conjunctiva, is seized with the forceps and divided with the scissors. The end attached to the globe is held in the grasp of the forceps until the end of the operation, to make traction. One blade of the scissors is passed beneath the tendon of the inferior rectus, which is then cut with its conjunctival covering: a like incision is made through the tendon of the superior rectus. The globe is now rotated outward to permit the closed scissors to be passed deeply into the orbit, where the optic nerve is divided; the ball is then easily drawn forward, the external rectus and the two oblique muscles are separated, and the enucleation is completed.

Iridectomy.—This operation is employed to remove a portion of the iris when an artificial pupil is necessary to the admission of light, in the treatment of recurrent iritis, or to reduce intraocular tension, especially in acute and chronic glaucoma. When employed for optical reasons, that portion of the iris should be removed which gives the best chance for the unobstructed admission of light; that is to say, where the cornea and lens are most transparent. The preferable position is to the nasal side and slightly below the horizontal diameter of the cornea, but any part may be taken if necessary. The portion of iris removed should be small and not extend to the entire width of the iris. In iridectomy for the relief of increased tension the cut should be made in the sclero-corneal margin, and be long enough and wide enough to allow the removal of a portion extending from the pupillary border to the circumference of the iris, causing a wide and peripheral coloboma. After the eye has been made insensitive with cocaïne and thoroughly washed with a solution of corro-

sive sublimate, the lids are separated by the speculum, and with fixation forceps the operator takes firm hold of the conjunctiva and subconjunctival tissues near the corneal border directly opposite the point selected for the iridectomy. If the operation is undertaken for the purpose of making an artificial pupil, the keratotome must be introduced at or in front of the apparent sclerocorneal junction, with its point directed at a right angle to the corneal surface, until it has passed through it, when by changing the position of the handle the plane of the knife is placed parallel with that of the iris, and it is pressed onward until a cut of 4 or 5 mm. has been made, taking care to keep the point of the knife in front of the iris and lens. The knife should be slowly withdrawn, to avoid a premature escape of aqueous humor. Tyrrell's hook, made of platinum and very smooth, may then be introduced sideways, passed carefully to the pupillary border, and rotated so as to catch the margin of the pupil, which is gently drawn up through the wound and a portion clipped off with scissors. The iris forceps may be used instead of the hook. The speculum having been removed and the eye washed with an antiseptic, it may be carefully rubbed by the finger over the closed lid with a view to replacing the iris and preventing the incarceration of its cut edges in the wound. If this manipulation does not answer the purpose, the spatula should be introduced at the angles of the cut and the iris gently liberated and returned to its proper place. A mydriatic and a light antiseptic dressing complete the operation. After twenty-four or forty-eight hours the dressing may be replaced by a shade worn over both eyes.

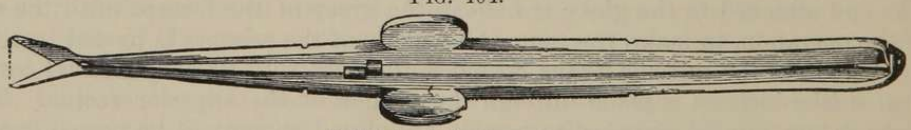
Iridectomy for Glaucoma (Figs. 403–409).—The primary object of this operation is to lessen tension, as already stated. The incision into the anterior

FIG. 403.



Silver Spatula (Swanzy).

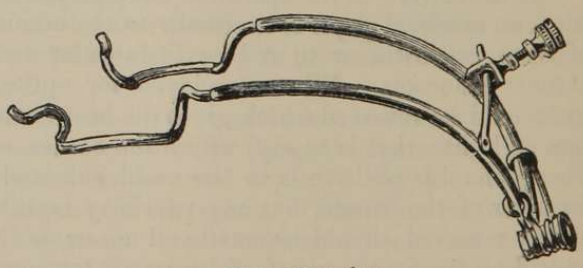
FIG. 404.



De Wecker's Forceps-scissors.

chamber should be as peripheral as possible, the cut extensive, using the largest keratotome, and forceps instead of a hook employed for seizing the iris. The iris must be drawn fully beyond the cut, and removed at its periphery by one or more cuts with the scissors. The point of election should be at the upper quadrant of the cornea, to have the protection of the upper lid afterward, and to prevent any blurring of vision from the entrance of too much light through the extensive coloboma. The anterior chamber is usually very shallow, and great care is necessary, in passing a large keratotome, to prevent its point

FIG. 405.



Spring Speculum.

Fig. 406.

Iris Forceps.

Fig. 407.

Fixation Forceps.

Fig. 408.

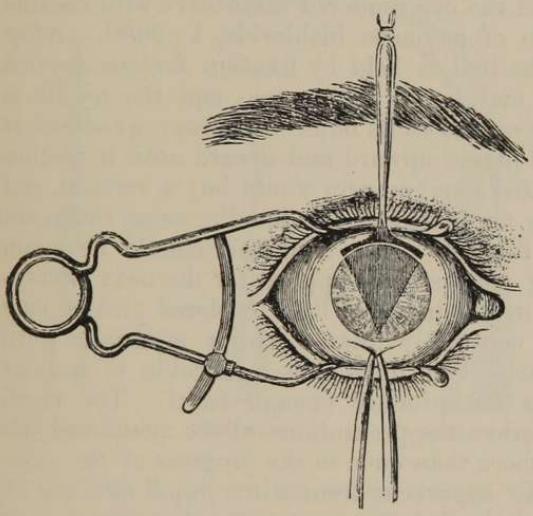
Keratotome.

Fig. 409.

Blunt Hook.

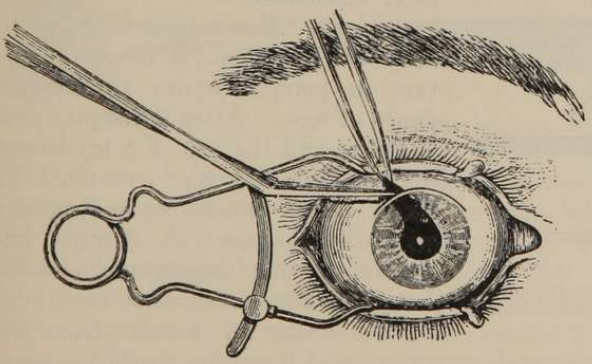
from entering the clear cornea on the one side and from wounding the ciliary region and iris on the other. The operation is done much as the former one, the large keratotome being chosen, and its point kept close to the posterior surface of the cornea until it reaches below the pupil (Fig. 410). In slowly withdrawing it one side may be made to increase the length of the corneal cut. The forceps are passed to the pupillary border closed, then opened as far as possible, the iris caught, gently withdrawn through the incision, and cut to the extent of that incision with the scissors (Fig. 411). Manipulation with the finger on the upper lid, which is closed, should be made to prevent the prolapse of any portion of the cut iris in the wound. The tension is markedly decreased by the operation, and the anterior chamber may not be restored for several days. The dressing is antiseptic. Place a piece of lint with vaseline over the lids and a light pad of antiseptic cotton over the lint, confining them in place by a black woven band fastened over the eyes with tapes. No mydriatic should be used in glaucoma. The

Fig. 410.



Operation of Iridectomy: keratotome within the anterior chamber (Juler).

Fig. 411.



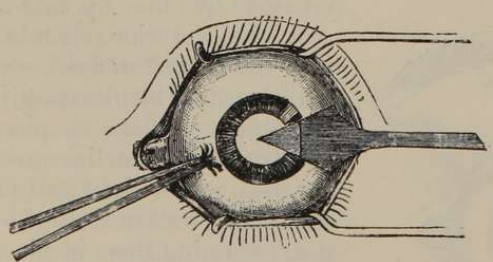
Iridectomy, removal of a portion of the Iris (Juler).

method here described may also be used in cases of iritis or in other cases requiring iridectomy.

CATARACT OPERATIONS.

Discission of the lens to promote absorption is the method used in the cataracts of children and in those of adults up to the age of twenty-five. After that time the nucleus has become hardened, and the iris is too prone to become inflamed to render the operation as safe as the entire extraction of the lens. It consists in tearing the anterior capsule of the lens so as to admit the aqueous humor to the lenticular fibers, which causes them to swell, become soft, and finally disappear by absorption; and this may require weeks and even months. The longer the incision into the capsule, the more rapidly the lens will become swollen, and by pressure upon the iris may set up an iritis or glaucomatous tension. It is well, therefore, to make the incision no larger than the undilated pupil, and later, if there is no reaction, to repeat the operation with a view to hastening the result. Should the eye become red, painful, and hard, and the anterior chamber be occupied by the softened lens, it is proper to do a linear extraction and give exit to the lens material. The instruments required are the spring speculum, a fixation forceps, and the stop-needle of Bowman. The pupil must be dilated with a mydriatic, and the eye rendered insensitive with cocaïne and washed freely with the solution of mercuric bichloride, 1 : 5000. After the introduction of the speculum the ball is held by fixation forceps applied to the conjunctiva near the inner margin of the cornea, and the needle is entered perpendicularly through the cornea at its outer and lower quadrant at the margin of the dilated pupil, and passed upward and inward until it reaches the lens at a point where the undilated pupil margin would be; a vertical, and then horizontal, cut is made by the movement of the handle, using the point of entrance into the cornea as the fulcrum. The mydriatic should be again used, and a light antiseptic dressing and bandage applied for the next twenty-four hours, the patient being kept in bed in a dim light; colored glasses may then be used, and the pupil kept constantly dilated with a mydriatic until the solution of the lens is complete. This method is applicable to zonular cataract where an iridectomy does not promise enough relief. The small wound renders this procedure safe when the precautions above mentioned are employed, and it may be repeated more than once in the progress of the case. Should the ball become hard or iritis supervene from a too rapid swelling of the lens fibers, or if it is required to hasten the treatment when the lens is extensively softened, the lens material can be removed either by suction or by manipulation as in the operation next described.

FIG. 412.



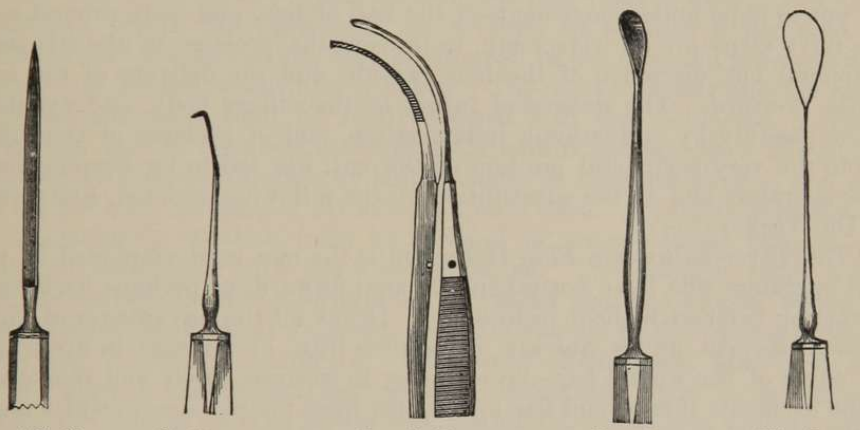
Linear Extraction: knife entered in horizontal meridian of cornea about 4 mm. from outer margin (Swanzy).

Linear Extraction is suitable only for the removal of soft cataract in persons under twenty-five years of age. After antiseptic precautions and the use of a mydriatic above described, the eye must be fixed at its inner corneal border with the forceps. A straight keratotome, with its point perpendicular to the corneal surface, is entered at a distance of 4 mm. from the outer corneal border at its horizontal meridian, and its plane made to correspond with that of the iris (Fig. 412). The keratotome is carried forward

until a cut of 6 mm. is made, which may be enlarged laterally as the knife is withdrawn if desired. If the capsule is intact, a cystitome is now passed into the wound, placed with its point at the opposite pupillary border in contact with the capsule, and this must be carefully torn as the instrument is withdrawn. If pressure is now made upon the outer part of the cut with the edge of a spoon, the wound will gape, and with gentle counter-pressure with the forceps on the other side the lens will be removed. Gentle pressure upon the cornea with the back of the spoon or with the finger through the closed lids may be made to clear up the pupillary space. This incision permits *suction* when the lens matter is soft enough, and for this purpose a Bowman's or Teale's syringe will be required.

From this linear operation, as a substitute for the old flap operation, was evolved the modified peripheral linear extraction of Von Graefe, a modification which has been so generally employed. This requires a speculum, fixation forceps, a Graefe's long, narrow cataract knife, curved iris forceps, scissors or forceps-scissors, cystitome, a hard rubber or shell spoon, spatula, and a wire loop (Figs. 413–417). Antisepsis and cocaïne are required. The lids are

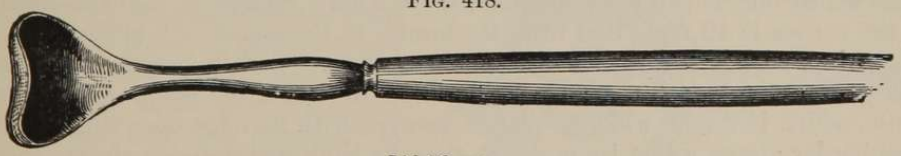
FIG. 413. FIG. 414. FIG. 415. FIG. 416. FIG. 417.



Cataract Knife. Cystitome. Capsule Forceps. Horn Spoon. Wire Loop.

controlled by the speculum or lid elevator (Fig. 418), and the ball held with spring forceps at a point near the inferior border of the cornea. The knife,

FIG. 418.

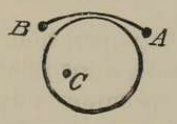


Lid Elevator.

which is 2 mm. in width, is placed flatwise at the upper border of the cornea to serve as a guide, and the point of entrance, which should be 2 mm. below a line tangent to the upper border of the cornea and 1 or 1.5 mm. behind the sclero-corneal margin, thus determined (Fig. 419). Its point should be directed toward C, and the blade must be pushed onward until it has entered the anterior chamber 7 or 8 mm., when the point is elevated by lowering the handle until it is directed to B, where a counter-puncture corresponding to the one at the point of entrance is made (Fig. 420). The blade should be passed well onward,

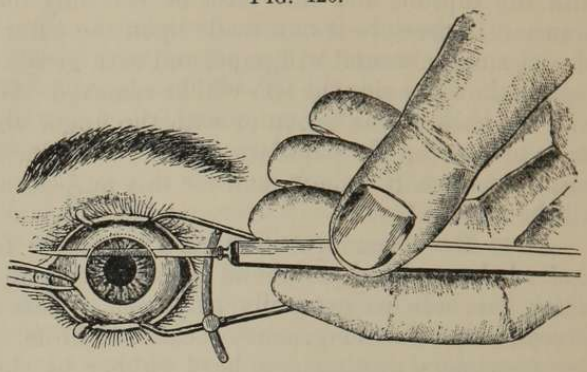
turned a little forward, and with a quick cut upward it should divide the tissues so as to be slightly within the conjunctiva. The advantage of this cut is its peripheral position, giving easy exit to the lens. But this cut was modified by Von Graefe so as to bring the knife out at the very margin of the clear

Fig. 419.



The Incision for Modified Peripheral Linear Extraction (Swanzy).

Fig. 420.



The Incision in Cataract Extraction (Juler).

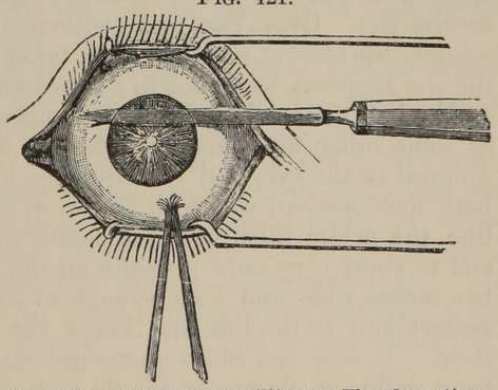
cornea, rendering it more linear, correspondent to a great circle of the eyeball, less apt to gape under movements of the ball or lids, and more prompt to heal. The next steps are an iridectomy, to prevent the prolapse of the iris into the peripheral cut, discission of the lens capsule, and the delivery of the lens by gentle pressure. The danger of injury to the ciliary body, and cyclitis, followed possibly by sympathetic inflammation, and of prolapse of the vitreous, due to the very peripheral position of the cut, has led to its abandonment by most operators and to the substitution of the following method, first proposed by De Wecker:

The Three-millimeter Flap Operation is the one most employed by prominent operators who have not taken the step forward, or perhaps backward, of extracting cataract without iridectomy. It has all the advantages of Graefe's incision, the cut unites quickly, it requires little or no care in dressing, and the edges of the wound have no tendency to separate easily and thus give rise to the accidents that attend flap operations, from the old one, in which one-half of the corneal border was cut away from its scleral attachment, to the lesser flap operations made by many distinguished surgeons in extraction without iridectomy. The dangers of a too peripheral cut are also avoided, and experience has shown that this method yields a high percentage of good results. It may be remarked, however, that the apparent difficulty of making this cut will be removed by one or two brief statements. We must remember that the diameter of the cornea is 12 mm., that from the border to the center is 6 mm., and hence that a line drawn midway between the upper border and the center of the pupil will give us the base line of the 3-mm. flap; so that if the blade of the Graefe knife, which is 2 mm. wide, be placed flatwise, with its edge over the clear corneal border above, a line 1 mm. lower than its back will indicate clearly enough where the point of the knife must be inserted. A second consideration is, that the entire cut, entrance and counter-puncture, is at the junction of the clear cornea with the sclerotic. In the more peripheral cut the entrance is in the opaque sclerotic, and as the blade descends into the anterior chamber the effect of refraction makes it appear one-third nearer to the posterior surface of the cornea than it really is, and unless the operator skilfully preserves the proper direction of the knife regardless of this appearance, he is apt to turn the point backward and to make his counter-puncture dangerously near, if not in, the ciliary region, and thus leave, after the completion of the cut, a gaping incision

larger than necessary, involving that portion of the eyeball where such an injury is most likely to be followed by dangerous inflammation. The patient needs little preparation: coughing or straining at stool must be considered and avoided. He may take a mild laxative the previous night. He should be undressed at the time of the operation, in order that he may remain as quiet as possible in bed for some hours after it.

The state of health as to chronic disease, or even advanced age, is of little importance. The presence of chronic conjunctivitis or purulent dacryo-cystitis would cause anxiety, and might lead to unfortunate complications. The most thorough antisepsis is indicated in every instance. The position of the patient in bed, chair, or couch, and the location and character of the light, must be carefully considered. There are many surgeons who have trained themselves to be ambidextrous, and these can take their position either in front of or behind the head of the patient and use either hand in making the incision. But for most operators the right hand must hold the knife, and the cut should be made while the surgeon is standing or sitting behind the patient when the right eye, and in front of the patient when the left eye, is to be operated on, in order to avoid interference with the patient's nose. A solution of eserine, 1 per cent., made with bichloride 1 : 5000, may be dropped into the eye fifteen, and again five, minutes before the operation. A solution of cocaïne, 2 per cent., in 1 : 5000 parts of the bichloride, may be dropped in the eye, and repeated until the cornea has become insensitive to touch. The lids externally and the entire conjunctival sac must then be freely washed with the bichloride, 1 : 5000, using especial care to disinfect thoroughly the canthi and puncta. The instruments must be rendered aseptic by boiling water or absolute alcohol, and then put in a 1 per cent. solution of carbolic acid until used. Pledgets of cotton wet with the bichloride solution must be at hand to remove blood, coagula, etc. The lids are held apart with the wire speculum. The surgeon takes a firm hold of the conjunctiva and subconjunctival tissues near the corneal border, at the lower end of the vertical diameter, and with the aid of the patient fixes the ball, turning it slightly downward. The point of entrance, usually 3 mm. below the apex of the cornea, having been determined upon in the manner described, the Graefe knife is passed into the anterior chamber, directly across it, and the point is made to emerge at a point 3 mm. below the apex, opposite the point of entrance. The blade is then carried well onward, so that enough of the cutting edge of the knife can be employed to make the rest of the section with one smooth, quick motion of the knife upward as it is withdrawn. The points of puncture and counter-puncture and the entire cut should lie just at the junction of the clear cornea with the sclerotic, as represented in the cut (Fig. 421). This completes the first stage of the operation.

Fig. 421.



Extraction by the Three-millimeter Flap Operation (Swanzy).

The iridectomy constitutes the second, and may be done more readily and with most precision when eserine is used, since the iris does not prolapse into the cut. The object now is not to remove a large portion of the entire width of the iris, but to make a small, narrow coloboma, involving the pupillary border, removing a

portion of the sphincter of the iris, and permitting the lens to escape. The iris forceps must be passed into the cut closed until the pupil is reached, when it is opened and a small portion of iris seized, withdrawn, and cut, either with three snips of the scissors, one on each side of the forceps and one at the base, or, if the coloboma is to be small, by passing the blades of the scissors from the cornea upward and cutting the iris with one snip close to the forceps. The latter method is more easy of execution, gives a better result, and is less dangerous, since the patient often makes involuntary movements of the eyeball at this stage, owing to the fact that the iris has not been rendered insensitive by the cocaïne. Great damage may result, even to the dragging away of the entire iris, from delay at this critical moment.

In the third stage the operator resumes control of the eye through the spring fixation forceps, having trusted it to an assistant while doing the iridectomy, and passes into the cut a properly-bent cystitome until it reaches a point near the lower border of the pupil, when he turns the point against the lens and divides its capsule with a cut upward and outward to the upper pupillary border: he returns the point to the lower margin, makes another upward cut inward, and unites these by a third across the base near the periphery of the lens. It is very desirable to have a full opening into the capsule, but great care must be taken to avoid the dislocation of the lens by any undue pressure upon it.

The fourth stage consists in the delivery of the lens, which is done by placing upon the lower half of the cornea the convex part of the rubber spoon or curette, and pressing backward and upward when the wound is seen to gape and the edge of the lens to present. A steady, gentle, and continued pressure upward is maintained until the greatest diameter of the lens has escaped, when it must be diminished to avoid a rupture of the zonula and the escape of vitreous humor. At the fourth stage the vitreous humor may appear before the lens escapes, and render any pressure upon the cornea impossible, or the lens may have been dislocated, and in these cases a vectis or wire loop must be passed gently and firmly down behind the lens, which is then lifted from the cut, the loop pressing it against the cornea. This is a most serious accident.

The fifth stage consists in the removal of any remaining cortical matter. This is done by gentle pressure of the spoon, aided, if it is thought best, by irrigation of the anterior chamber with a mild boric acid wash or by manipulation through the closed lids with the finger until the pupil presents a black appearance and the patient is able to distinguish the fingers at the distance of several feet. Great care and gentleness are required for this "toilette" of the wound: the clots of blood must be taken away with the forceps, the cut edges of the iris replaced, so as not to be incarcerated in the scar, and blood remaining on the ball removed by frequent application of the antiseptic lotion. Atropine or some other mydriatic, in solution, is instilled, the bichloride wash finally dropped in the eye, and the dressing applied. Preferably, the closed lids of both eyes are covered with pieces of antiseptic lint smeared freely with vaseline, the orbits filled with antiseptic cotton to keep the dressings in position and to exert very mild pressure on the eyelids; a strip of knitted black yarn, two inches wide and long enough to cover both eyes, is used. This dressing secures rest to the lids and keeps the dressings in position during a restless sleep. It does not cause undue pressure, and is easily removed if pain ensues from enforced closure of the lid and consequent retention of the tears. The color of the bandage enables the patient to go in the open ward of a hospital or to remain in a lighted room without discomfort or danger. A narrow flannel roller bandage may be preferred to keep the dressings in position. The

antiseptic wash may be used daily, and a mydriatic introduced without lifting the upper lid for several days. After the fifth day the dressings may be made lighter, and dark glasses or shades substituted, and usually in a fortnight the patient is able to leave his room.

The most serious complication is suppuration of the wound, rarer now than before the use of antiseptics. It is attended within the first twenty-four hours by severe pain of a continuous aching kind. On removing the dressing the wound may be found covered with a muco-purulent mass, the cornea may present some opacity, the iris be inflamed, and the eye be injected and full of tears. This may increase each hour, the anterior chamber become full of pus, the ciliary body and choroid become involved, and the eyeball be hopelessly destroyed by a panophthalmitis. In the less severe cases of inflammation which recover, the iris is generally drawn upward, the pupil perhaps occluded, and the vision useless until some further operation upon the iris can be done to make an artificial pupil. The treatment is either to cauterize the entire corneal wound by the galvano-cautery or to reopen the entire cut with a spatula and irrigate the anterior chamber and conjunctival sac with a bichloride solution, repeated, if necessary, at intervals of six hours, or a solution of silver nitrate, of the strength of 2 per cent., applied to the cut. Iritis is a frequent complication, due to the irritation of lens masses left behind or too early exposure to light or to cold. It should be treated by strict confinement to a dark room, leeching, hot fomentations, and opiates, with the persistent use of mydriatics. The danger of sympathetic inflammation and loss of both eyes gives these cases a peculiar importance.

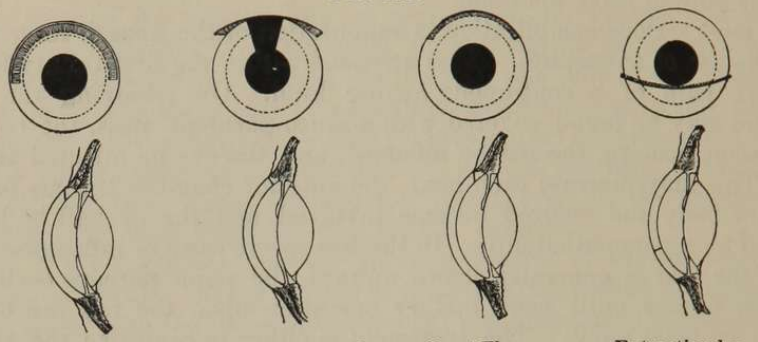
Cataract Extraction without Iridectomy.—This method is growing in favor. It is preferred by some of the most distinguished operators, and must be judged later by its results. The instruments and procedures differ but little from those described, except that the incision into the corneal border must be more extended, involving two-fifths of its circumference. After the laceration of the capsule more pressure is needed to dislodge the lens and force it through the pupil, and it may be difficult to remove the cortical material stripped off the surface of the lens. The main objections to the operation, however, are the liability of a prolapse of the iris, its incarceration in the wound, and the danger of cystoid cicatrix. The use of eserine in the after-treatment is imperative, whereas atropine would be indicated where an iridectomy had been performed. A more careful adjustment of the bandage and its retention until the sixth day are also necessary.

It may be useful to compare briefly the various methods of making the corneal incisions and their advantages:

The old flap demanded the division of one-half the entire corneal attachment, and was made by pushing a Beer's knife through the sclero-corneal border, entering it on the horizontal line, and dividing the cornea through half of its periphery. No iridectomy was done, but suppuration frequently took place, and great difficulty in keeping the cut parts in apposition was encountered. The reverse of this is true of the original Graefe cut at the very periphery of the anterior chamber, linear in form, its edges remaining in close contact, but demanding iridectomy to remove the prolapsed iris. The irido-cyclitis so often following led to the three-millimeter cut, and now a still larger flap without iridectomy is in vogue. To fix this in the mind (Fig. 422), we may remember that Graefe's cut is 2 mm. below the apex of the cornea, the three-millimeter cut 1 mm. lower, and the cut for the last method 4 mm. below, or 2 mm. above the horizontal diameter of the cornea. One may compare the cornea to the dial of a watch, and remember that Graefe's

cut should extend from 1 to 11 o'clock, but that the puncture and counter-puncture are $1\frac{1}{2}$ mm. behind the transparent cornea. In the three-millimeter

FIG. 422.



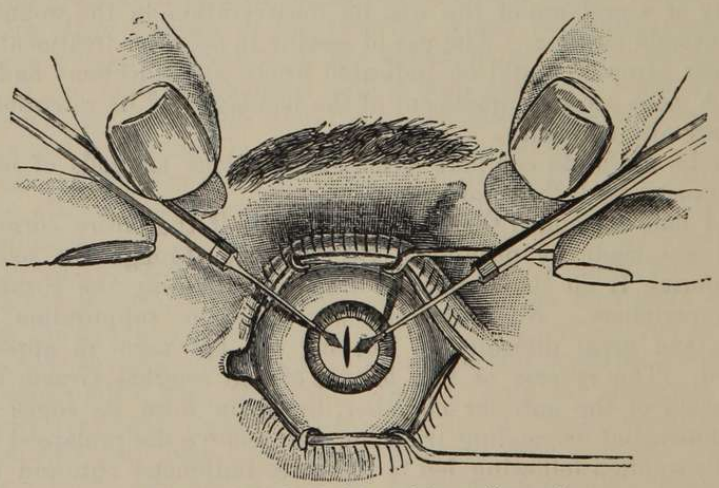
Flap Extraction. Modified Peripheral Linear Extraction Short-Flap Extraction. Extraction by Corneal Incision.

(De Schweinitz.)

cut the puncture and counter-puncture would be from midway between 1 and 2 to midway between 10 and 11 o'clock, whilst the method without iridectomy requires a puncture and counter-puncture at 2 and 10 o'clock, or, better, from between 2 and 3 to between 9 and 10 o'clock, and the old flap from 3 to 9 o'clock. The first cut involves less than one-third of the total corneal circumference; the second, one-fourth; the third, one-third; and the fourth, one-half of it. The optical and cosmetic results are probably better without iridectomy, but where an opaque capsule has to be torn or displaced a coloboma may be an advantage

The test of time alone will decide which method will become the favorite, but we can all perceive that if we avoid injury to a tissue like the iris, as in the last method, we are obliged to incur the danger of a larger incision in the sclero-corneal junction as a consequence, and to give more careful attention

FIG. 423.



Bowman's Method of Capsulotomy (Swanzy).

to the dressing and after-treatment of the case than in the former operations with iridectomy.

We owe to Knapp the most complete method of simple extraction, and from

personal observation in his hands, experience, and a study of his statistics it appears at this time to offer the best prospect for success.

Operation for Secondary Cataract is required in cases where the capsule is wrinkled in the healing process or becomes partially opaque from changes in its epithelium, or where iritis has left a membrane, more or less dense, which prevents the transmission of light. The first class requires the tearing of the thin capsule with a single needle, as in the needle operation, with, of course, cocaïne, a mydriatic, antiseptics, and perhaps artificial light. The second class may be treated by Bowman's method, with two needles, one to fix and hold the thickened capsule, the other to tear it sufficiently (Fig. 423). The third class demands the operation of *iridotomy*. With a needle-knife a cut is made in the iris at that point where the strain upon the fibers gives the best reason to hope for a gap after the incision. Or De Wecker's forceps-scissors, with one sharp and one blunt blade, may be passed into the anterior chamber through a vertical incision 3 mm. long, and the same distance from its border, and the sharp point thrust through the thickened iris and a portion cut by closing the blades.

STRABISMUS OPERATIONS.

These operations may be divided into two classes, and are limited to the tendons of the muscles which cause the deviations. They are divided into *tenotomies* and *advancements*.

Tenotomy.—The instruments required for this operation are the spring speculum, straight blunt-pointed or slightly curved scissors, sharp-pointed forceps, and two strabismus hooks. The highest degree of success is not to remove a cosmetic defect only, but to obtain, if possible, proper binocular fixation. This belief led Thomson to dispense with ether long before the days of cocaïne, since frequent testings with a candle-flame, colored glasses, and prisms are necessary to enable the operator to learn from the patient when the eyes are placed in the position most favorable for normal fixation. The anesthesia of cocaïne in a 2 per cent. solution is sufficient to render these operations painless, and does not affect the results. A solution, 1 : 5000, of corrosive sublimate should be freely used before the operation and after it has been completed.

Graefe's Method is the one most in use, as it enables the effect of the tenotomy to be limited or increased by a greater or less division of the conjunctiva and capsule of Tenon from the tendon, and allows, moreover, the use of a limiting suture placed horizontally when it is found that the result obtained has been greater than was desired. The surgeon places himself in front of or behind the patient according to his convenience. With the forceps he picks up a fold of the conjunctiva over the attachment of the tendon and makes a vertical incision through it. Through the opening thus formed he passes the points of the scissors, and by snips separates the conjunctiva as his judgment directs. He may go as far back over the muscle as the caruncle if a very large effect is desired. He then introduces the hook, and turns its point beneath the tendon at its upper or lower border, lifts it up, introduces the scissors, and divides it fully at its attachment into the sclerotic. The second hook may now be swept above and below to ascertain if any small shreds of tendon have escaped. No suture will be required unless it be found that the effect is too great, when a needle with silk can be introduced as far backward into the conjunctiva as may be wished, brought out through the conjunctiva near the cornea, and tied.

Arlt's Method is more brilliant: after the first division of conjunctival and

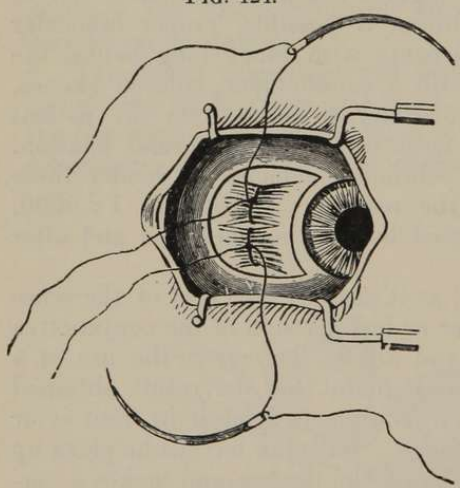
subconjunctival tissues the tendon is seized with the forceps and divided with the scissors.

Critchett's Subconjunctival Method is much used in England.

Snellen's Method enables the operator to divide the tendon with but little disturbance of the conjunctiva and capsule. A horizontal incision is made in the conjunctiva over the middle of the insertion of the tendon, which is then picked up with the forceps and snipped in its center by the points of the scissors. Through this opening a small strabismus hook is passed upward, catching one-half of the tendon, which is divided, and then downward in the same manner. This method of attacking the middle of the tendon and cutting each half separately, when done with delicate instruments, enables us to divide the tendons of all the straight muscles through very small incisions in the conjunctiva in cases of heterophoria or latent squint, involving often the superior and inferior recti.

Advancement of a Rectus Muscle.—An incision is made vertically in the conjunctiva of the width and at the insertion of the tendon, which is isolated by lifting it upward with the hook. Two needles with sutures are then passed from above and below and from within outward through the middle of the tendon, and each suture tied upon it, leaving one end of each long. The tendon is then divided, the conjunctival flap near the cornea loosened, and the needles passed through it, it may be as far as the vertical meridian of the globe, one above and one below the cornea. The proper ends of the sutures are then tied (Fig. 424). Or, after the tendon has been exposed, a suture may be placed around it and securely tied and the tendon divided. A stout silk suture, having one needle at its center and one at each end, having been prepared, the tendon is lifted up and the suture is then drawn outward through the base of the tendon and the conjunctiva; the other needles can be passed, the one above and the other below, beneath the flap of conjunctiva, and brought out in the conjunctiva near the vertical meridian of the cornea. The first thread may be cut away with a portion of the tendon; the middle needle is then cut off, leaving two ends. Each suture can now be knotted, and nearly equal traction made on the muscle as it is brought forward. These operations may cause severe reaction, and the eye should be kept quiet under a retentive bandage for twenty-four hours or more, and dressed antiseptically each day.

Fig. 424.



Advancement of External Rectus (Swanzy).

Allusion has been made to operations on the tendons for the treatment of so-called insufficiencies in cases of muscular asthenopia and for the relief of reflex neuroses. The subject is too broad and too little understood, however, to warrant description in a work of this character. The operations involve tenotomies and partial tenotomies, which are, in the main, performed by methods already described.

CHAPTER XI.

SURGERY OF THE EAR.

CONGENITAL DEFECTS.—Congenital defects consist in total absence, plurality, and abnormal position and shape of the auricle; partial or defective development also appears in some instances as the person grows older.

Congenital defects in the auricle may be confined to one side or may occur on both sides of the head, in conjunction with other defects induced by altered or imperfect development of the visceral arches. These defects generally interfere with fineness of hearing. Supernumerary auricles or parts of the auricle may coexist with perfect hearing in some cases. Such appendages may be amputated for purely cosmetic reasons. Malformations of the auricle are generally observed in connection with defects in or absence of the external auditory canal. In an incomplete development of the integumental part of the ear—viz. of the auricle and outer part of the soft meatus—there is usually absence of the tympanic ring, and consequently of the bony auditory canal. There is generally also a defective tympanic cavity, and often an attendant irregularity or deficiency in the development of the malar, palatal, and maxillary portions of the face and mouth. In deformities of so high a grade a normal auditory canal has never been found. When no auditory canal exists, the auricle is usually nearer the cheek and neck than in a normal case, and is very movable in all directions. This should be a guide in determining the surgeon not to operate, as an operation for an artificial canal would be useless in view of the fact that a normal osseous canal does not exist beyond such a defective auricle and meatus.

Congenital Fistula of the Ear is a rare form of arrested development near the ear. It consists in a deep fossa or small fistulous opening close in front of the tragus or in the helix, or just in front of it above the tragus, or in the concha, which may extend in some cases as far as the tympanic cavity. It may be symmetrical, and in some instances, after earache, pus may be discharged from it. The cause of the anomaly seems to be an arrest of development in the first visceral cleft. It does not demand treatment unless it should form the exit of a chronic purulent discharge, and then antiseptic injections are required.

DISEASES AND INJURIES OF THE AURICLE.

FROSTBITE.—In very cold weather in our latitude and in cold climates every winter frostbitten ears are not uncommon. No special treatment is demanded in acute cases. Care must be taken to avoid too sudden a reaction from cold to heat, and also not to break the now brittle auricle. The gentle application of snow or iced water at first, followed by the gradual application of warmer water, is the best means. If vesicles and subsequent excoriations occur, the access of air to the affected parts must be prevented by the application of emollient cerates or soft linen smeared with vaseline, cosmoline, albolene, or glycoline.

MORBID GROWTHS.—The auricle may be the seat of various morbid growths, such as cysts, angioma, myxo-sarcoma, nævus, fibrous tumors, sarcoma, epithelial cancer, lupus, and glandular hypertrophy of the lobule. Their treatment

should be guided by the general principles of surgery, and does not demand special attention here. In general they should be removed.

Othematoma (*Hematoma of the Ear*) demands a special word or two, as an idiopathic form occurring in the insane is described by some writers. This peculiar blood-tumor of the auricle is characterized by congestion and heat in the auricle and a rapid effusion of blood between the cartilage and perichondrium. The tumor in the course of a few hours or a day attains the size of a large bean or an egg at the upper part of the auricle, the color of which may remain normal or become purplish. Though the tumor is somewhat dense, fluctuation can be detected in it, and generally there is some burning pain in the new growth, with a feeling of weight and distention. The earliest manifestations of the disease are rapid, but after the tumor has fully formed it may remain apparently indolent for days or even weeks. At last it may rupture spontaneously, the most frequent mode of disappearance, or its contents may coagulate and absorption take place without rupture, causing considerable deformity, but much less than when the tumor ruptures spontaneously or is opened artificially (Hun). Its occurrence is more frequently unilateral, but an attack on one side is often followed by an attack on the other. The tumefaction rarely extends to the meatus and interferes with hearing, and the lobule is never implicated in othematoma.

Etiology.—It seems highly probable that othematoma is always traumatic, but that it requires very little violence applied to the auricle in the insane, with their weakened vascular system and general turgescence of the head, to produce this kind of tumor on the auricle. The undoubtedly traumatic variety is seen frequently in boxers.

Treatment.—The sac is not to be opened by the surgeon unless suppuration takes place. Then the cavity of the sac should be washed out with a 1 per cent. solution of carbolic acid, and the walls of the sac brought together and kept so by gentle compression. In all other cases painting the tumor with iodine, gentle pressure, and massage of the growth will be the best treatment. Some deformity will ensue in any case, but the least under the last-named course. In a sthenic form, with much heat and redness, the careful application of ice may be added to the iodine painting.

Operation for the Correction of the Deformity of Prominent Auricles.—There are three methods of operating for correcting this deformity: first, that of Ely, in which an oval piece is taken out of the entire thickness of the auricle, including skin and cartilage; a second is that of Keen, in which a large oval piece of skin is taken from the back of the auricle and a vertical V-shaped groove then cut in the cartilage. Great care must be taken not to cut through the skin on the anterior surface of the auricle in this method. The cartilage may be brought together by two or three buried catgut stitches, in addition to those put in the skin-edge of the cut. In one of Keen's cases the cartilage of one ear was thus stitched, while the other was not. The result was equally satisfactory on the two sides. The stitches were purposely not removed until the tenth day. A third method is that of Monk of Boston, consisting in the removal of skin alone from the back of the auricle, as it is claimed that this is all that is required unless the auricular cartilage should be very thick and stiff, as in some adults. Of course the wound must be dressed antiseptically, and the auricle bound against the head with bandages for from ten to twelve days. As a precautionary method some kind of bandage or night-cap should be worn at night for several months to take the strain off the cicatrix and prevent the patient from forcing the pinna forward by turning on the pillow.

Injuries of the Auricle.—The general surgeon is often called upon to treat wounds of the auricle. These consist in injuries from various weapons and from blows and bites. The treatment should consist in adjusting the wounded and displaced parts, keeping them in position with a few judicious stitches, and then the general principles of antiseptic surgery must be observed during the rest of the treatment.

Traumatic Cleft of the Lobule.—A not uncommon injury of the auricle is due to tearing out an earring, thus leaving a cleft lobule. If left to nature, as it generally is, this wound heals by forming skin over both cut surfaces of the two flaps. The ear then seems to possess two teat-like lobules.

Treatment.—An operation similar to that for hare-lip entirely removes the deformity of the lobule.

DISEASES AND INJURIES OF THE EXTERNAL AUDITORY CANAL.

Otitis Externa Circumscripta, or Boil.—Circumscribed inflammation in the external auditory canal, or furunculosis, is a very common and painful disease of the ear. It is generally due to the efforts of the patient to clean his own ear by boring or swabbing it with some form of probe. This manipulation on his part rubs dirt into the hair-follicles of the meatus and external canal, and septic matter, being thus impacted, sets up inflammation in the follicles, causing the formation of boils. These may be very small, but if seated in the canal beyond the meatus are always very painful. The patient experiences rather suddenly a sense of itching in the canal of the ear. This leads to scratching, which, however, aggravates the congestion and swelling, and soon the ear becomes sensitive to the touch and very painful.

Treatment.—Unfortunately, at this stage all kinds of applications are used in the ear, which only make it worse. Syringing with very warm water as often as the patient desires is always safe and soothing. But all irritating applications must be avoided, as they increase the swelling in the inflamed skin and augment the pain. Black-wash and glycerin—seven parts of the first to one part of the second—may be dropped into the ear if the furuncle is deep in the canal, or cotton soaked with this mixture may be applied directly to the boil if within easy reach, and kept constantly upon it until resolution or suppuration occurs. It is *not* best to incise a boil in the ear unless it has acquired a distinct suppurated head. Incision before this period only increases the swelling, intensifies the pain, and opens a fresh furrow for the implantation and growth of septic germs. Twenty per cent. solutions of ichthyol in water or in glycoline tend to shorten furuncles in the ear.

Otitis Externa Diffusa.—Diffuse external otitis, involving generally the superficial portions of the skin lining the external auditory canal, is usually the result of the entrance of some irritant. It is characterized by general diffuse redness and swelling of the skin lining the auditory canal, with narrowing and closure of the passage and sometimes great pain.

Treatment.—Instillations of warm alcohol, black-wash, ichthyol, and lead-water generally relieve the inflammation and pain.

Tumors.—In the auditory canal are found hyperostoses, exostoses, wens, epithelial cancer, lupus, and polypi. The latter may be considered best under Chronic Purulent Otorrhea.

Hyperostoses and Exostoses.—Exostoses are probably of rheumatic origin. They are found sometimes in subjects of otorrhea, but most frequently in the ears of those who swim a great deal and into whose ears cold water frequently enters. In both instances fluid matter which flows from and into the

ear acts as an irritant. In the case of the swimmer, as, for example, in the aborigines of the Sandwich Islands, whose ears always contain exostoses (C. J. Blake), the latter seem to be thrown up by nature as a barrier to the entrance of cold sea-water into the ear. Hyperostoses demand no treatment unless they mechanically close the auditory meatus and produce hardness of hearing. Then, with the patient under ether, these growths may be drilled through their base (they are usually conical in shape) at two or three points with a drill 1.50 mm. in diameter, and the tunnels thus made split through simultaneously by a smart blow from a small chisel struck by a hammer. The propelling power of the drill used for tunnelling the base of the exostosis is the dental lathe. When exostoses are pedicellated, like a polypus, as they sometimes are, and are situated near the meatus, they may be cut off by severing their bony pedicle with stout bone forceps or by a sharp blow at the pedicle by means of hammer and chisel, without etherization. In using the drills run by the dental lathe care must be taken not to run too long without a pause, as prolonged boring of the ivory-like bone with the swiftly-turned drill soon produces intense heat, and the patient may be burnt. Before drilling or in any way cutting into these bony tumors the skin should be removed from the point of operation by means of what dentists call a "scaler."

Wens, or Sebaceous Tumors, resembling those found in the scalp, are sometimes found in the outer part of the auditory canal. These grow rapidly and entirely close the meatus, producing tinnitus and deafness. Their continued growth causes ulceration in the walls of the canal, usually the upper one, and the cerebral cavity may thus be involved, fatal cases having been reported by Toynbee. They should be incised at once, their contents turned out, and the sac well cauterized. If seen in time and promptly treated, they can be entirely removed, the hearing restored, and all bad results prevented.

Epithelial Cancer is not uncommon in the external auditory canal. Its rather rapid growth, its tendency inward to deeper parts of the ear, and the pain caused by its growth in a confined bony cavity will aid in diagnosis. With the patient under ether the diseased tissues may be scraped away with a sharp spoon. In such an operation the illumination of the auditory canal by means of the electric head-lamp is essential if ether is used as the anesthetic.

Wounds.—The most common wound in the auditory canal calling for surgical consideration is a rupture in the delicate skin lining the canal, producing hemorrhage. This occurs in consequence of blows near the ear or falls in which the head or the mastoid is struck. Sometimes hemorrhage occurring after such an injury leads to the suspicion of a fracture at the base of the skull, but examination will reveal the rupture of the skin in the canal and the hemorrhage from it. (See Fracture of the Base, p. 510.) Such hemorrhage usually requires no further treatment than syringing with hot water.

Collections of Cerumen or Wax in the Ear.—Through the efforts of patients to cleanse the meatus by swabbing in some form, cerumen is often pushed in, rather than taken from, the external ear. This improper hygiene (for ear-wax is not "dirt," and all that is superfluous will fall from the ear if not pushed back and impeded) leads to the collection of obstructive masses which cause singing and buzzing in the ear and more or less hardness of hearing.

Their presence is diagnosticated by the appearance in the meatus of a brownish object filling the caliber of the canal, and they are most easily and safely removed by syringing with warm water. They may be previously softened by the instillation of soapsuds or a solution of bicarbonate of sodium in water and glycerin, as follows: ℞ Sodii bicarb., gr. xx; glycerini, f℥j; aquæ, q. s. ad f℥j. Ten or fifteen drops of this, warmed, may be dropped into the

ear several times during the day before the final syringing. Usually, however, simple warm-water syringing is all that is required.

FOREIGN BODIES IN THE EAR.—Extraneous foreign bodies liable to get into the ear may be divided into two classes: viz. *animate* and *inanimate*. In the *first* class are to be placed roaches, fleas, bedbugs, flies, and various small insects. The movements of all such usually found in the ears of adults are extremely painful, especially if maggots, from the larvæ of flies, gain a hold in the sensitive skin of the auditory canal. A drop or two of sweet oil or any fixed oil of equal blandness will instantly smother all insects, and they can then be removed by syringing or by means of slender forceps carefully used under perfect illumination of the ear. Maggots must be killed by a few drops of ether or chloroform instilled into the ear. They then require careful removal with forceps.

The *second* class, the inanimate objects, are usually found in the ears of children, where they are put in play. They comprise beads, beans, peas, little buttons, and the like. The mere presence of such objects in the ear is of no serious consequence, unless they are liable to swell from moisture, as dried peas and beans do. Most of the accidents following the entrance of an inanimate foreign body into the ear are the results of harsh and unskilful endeavors to remove such an object from the ear. It is better to allow the foreign substance to remain in the ear indefinitely than to do the wrong thing for its removal.

A few syringefuls of warm water will usually remove any foreign object a child can put in its ear. But if, instead of this, harsh methods are employed, inducing swelling in the skin of the canal and closure about the foreign body, or if the foreign body itself swells and produces much pressure, then the patient suffers greatly, and only a careful and skilful surgeon can remove the object now impacted in the auditory canal. In such a case the patient must be etherized and the foreign substance dislodged and drawn out by means of small blunt hooks or special forceps, to be applied only under perfect illumination and by a skilful hand. *Molten lead* sometimes is poured into the ear intentionally or by accident. Shield has recently used metallic mercury to remove it, and thus has avoided a difficult and dangerous operation.

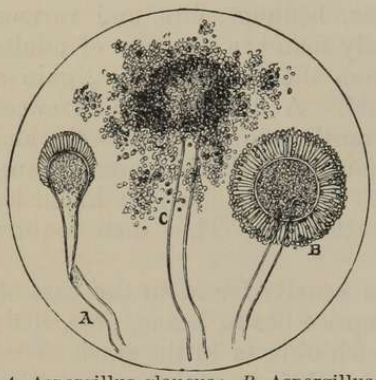
DISEASES AND INJURIES OF THE MEMBRANA TYMPANI.

MYRINGITIS.—The membrana tympani is always involved in any inflammatory process in the external or middle ear. The only disease limited to or originating in the membrana is an acute myringitis. This may be excited either by the entrance of cold air or cold water or any external irritant into the ear, and also by the growth of the fungus aspergillus upon the membrana.

The **symptoms** are pain of a stinging, sharp nature, when the myringitis is excited by the entrance of cold water or cold air into the auditory canal. When the myringitis is excited by the growth of the *aspergillus* on the drumhead, the symptoms consist in itching, stinging, and some slight pain in the ear, soon followed by a scanty watery discharge. In the first instance the membrana will be found reddened, lustreless, and swollen. In the second instance, a false membrane, looking like wet newspaper, will be seen covering the membrana and sometimes extending outward over the walls of the canal. When the false membrane is removed, the membrana tympani will be found macerated and reddened.

The **diagnosis** of aspergillus in the ear can be confirmed only by the microscopical examination of a small piece of the false membrane (Fig. 425).

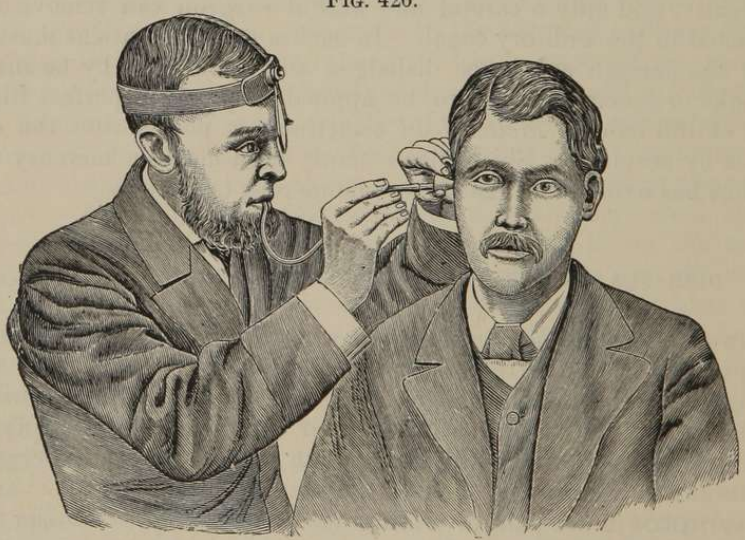
Fig. 425.



A, Aspergillus glaucus; *B*, Aspergillus niger; *C*, ripe fructiferous head of Aspergillus niger throwing off spores (Burnett).

Treatment.—In a case of ordinary myringitis from the entrance of cold water or cold air into the ear, dry heat, applied over and about the auricle, will give the quickest relief. Nothing should be dropped into an ear thus inflamed, as pressure mechanically increases the inflammation and pain. If the congestion of the membrane is intense, a few scarifications with a paracentesis knife will give relief. If secretion forms, the ear must be syringed with a warm solution of carbolic acid (1 : 40), and then a little boric acid powder blown into the ear. When the membrana tympani is attacked by aspergillus, the false membrane should be detached, preferably by syringing with warm water and alcohol, one part of the latter to three parts of the former, or by gentle detachment by means of a probe or slender forceps under perfect illumination from the forehead-mirror. After the ear is thus cleansed, a little powder, composed of one part of salicylate of chinoline to sixteen parts of boric acid, should be insufflated into the ear and over the membrana tympani (Fig. 426). One application of this powder usually suffices to sterilize the region where the fungus has gained a hold and to prevent its further growth. In all

Fig. 426.



Burnett's Method of insufflating Powder into the Ear (Burnett).

insufflations of powder into the ear only enough should be blown in to cover the fundus slightly: it should never be packed in nor put in in large quantities.

Injuries of the Membrana Tympani.—**Ruptures** of the membrana result from explosions, boxes on the ear, and direct perforating wounds, as from slender pencils, twigs, etc. When the membrana is thus accidentally and violently ruptured, usually there is at once a ringing sound in the affected ear, with more or less altered hearing. There is commonly also pain in the ear

when the membrana is perforated by direct violence from a slender-pointed object, such as a pencil or pen-holder. In many instances there are nausea, vomiting, and dizziness immediately after traumatic perforation.

Treatment.—As soon as a membrana tympani has been thus violently ruptured the ear should be gently plugged with some aseptic or antiseptic cotton. Nothing should be dropped or syringed into the ear, as the entrance of anything through the perforation into the tympanic cavity will inflame the middle ear. In most cases, if the meatus is stopped as just directed, the perforation will heal in a few hours, or at most in a day or two. In medico-legal questions arising in a prosecution for injuries to the membrana tympani the previous condition of the wounded ear should be ascertained, and also whether or not anything was put into the ear, except the cotton stopper at the meatus, after the rupture in the drum-membrane occurred.

DISEASES OF THE MIDDLE EAR.

The **middle ear,** or tympanic cavity, *is the seat of from 75 to 85 per cent. of all aural diseases.* The acute processes are known as otitis media catarrhalis and otitis media purulenta. The first is a common result of a "cold in the head," while the second is found as a sequel to the exanthemata and to diphtheria in children.

The **earache** of childhood is caused by an acute inflammation in the middle ear. Sometimes it does not go beyond a catarrhal form: more commonly it passes into the purulent form of otitis media.

When a child or an adult is found to be suffering with a **catarrhal otitis media** (the purulent form often begins as a catarrhal or mucous form of inflammation), it is a mistake to begin dropping various medicaments into the ear to soothe the pain, as the mechanical pressure alone increases the sufferings of the patient. If anything can be endured, it will be found to be hot water irrigation. The most efficacious means of relief to pain in acute otitis media, in the catarrhal stage, is *dry heat*, kept constantly over or in front of the auricle. This can be accomplished by a flat four ounce bottle filled with very hot water, or by the hot water bag, or by means of a Japanese hand-warmer or small tin "kiro." If none of these simple methods of applying dry heat to the aching ear relieves the pain, no form of drops will. If the pain is still severe and continuous, an anodyne may be given internally. No form of inflation of the tympana should be employed in acute otitis media, lest septic matter from the simultaneously-inflamed naso-pharynx be forced thereby into the middle ear and further irritation ensue in that cavity. The continuation of the pain indicates the probable passage of the catarrhal otitis into a *purulent otitis.* If spontaneous rupture of the membrana and an outflow of exudation do not take place after six or eight hours of continuous and increasing pain, the membrana tympani must be artificially perforated by an incision with a paracentesis knife. In children this will usually require the administration of ether to keep the chlid still enough to make the incision properly. When secretion takes place behind the membrana tympani, the latter will be seen to bulge below the folds of the membrane. If the secretion is in the attic space (the upper part of the tympanic cavity), the membrana flaccida (the part above the folds) will be found red and bulging, while the membrana tensa (the part below the folds) will be found nearly normal. Pus rarely collects in both spaces at once, so that the membrana tympani is not found bulging at the same time both above and below the folds. In any case of otitis media acuta, if the pain continues, it is well to incise freely the reddened and inflamed membrana at its

most prominent point, without waiting for positive signs of the formation of pus in the drum-cavity. To do this properly, even in adults, the patient should be etherized. This method always shortens the painful period and favors a rapid recovery.

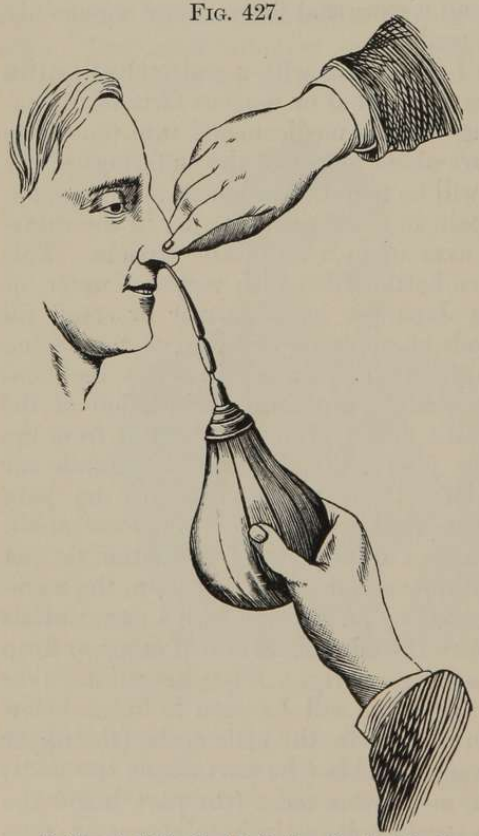
The chief *chronic* diseases of the middle ear are called "chronic catarrh" and chronic purulent otitis media or chronic otorrhea.

As soon as discharge from the ear sets in, either after a spontaneous or surgical perforation of the membrana, the ear should *not* be syringed, but drained by a narrow strip of iodoform or carbolic-acid gauze placed in the canal for about an inch, but not far enough to touch the membrana, and the concha filled with a soft cushion of iodoform or boric-acid cotton. The ear should now be left alone for twelve hours, or even longer, according to the quantity of the discharge. If the cotton in the concha becomes saturated, a fresh tuft may be put in. The outflow of exudation must be thus promoted, and secondary infection by pyogenous germs avoided by abstaining from putting any form of medication in the ear-canals.

Chronic Catarrh of the Middle Ear is generally due to repeated attacks of acute catarrh of the naso-pharynx and middle ear. At last a chronic hypertrophic condition, followed by a sclerotic process, is induced in the mucous membrane of the tympanic cavity and its contents, the ossicula auditûs.

Treatment.—As chronic catarrh of the middle ear is usually caused by chronic catarrh of the naso-pharynx and Eustachian tube, these parts must be treated in order to overcome the impediment to aëration of the drum-cavity produced by the catarrhal swelling of their mucous lining. At the same time the drum-cavity must be artificially inflated, so as to overcome the retraction of the membrana tympani and the ossicles of hearing and their partial ankylosis. If the hypertrophic catarrh of the naso-pharynx is in an early stage, sprays, as set forth in the standard rhinological text-books, may be thrown into the nares and naso-pharynx once daily or thrice weekly according to the severity of the disease. Then the tympana are to be inflated either by Politzer's method or by the Eustachian catheter.

Fig. 427.



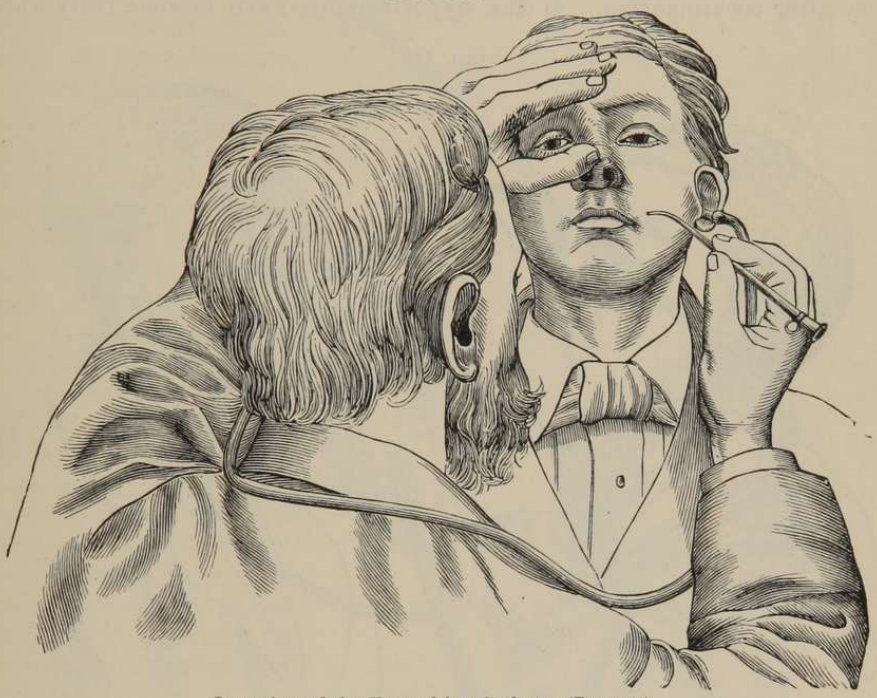
Politzer's Method of Inflating the Middle Ear.

Methods of Inflation of the Tympana.—There are several methods of inflation of the tympana. The one most widely and easily employed is *Politzer's*. In this method air is thrown into both tympanic cavities at the moment of swallowing. To ensure swallowing at the desired moment, the patient is given a sip of water, to be held in the mouth and swallowed at the command of the surgeon when he is ready to inflate. An inflation-bag specially arranged for this method is

used (Fig. 427). Instead of swallowing water, patulence of the Eustachian tube may be obtained by causing the patient to distend his cheeks with his breath, as suggested by Holt of Portland, Maine. *Valsalva's method* of self-inflation consists in the patient's holding his nose and, with his mouth closed, forcing his breath into the naso-pharynx and middle ear. But this method, being attended with great congestion of the head, is not advisable in the vast majority of cases.

The only method of inflating one tympanum at a time is by means of the *Eustachian catheter.* This instrument consists of a tube of pure silver or hard rubber, from 13 to 16 cm. long and from 1.50 to 2.50 mm. in outside diameter, and slightly curved at its distal end, as shown in Fig. 428.

FIG. 428.



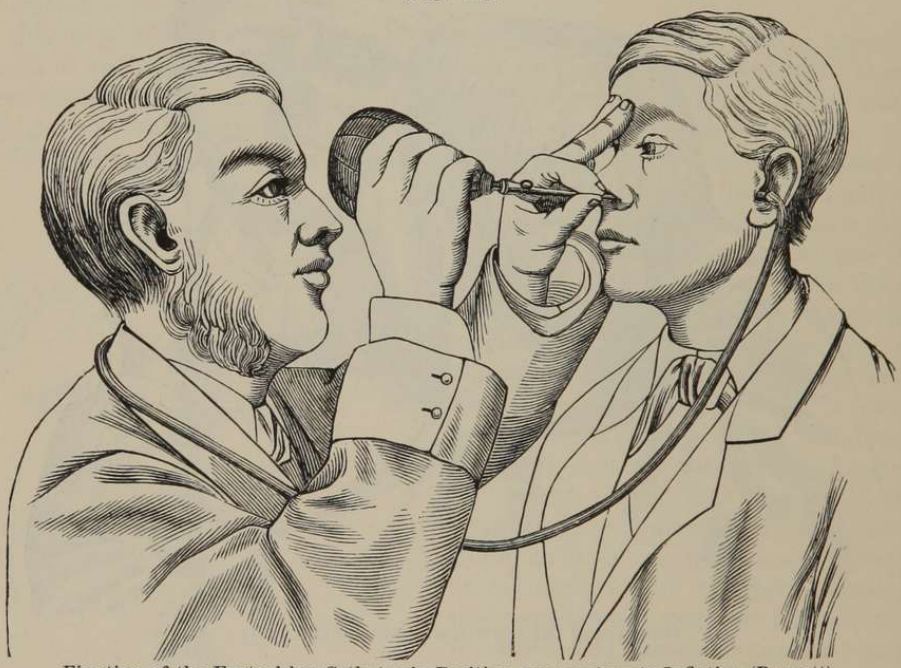
Insertion of the Eustachian Catheter (Burnett).

Provided with a catheter, auscultation-tube, and inflation-bag, the surgeon may proceed to catheterization of the Eustachian tube. The patient should sit far back in the chair, his head being supported. The face must be kept in the median line and the chin well down. The surgeon may sit or stand as he wishes. The auscultation-tube should be about a yard long, with small ivory or bone tips to fix in the meatus. One tip must rest in the surgeon's ear, the other in the patient's ear. Then let the surgeon lift up the end of the patient's nose with his left thumb, the left hand being supported against the patient's forehead, as in Fig. 428, and grasp the catheter, as he would a penholder, with the right hand. Now insert the beak of the catheter into the nostril corresponding to the ear to be catheterized, and with a compound upward and backward motion carry the instrument along the floor of the nose until the beak reaches the posterior pharyngeal wall. The ring at the proximal end of the catheter must be in the plane of the curve of the beak, and will then always show the position of the latter. The ring should point directly downward when the beak reaches the naso-pharynx. With the distal end of the

catheter at the posterior pharyngeal wall, the beak should be turned outward toward the ear to be catheterized. This movement throws the beak into the fossa of Rosenmüller. Now draw the catheter forward, letting the beak slip over the large posterior lip of the Eustachian tube, and, as soon as this is done, turn the catheter so that the ring-indicator will point toward the catheterized ear at an angle of 45°. As soon as this is done the beak slips into the faucial mouth of the Eustachian tube. The middle ear is then inflated by the Politzer bag as shown in Fig. 429. No form of inflation of the tympana should be applied if the naso-pharynx is filled with secretion, for fear of secondary infection of the middle ear.

If the hypertrophies in the nares do not disappear under local and general medical treatment, the soft hypertrophy may be incised with the electro-cautery after cocaïnization. If the hypertrophies have become truly fibrous,

FIG. 429.



Fixation of the Eustachian Catheter in Position, preparatory to Inflation (Burnett).

they may be removed by means of Jarvis's snare. If all these means fail to give relief to the dulness of hearing, and the tinnitus aurium and vertigo continue, entire relief of the tinnitus and vertigo may be given by tympanotomy and liberation of the stapes by the removal of the incus, the membrana and malleus being left in position. This operation requires entire quiescence, not to be gained except under anesthesia, as it is most painful. The ear is illuminated by a six-volt electric lamp (2 to 3 c. p.), held on the forehead by a head-band and supplied by means of a portable storage-battery.

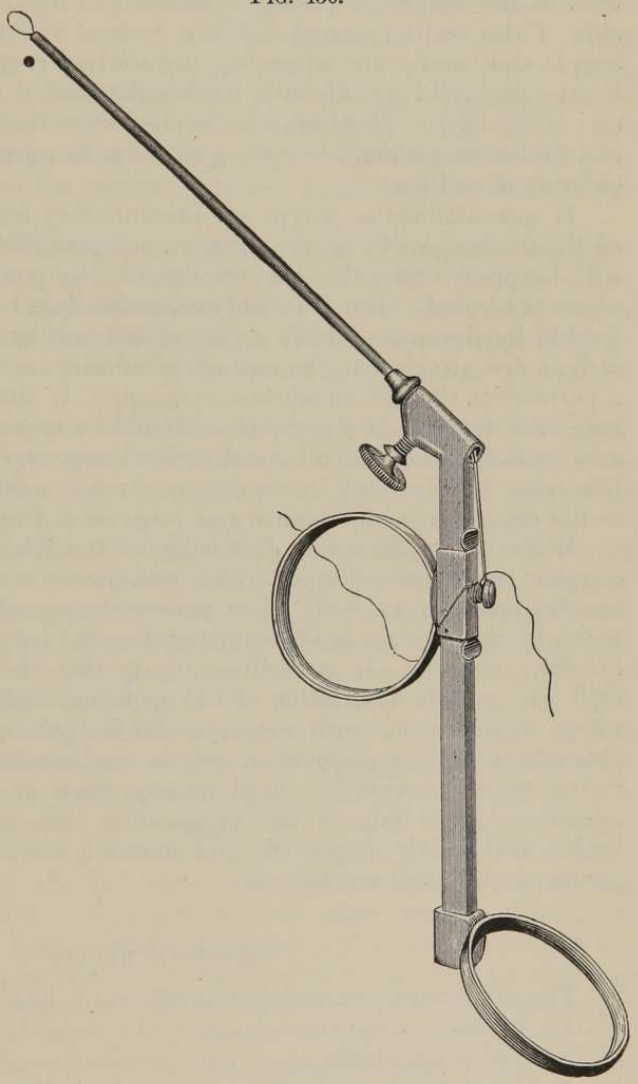
CHRONIC OTORRHEA, or OTITIS MEDIA PURULENTA CHRONICA, the second disease named at the head of this section, is one of the commonest, most disagreeable, obstinate, and dangerous of aural diseases. It is usually a sequel of scarlatina, less frequently of measles.

The well-known symptom is a chronic muco-purulent, more or less offensive discharge from the ear or ears. The naso-pharynx is often affected simultaneously with an active, hypertrophic, secretory catarrh. In a large proportion

of the cases of chronic otorrhea either granulations or polypi are found. Long-continued purulent inflammation of the middle ear is always attended with perforation of the membrane, and is sometimes followed by cholesteatoma of the mastoid antrum, by caries and necrosis of one or all the ossicula auditûs, the inner tympanic wall, the tegmen tympani, the mastoid cells, the groove for the lateral sinus, and the mastoid cortex. More remote results of chronic purulency in the drum-cavity are cerebral abscess, phlebitis, and thrombosis of the lateral and petrosal sinuses and of the internal jugular vein, embolism of the lung, liver, or spleen, with general pyemia, and, in rare instances, ulceration of the carotid.[1]

It is now generally conceded that carcinoma of the ear is due to chronic purulency of the mucous membrane of the tympanic cavity. Cases of chronic purulent discharge through a single perforation in the membrana flaccida dependent upon disease in the attic space of the drum-cavity are among the most obstinate and dangerous to life. Their obstinacy is due to the defective drainage, caused by the fact that the head and neck of the malleus and the body of the incus lie immediately behind the perforation, and the pus has to find its way around them. Their dangerous nature is due to the proximity of the pus to the tegmen tympani and cranial cavity.

FIG. 430.



Aural Polypus Snare, with Fenestrated Canula (Burnett).

Treatment.—In the treatment of chronic purulent otitis media, with only the sole perforation in the membrane below the folds, by far the commonest form, cleanliness and antisepsis play the most important part. The ear should be cleansed and treated by the *physician himself* if possible, as this important operation is rarely well performed by the patient or his friends. If the ear discharges copiously, it should be cleansed and treated daily. This is best done by syringing with warm water and salt (1 to 2 per cent.) if the matter is tenacious

[1] According to Politzer, only fourteen cases of the latter accident have been recorded.

and copious. If neither tenacious nor copious, the matter may be carefully mopped out with absorbent cotton on a cotton-holder under perfect illumination. After the ear is cleansed in this simple way, if the perforation in the membrane is small, solutions of carbolic acid (1 : 40) and of bichloride of mercury (1 : 6000) or absolute alcohol may be instilled into the ear, ten drops at a time of any of these fluids being enough. If the perforation in the membrana tympani is large, comprising a quarter or more of the membrane, insufflations of finely-powdered boric acid, or seven parts of boric acid in combination with one part of iodoform or with one or two parts of aristol, may be used. Only enough of any powder should be blown into the ear to cover the fundus with a thin stratum. In no form of ear disease should alum be used in the ear, as it quickly congests and inflames the drum-cavity and the skin of the auditory canal. Many cases of chronic purulency will yield to a simple and careful antisepsis like the above if carried out by a skilful surgeon. Some cases yield quickly to a few instillations of a solution of nitrate of silver (gr. 50 @ f℥j). These must be applied after the ear is cleansed. After their instillation they should be syringed out with warm water, without addition of chloride of sodium.

If granulations or polypi are present, they must be removed before a cure of the discharge can occur. Sometimes granulations, if quite small and flat, will disappear under the "dry treatment" by powder or under instillation of absolute alcohol. But true **polypi,** pedicellate bodies, must be removed, preferably by the snare, before a cure of the purulent discharge can be expected. Polypi are attached to the mucous membrane, usually to that on the edges of a perforation in the membrana tympani. If the point of attachment can be seen after removal of a polypus, it should be touched with a little fluid chromic acid on the end of a small metal probe 1 mm. in diameter. The greatest caution must be observed in its use, as chromic acid is too powerful to be used in the ear, even in the quantity *as large as a drop.*

If the antiseptic course just outlined and the removal of the polypi fail to conquer the disease, the perforated and necrotic membrana and the diseased ossicles must be excised. The patient being etherized and the ear illuminated by the electric head-lamp, the diseased tissues are to be removed under careful antisepsis. It is needless to say that this operation demands special skill, and minute description of the operation and results must be sought elsewhere in works on aural surgery. In fact, those cases of chronic purulency characterized by a perforation only in the membrana flaccida, and known as "attic cases," cannot be cured in any other way than by the above-named operation. Not only is the suppuration thus cured, but the hearing and health are greatly improved, and mastoid necrosis and other sequelæ dangerous to life are warded off.

MASTOID NECROSIS.

The three most common results of chronic purulent otitis media are necrosis of the mastoid, sinus-thrombosis, and cerebral abscess. The last two are **intracranial sequelæ** of chronic purulent otitis media, demanding trephining of the skull, ligation of the internal jugular vein, and possibly, in some cases, ligation of the carotid artery, and will be found described in the section on Cerebral Diseases arising from Ear Disease (p. 525). Here only mastoid diseases will be described.

Sometimes periostitis of the outer mastoid surface occurs in connection with acute as well as with chronic processes in the external and middle ear.

But caries and necrosis of the mastoid structures are found only in connection with chronic purulent otorrhea.

After a long-continued purulent discharge from the middle ear, there may suddenly arise a violent, acute inflammation in the affected organ. This usually occurs in consequence of exposure of the ear to cold air or to a cold-water bath, or after a blow on the ear. Doubtless, mastoid inflammation may be induced by improper treatment of the chronic purulency in the drum-cavity. Treatment of this disease should always be antiseptic and solvent, rather than astringent or of a mechanical form likely to retain purulent or cholesteatomatous matter in the drum-cavity or mastoid antrum.

The **diagnosis** of an acute inflammatory process with suppuration in the mastoid cells in connection with a previously suppurating middle ear is not always easy. The pain is severe and of a throbbing and boring kind. It is felt in the mastoid, in the brow, and in the parietal and even in the occipital regions of the affected side. Sometimes both mastoids are affected simultaneously. Perhaps the one surest guide in the diagnosis of intramastoid suppurative inflammation is tenderness upon *deep pressure* over the mastoid region near the antrum, close behind the auricle, near the upper wall of the external auditory canal.

Facial paralysis is a common occurrence in this form of tympanic and mastoid inflammation, and is due to pressure of the greatly swollen mucous membrane or of inspissated pus upon the facial nerve through dehiscences in its canal in the upper back part of the drum-cavity. The facial paralysis is, however, of no great moment, since it usually disappears as the mastoid symptoms subside.

The chronic discharge of pus from the ear usually diminishes or ceases altogether with the first engorgement of the vessels in the tympanic and mastoid cavities. In a few hours, however, it begins again, though generally altered in quality, being now thinner and often very offensive in odor.

In true intramastoid inflammation the febrile symptoms are always well marked. If at the same time the inner mastoid wall over the lateral sinus is involved, or if the tegmen tympani is diseased and the cranial cavity involved in this direction, the surgeon is confronted with an alarming and puzzling complex of symptoms, as the sinuses, the meninges, and the cerebral tissue may be affected either singly or in combination from the advance of the tympanic disease into the cranium. So long as inflammatory disease is limited to the mastoid, and no pus is retained there under tension, though the patient may suffer intensely and appear very ill, no bad results follow. As soon as the disease spreads beyond the tympanic and mastoid portions of the petrous bone into the cranium or by embolic processes into other viscera, as it will if an outlet to the pus is not quickly afforded either by nature or by surgical art, the results are fatal. The majority of simply mastoid cases recover if prompt relief is given to the retained pus. Risks of deeper trouble are diminished by affording perfect drainage by an opening in the mastoid cortex and by clearing the drum-cavity of all obstructions. If intracranial disease has developed before the mastoid operation has been performed, this operation will be the preliminary step toward further operations for exposing the lateral sinus or the cranial fossæ and draining the seat of purulent disease which has developed within the cranium. V. Bezold has described a variety of mastoid inflammation in which the pus escapes through an opening on the median surface of the mastoid process at the origin of the digastric muscle. The pus may then burrow along the course of the muscle toward the pharynx and backward under the deep muscles and fascia of the neck.

Treatment.—As soon as the surgeon is confronted by an inflammation within the mastoid cavity, he must at once make an artificial opening in the mastoid as nearly as possible over the mastoid antrum and lay bare this cavity. The operative procedure is described on p. 526. If no intracranial sequel of chronic otorrhea has occurred, the pain in the ear, head, and mastoid will cease after the mastoid has been opened and pus allowed to escape from it. Under continued antiseptic treatment by means of injections of peroxide of hydrogen, carbolic acid (1 : 40), or bichloride solution (1 : 5000 or 6000), through the opening in the mastoid into the tympanic cavity, and vice versâ, until the opening in the mastoid closes, the chronic purulency of the drum-cavity is usually checked. In the form of inflammation described by V. Bezold the mastoid must be thoroughly opened as before, the pus-cavity among the muscles curetted and packed and treated as any other abscess.

MECHANICAL APPLIANCES IN THE TREATMENT OF DEAFNESS.

There are many forms of hearing-trumpets, any of which may be useful in aiding the very deaf to hear. It is always well for one about to purchase a hearing-trumpet to try various forms, to see which gives the most aid, before buying one. Many forms are very good and comparatively inexpensive, but they are made to fit into the meatus auditorius. This arrangement usually bruises, and often excites boils in, the auditory canal. All forms of small, so-called invisible drums, resonators, ear-tubes, auricles, audiphones, dentaphones, etc. are useless. The small ones made to lie in the canal and down upon the drum-membrane or its remnant are worse than useless, as they irritate and inflame the ear.

From the nature of sound, it must be reinforced by resonance in any case of deafness due to disease in the conducting apparatus. If the nerve is organically affected, nothing can make the patient hear. Therefore some form of tube which is at least one-quarter the length of an ordinary sound-wave, such as we all ought to hear in ordinary life, must be used as a resonator or strengthener of sound conveyed to the deaf ear. Nothing smaller than this will answer the purpose, and, while large ones would render still further aid, their size prohibits their use.

BOOK IV.

OPERATIVE SURGERY.

CHAPTER I.

GENERAL PRINCIPLES.

THEPE are certain general principles which must guide the surgeon in the performance of every surgical operation. These principles require careful consideration, and no operation either of small or great magnitude should be undertaken without a full knowledge of their importance.

Dangers Common to all Operations.—It may be stated as an aphorism that no surgical interference is free from danger to life. This must be borne in mind in the consideration of every surgical operation. The distinction, however, must be recognized between an operation performed for some cosmetic effect and one performed to relieve human suffering and to save life. In the former case the danger should enter prominently into the consideration of the propriety of the operation, while in the latter case the same danger would have little weight. There are cases that may stand midway between these two extremes, and under these circumstances each individual case must be considered upon its own merits.

The first general danger is *Hemorrhage*. Some loss of blood must always attend an operation, but the aim of the surgeon should be to sacrifice the smallest amount consistent with the completion of the operation. The more blood lost during an operation, the less rapid the healing process and the greater the shock. The hemorrhage may occur during the operation, or it may ensue shortly after its completion, or it may take place after the wound has nearly healed. The time of its occurrence is of less importance than its results. The methods of arresting hemorrhage are considered elsewhere.

Anesthesia is a second danger; hence the administration of an anesthetic is a most important part of an operation and requires the services of a thoroughly trained and experienced physician.

Shock is a danger common to all operations. By this condition is meant a functional depression of the circulatory system. The degree of depression depends upon the situation of the injury, the character of the operation, and the idiosyncrasy and age of the individual. The nervous system is primarily affected in shock, and secondarily the circulatory. This is evident, because with a normal action of the heart shock is impossible. Age likewise is a factor to consider in estimating the severity of shock, although age is a relative term. The aged as well as children suffer greatly from shock. The important difference, however, must not be overlooked that the aged do not react from shock as readily as children. Shock associated with traumatic delirium is a most serious condition. No operation, except such as the arrest of hemorrhage or the relief of a strangulated hernia, should be undertaken under these circumstances. The aged with healthy viscera suffer less from shock than the middle-aged with diseased viscera.

The **prognosis** in shock depends upon the nature of the injury inflicted, the special organs involved, and the individual idiosyncrasy. A temperature persistently below 96° F., or a feeble and frequent pulse and shallow breathing with sudden rise of temperature, indicates a most grave condition.

Special Dangers of Operation.—*Entrance of air into veins* is a most serious accident occurring during an operation upon the neck, where the cervical fascia holds the veins patent, or as a result of a wound of a vein in this region. The internal and external jugulars, the subclavian, the veins at the root of the neck, the axillary, subclavicular, subscapular, and thoracic veins, and the cerebral sinuses, are the vessels the wounds of which are most likely to be attended with entrance of atmospheric air. A wound of the facial or of the femoral vein has given rise to this serious accident, and cases of sudden death after delivery have been ascribed to the entrance of air into the uterine sinuses. Air in the form of putrid gas has been sent to the heart and caused death in cases of gangrene.

The way in which the entrance of air into veins causes death has been the subject of much study and experimentation. If air enters through a wound of one of the veins, it is carried by suction to the right auricle and ventricle, where it becomes mixed with the blood in these cavities, forming aëriform emboli. The right heart endeavors to force the blood and air through the lungs, but fails, and as a consequence the left heart is collapsed from want of blood, and, no blood being sent to the cerebrum, a fatal syncope follows. Experiment upon animals has undoubtedly shown that they can live after the direct injection of large quantities of air into the circulation (Hare), but the clinical fact remains that patients have repeatedly died from the accident, and hence it is to be carefully guarded against, especially in all operations about the neck.

The **symptoms** of entrance of air into the veins may be constitutional and local. The constitutional symptoms are syncope, feeble and frequent pulse, irregularity of respiration amounting to cardiac dyspnea, and dilatation of the pupils. Auscultation over the precordial region reveals the presence of a churning sound synchronous with the ventricular systole and accompanied by a violent and irregular action of the heart. These symptoms are usually preceded by a gurgling noise, and in a few seconds convulsions and fatal collapse ensue.

The local signs are the appearance of bubbles of air in the wound and a patent condition of the veins. The mouths of the veins are prevented from closing by the fascia which surrounds them, and the canalization exposes them to this danger.

The **treatment** for entrance of air into the veins must be prompt and bold. The head should be immediately lowered to prevent fatal anemia of the brain. Hypodermatic injections of brandy or digitalis should be at once administered, and artificial respiration resorted to without delay, in order to re-establish the pulmonary circulation and thus convey more blood to the left heart. Treves has suggested pouring water into the wound to prevent any further ingress of air and at the same time to allow the air to bubble out of the wound. The patent vein should be instantly closed by the finger, and then immediately ligated. Elastic bandages can be applied to the upper extremities with a view of facilitating the afflux of blood to the trunk and heart. The inhalation of oxygen gas has been recommended. Tracheotomy has been suggested, with inflation of the lungs through the tube, in order to stimulate the pulmonary circulation and thus force out the air emboli. In all operations upon the neck when the veins are likely to be interfered with the surgeon

should guard against the entrance of air into wounded veins by not cutting tissues when tensely stretched, and by having an assistant ready to compress the vein between the wound and the heart in case of its division: he should use the handle of the scalpel in the separation of the deep tissues of the neck, and should, when possible, tie the veins lying in the course of an operation with two ligatures and cut between them.

Hemophilia.—Operations upon persons the subjects of hemophilia—"bleeders"—are most dangerous, because, in spite of every possible human device to arrest the hemorrhage, it will often persist. The pathology of the disease is but little understood. Hemophilia may exist in several members of a family, and there seems to be undoubted foundation for the opinion that the disease is often hereditary. The slightest traumatism, such as a scratch or a laceration of the gums with a toothpick, induces a hemorrhage. The hemorrhage may occur idiopathically from the nose or from the rectum, or may appear as minute extravasations under the skin. When the hemorrhage occurs from a wound either as the result of traumatism or in consequence of a surgical operation, the blood oozes freely from the entire surface, and may not be controlled by heat or cold, by styptics, by compression, by ligature, or by the cautery; but all these means should be tried. The bleeding continues until the patient becomes anemic and exsanguine. Ergotine has been used to contract the vessels, but its efficiency is doubtful.

Preliminary Examination of the Patient.—Before undertaking any operation certain examinations should always be made and certain indications and contraindications considered.

The *mental state* of the patient is of no little importance. A patient who is in fear of a fatal result or a soldier who is depressed by defeat is always a much poorer subject for an operation than one who is cheerful and bright or, it may be, indifferent. Hence in this respect children, who are not subject to gloomy forebodings, and for a similar reason the insane, are very good patients surgically.

No patient should be operated on without a careful examination of the *heart and lungs.* Any serious disease of the heart should make us hesitate, and if an operation be contemplated for mere cosmetic purposes, it should be abandoned; if the necessity for it be absolute, it must be undertaken, but with great caution, especially as to the use of the anesthetic. If the lesion be at all pronounced, the patient and the family should be so informed, and deliberately make a choice, with a full knowledge of the danger. The lungs also should be examined, for in case of bronchitis an operation which could be deferred should be postponed until the bronchitis has been cured, or, if the operation must be done, chloroform should be used instead of ether. Operations, especially on the brain, on the eye, and on the abdomen, should not be done during an attack of bronchitis, for the cough suddenly produces great intracranial, intraocular, and intra-abdominal pressure which may do much harm.

Deformities of the Chest, such as are produced by Pott's disease, if moderate, offer but a slight objection to operations, and even if severe may result in no disadvantage to the patient. The anesthesia, however, in these cases should be as brief as possible, and that method of operation chosen which is the shortest; for instance, in stone in the bladder lithotomy instead of litholapaxy.

The *urine* should invariably be examined, and if there be Bright's disease caution should be exercised as to the anesthetic and the functions of the kidney watched afterward. Surgical opinion is at present somewhat divided as to whether ether or chloroform should be preferred in Bright's disease, but the weight of authority is in favor of the latter. If diabetes is found, no

operation should be done unless the need is absolute, for diabetics are markedly predisposed to hemorrhage, suppuration, erysipelas, and shock.

The *general vitality* of the patient should also be considered, and in poor states of health all operations should be postponed if possible. On the other hand, it must be remembered that operations for pathological causes, such as tumors, joint disease, etc., are borne far better by feeble subjects than similar surgical interference by the robust and hearty. A man in the prime of life with all his functions active, whose leg is crushed to such an extent as to need amputation, runs two or three times the risk that a patient does who has been bedfast for weeks in consequence of a joint disease, and the interruption to whose activities is far less than in the case of the robust and hearty man. Very fat patients also are poor subjects for operation. Women, for instance, with very large, fat breasts are apt after operation for cancer to suffer necrosis of the fatty tissues, with development of butyric fermentation, accompanied by abundant discharge and very foul odor, even without infection from pyogenic bacteria: suppuration itself often occurs. A very fat abdominal wall is also an obstacle, not only by reason of the ready breaking down of the fat, but also in a mechanical sense, as it renders access to the abdominal cavity difficult.

Age.—Very young children do not bear operation well. Mr. Dent's statistics show that under five years of age the mortality after amputation was 12.5 per cent., between five and ten it fell to 3.3 per cent., and between ten and twenty rose again to 16.1 per cent.; so that children bear operation better than infants or adults. One reason for this mortality is that very young children bear shock badly; pain is borne, if possible, still less well. Moreover, it is difficult to keep young children clean, and wounds below the waist may especially easily become infected through the urine or feces. It is often stated that children bear the loss of blood badly, but, while the loss of the same quantity of blood is borne badly as compared with adults, yet if the amount of blood lost be regarded in relation to their age and size, they probably bear it quite as well as adults. Old age is likewise a factor for evil. After forty, patients bear operations increasingly less and less well as their age advances, and if we add habitual intemperance we have the worst possible patients for an operation.

Sex.—Women bear operations, as a rule, better than men, since they are less active physically, and usually are of a more equable temperament. Operations, naturally, should not be undertaken during the menstrual period unless necessary, nor during pregnancy; but menstruation is not an absolute bar, and many operations, even up to amputation at the hip-joint, have been done during pregnancy without ill results. If sepsis occurs, abortion is sure to follow. One rule should be absolute: never to operate on a breast during lactation, on account of its great vascularity. If operation is necessary, we should wait until weaning is accomplished.

Disease.—Bright's disease and diabetes have already been alluded to. Tubercular patients react well after operations, and especially tubercular children. The same may be said of patients with acquired syphilis, but those subject to hereditary syphilis, from the feebleness of their constitution, stand operations poorly.

Synchronous operations—as, for instance, amputation of two or three extremities—are sometimes necessitated by multiple injuries. Of course there is no choice in such a case, but they should be done with all speed, so as to diminish shock, and it is of advantage if they can be done simultaneously by two operators. Hemorrhage in such a case should be especially guarded against.

THE MANAGEMENT OF THE PATIENT BEFORE OPERATION.—The management of the patient *before* an operation involves a knowledge of his temperament, habits, and constitution. If the patient is not in good physical condition and the circumstances of the case permit, the operation should be postponed for a short time until, by the use of tonics, by rest, and by nutritious diet, the general health is improved. A study of the habits and temperament of the patient is often of great benefit to the surgeon. Sometimes a patient is very nervous, irritable, and restless on account of the dread of an operation, and in such a case the surgeon should do all in his power to allay his fears, to assure him of the safety of the operation, and to point out the fact that modern antiseptic surgery can offer relief or save life with but little suffering as a rule. A thorough examination should be made of the patient's viscera, especially the heart, lungs, kidneys, and liver, in order to have a comprehensive knowledge of all the emergencies that might subsequently arise. The technique of preparation of the patient is fully discussed later.

HYGIENIC CONDITIONS WHICH SURROUND THE PATIENT.—These greatly influence rapid recovery after a surgical operation, as well as often induce or prevent death from septic causes.

The surgeon should perform an operation under the most favorable hygienic conditions possible in the case. The room in which the patient is to be operated upon, as well as the one he is to be placed in during convalescence, should be large, exposed to the sun, well ventilated, and scrupulously clean. The bed and bedding should be free of any contamination from prior exposure to infectious disease, and all the appliances for dressing the wound should be aseptic. The sanitary arrangements of the house should be perfect. Too much importance cannot be placed upon the question of ventilation of the sick-room. In the air of a room there are held in suspension particles of organic matter, epithelium, and dust, also the exhalations from the lungs, desquamations from the skin, and floating particles derived from clothing and other sources. Pasteur has pointed out the fact that an ill-ventilated room is a source of great danger, because the dust held in suspension may act as a carrier of septic germs and cause infection in a wound. It is thus evident that a well-ventilated chamber is an important condition to ensure safety and rapid recovery. An open fireplace is a safeguard, because it leaves no damp surfaces upon which floating and germ-laden dust can settle, and also because it produces a free outward draught from the room.

In the event of a serious operation the carpets should be removed, as well as all the hangings and upholstered furniture. The ceilings and side walls should then be brushed down with a towel saturated in bichloride. Papered walls require a dry towel. When the room is thus made empty and dusted, the floor and all the woodwork and furniture should be well scrubbed and washed with a solution of bichloride of mercury of the strength of 1 : 500. A plain kitchen table is the best for an operating table. There should be placed in the room four plain wooden or cane-seat chairs, a washstand, and a table for instruments, medicines, etc. The operating table should have a rubber under it, and a waste-water pail should be placed under the table. Five or six china washbowls and as many pitchers should be provided, two or three of them filled with distilled or cooled boiled water. Plenty of boiling water must be provided.

Two blankets should be placed on the bed instead of sheets, and ten well-corked hot-water bottles or bags provided to place around the patient after the operation. Three or four sheets and a dozen or more towels, wrung out of a 1 : 1000 sublimate solution and rough-dried the night before the operation,

should be provided. Many surgeons prefer to wet them in a hot solution at the time of the operation and then spread them all around the field of operation.

The Preparation of the Patient.—If possible, before the operation the patient should rest in bed for a day or two. The night before the operation he should have a mild laxative, and an enema the morning of the operation. In certain operations antiseptic injections should be used in the vagina and boiled water in the rectum.

Too much importance cannot be attached to the preliminary disinfection of the field of operation. Cheyne has pointed out the fact that there are more pathogenic micro-organisms in a square inch of the cutaneous surface than would be found in the ward of a well-ventilated hospital. This fact demonstrates how inadequate is any attempt to disinfect the air in a ward, and at the same time emphasizes the importance of disinfection of the field of operation as well as of the hands of the operator, his assistants, and the nurse. The skin is covered with desquamated epithelium and filled with innumerable micro-organisms. The day before the operation, therefore, the part must be shaved, and then the micro-organisms be got rid of, first with soap and water, then with ether or alcohol, and lastly with a sublimate solution, 1 : 1000, or in specially dirty regions 1 : 500. Some surgeons advise the prior application of a soap poultice to the skin with a view to separation of the effete material. A sublimate gauze dressing should then be applied and retained in place by a bandage or binder, and allowed to remain until the operation is to be done. In operations about the male genitals the penis should always be wrapped round with some aseptic gauze. Disinfection of the mouth, nose, and ear has been described on page 512. The navel, the pubes, the scrotum, and the armpits require especial care, since they are peculiarly apt to harbor dirt. The same is true of the scalp, and in operations on the head it is better, as a rule, to shave the entire head. On the scrotum and head the sublimate solution should not be stronger than 1 : 2000, lest pustulation or excoriation follow. In traumatic cases, where the patients are begrimed with the ordinary dirt of the streets, oil and grease from machinery, etc., if sweet oil be well rubbed over the parts the dirt will be much more readily removed by the soap and water. In operations about the upper part of the body the arms, and in operations about the lower part of the body the legs, should be wrapped in bichloride or sterilized sheets or towels, lest the patient contaminate the wound by touching an unclean extremity to it. In operations about the chest, the neck, or the face a bichloride or sterilized towel should always be wrapped around the hair and another around the inhaler. In operations involving much exposure or great shock it is well to wrap the patient's body, arms, and legs in a thick layer of cotton, kept in place by bandage and binder, in order to maintain the body-heat. This can be done also by hot-water bottles, or in some cases the operation may be done on a hot-water bed.

Asepsis and Antisepsis.—The stage of controversy and of argument as to the benefits of asepsis and antisepsis is past. With the exception of a very few superfluous laggards, the surgical world is at one as to the value of these methods. Even those who oppose them practically apply the same principles by different methods. Heat and carbolic acid in this regard are equivalent means. The bacteriological proof that suppuration, erysipelas, pyemia, and all other similar dangers arise from pyogenic organisms is now practically absolute. The clinical proof is equally strong. The statistics of all operations in the pre-Listerian days, as contrasted with those of the last twenty years, show that all those septic diseases which were rife in private and especially in hospital practice, and slew their thousands and tens of thousands, have almost disap-

peared. Compound fractures, which then were among the most dangerous accidents, are now scarcely more dangerous than simple fractures, and the mortality-rate after amputation and abdominal section has fallen nearly to zero.

Two methods are employed, the aseptic and the antiseptic. In the *aseptic method* chemical antiseptics or heat, or both, are used for the purpose of obtaining absolute surgical cleanliness, including in this the patient's person, the hands of the surgeon and his assistants, all instruments, dressings, etc.; and after this no chemical antiseptic is used, but only such solutions, dressings, etc. as have been sterilized and made germ-free by heat. In the *antiseptic method* the same antiseptics are used for procuring cleanliness, and in addition chemical antiseptic solutions and dressings impregnated with them are used during and after the operation. One thing must be clearly understood: that either method must be thorough or it is useless.

Antiseptics.—As an antiseptic the most universally valuable and available is heat. A temperature of 140° F. for ten minutes is fatal to all pathogenic bacteria except the tubercle bacillus and anthrax spores, which require a moist heat of 212° F. for at least four minutes (Sternberg). Moist heat is far more efficient than dry heat; *e. g.* the spores of the tubercle bacillus if exposed to dry heat require for their destruction a temperature of 284° F. for three hours. It is especially well to remember that even in the country this method of abolishing sepsis can always be used. Instruments and dressings can always either be boiled or placed in an oven and thus be entirely sterilized at a moment's warning. It is not necessary that the surgeon should have all the appliances of the modern hospital or drug-store. Old sheets can be prepared extemporaneously by heat, and will form excellent sterilized dressings.

Of antiseptic drugs there are a very large number with more or less bactericidal power. Among them should be especially mentioned carbolic acid, bichloride of mercury, biniodide of mercury, and hydronaphthol. Iodoform is undoubtedly useful in many cases in tuberculosis and in inhibiting the growth of pyogenic organisms, but it should itself be sterilized before being used: by some surgeons, except in cases of tuberculosis or chronic suppuration, it is entirely discarded; by others it is depended upon in the permanent dressings to the exclusion of all other antiseptics.

Peroxide of hydrogen has been largely used as an antiseptic, but its precise value has yet to be determined. The ordinary solutions are not invariably germicidal. The bacteria of tetanus, for instance, have been grown under a fifteen-volume solution (Kyle). Its antiseptic action seems to be dependent upon its destruction of the albuminoid element upon which the bacteria live; hence it has a definite field of usefulness in suppuration. Practically, carbolic acid in solutions of 1 : 20 to 1 : 40, and bichloride of mercury in solutions externally of from 1 : 1000–4000, and internally in solutions of from 1 : 5000 for the irrigation of joints to 1 : 10,000 for the peritoneal cavity, are the antiseptics with which the modern surgeon has to deal. Most surgeons prefer to use boiled water only in the peritoneal cavity.

Preparation of Surgeon, Assistants, and Nurse.—The surgeon and his assistants may wear ordinary clothing, but should be in their shirt-sleeves, with the sleeves rolled up well above the elbows. Partly for the protection of the patient and partly for the protection of their clothing they can wear either white coats or aprons, or else should be protected by a sheet folded several times, so as to be about half a yard wide and five or six feet long. One end of this can be turned in next the person over a bandage which is tied around the neck, and another bandage is tied around the waist. This serves an excel-

lent purpose as an extemporaneous apron. Whichever is worn, coat, apron, or sheet, it should have been made aseptic by sterilizing by heat or by having been dipped the night before in a bichloride solution and rough-dried, but it must be remembered that no *dry* material is actively antiseptic, or even reliably aseptic, if dust or dirt of any sort comes in contact with it. It is not uncommon to see the sweat dropping from the head or chin of a surgeon during an operation. This, of course, is excessively dangerous, since it carries the germs of the face and hair directly into the wound, the abdominal cavity, etc. Persons who sweat profusely, therefore, should tie a towel around the forehead and head to absorb all this excess. On no account should they wipe it off with their hands, since the hands are immediately infected by such contact. A sterilized towel must be used. The nurse should wear some wash-goods, such as white muslin or a neat calico. If she assists at the operation otherwise than with the sponges, she should wear an apron or a sheet.

Disinfection of the Hands.—When the antiseptic method was first introduced, it was thought that the principal source of the germs of suppuration was the air, and hence the use of the spray, which is now practically abandoned. Its abandonment has been due to the fact that surgeons have recognized the fact that the three chief sources of infection are, first and foremost, their own hands and those of their assistants; secondly, instruments not properly disinfected; and thirdly, sponges and dressings. Hence, above all, the hands and forearms of every person who is to touch the wound must be disinfected. The first means of cleansing the hands is that which commends itself to common sense—viz. the removal of the dirt rather than its attempted disinfection. Hence the hands and forearms should be washed with hot water and soap and nail-brush continuously for several minutes. During this washing the nails should be very thoroughly cleaned by scraping under their free ends and also along their sides and bases with a penknife, nail-cleaner, or other similar instrument. This portion of the disinfection is most important, since infection is carried more frequently by the hands than by any other means. The nails should also be cut very short. The nail-brush, moreover, should be aseptic. Especially in hospitals, where it is constantly used and is apt to become foul, it should be always kept in a 1 : 40 carbolic solution or in a 1 : 1000 sublimate solution, either of which should be frequently changed. One brush should be kept for the soap and water, and another separate one for the disinfection.

Two methods are chiefly in vogue for disinfection of the hands. The first one is the method of Fürbringer, and is as follows: The forearms and nails having been cleaned as just directed, they are dipped into absolute alcohol for at least one minute, and then are plunged while wet into a hot sublimate solution, 1 : 1000, and well scrubbed with a nail-brush, the nails receiving extra attention. This antiseptic scrubbing should be continued for not less than one minute. Whenever the hands or forearms touch any object which has not been disinfected they should immediately be washed again in a bichloride solution. Even when this method is scrupulously carried out, if the bichloride is precipitated by sulphide of ammonium, numerous colonies can then be grown by inoculating culture-tubes from the hands. In fact, sterilization of the hands is a relative asepsis, and not an absolute one. Fortunately, the human body does not provide a soil in which, as in the culture-tubes of the bacteriologist, everything is favorable for the growth of the pyogenic or other micro-organism, else every accident would be followed by septic infection. By phagocytosis, by the bactericidal action of the blood-serum, or by other means the comparatively few germs which find access to the tissues by

hands thus prepared are, as a rule, destroyed or rendered inert, but occasionally, especially if the details are not rigidly observed, infection will occur.

The other method is by means of the potassium-permanganate and oxalic-acid solutions (Kelly). The three steps insisted upon are as follows: First, the cleansing of the hands with soap and water, frequently changed, as before. Secondly, immersion of the hands in a solution of permanganate of potassium made by adding an excess of the salt to boiling distilled water, until every part of the hands and forearms is stained a deep mahogany-red or almost black color. They are then transferred to a saturated solution of oxalic acid until completely decolorized and of a healthy pink color. Thirdly, washing off the oxalic acid in warm sterilized water. The chief objection to this method is the annoying irritation of the skin, especially of the forearms, which often follows. This may be avoided by washing with lime-water after using the acid.

Disinfection of Instruments.—The best method by far is to boil the instruments for ten minutes in a 1 per cent. solution of sodium carbonate. The sodium carbonate is added to prevent rusting. It is also a powerful antiseptic solution, destroying staphylococci in two or three seconds and anthrax spores in two minutes (Schimmelbusch). When taken out of the boiler the instruments should be rinsed in a 1 : 20 solution of carbolic acid, and then placed in trays in water which has been boiled and allowed to cool. To this some boiling water may be added in order to make it more agreeable to the hands. On no account should the boiling water be cooled by freshly-drawn unboiled water, since, as this has not been sterilized, it will contain many germs. As the instruments are soiled they should be cleansed by a nurse with aseptic hands in an aseptic solution and replaced in the tray. Placing the instruments in a 1 : 20 solution of carbolic acid for fifteen minutes will also sterilize them very well, and in case the instruments have wooden handles it will be essential that this method be followed, since boiling would loosen the handles. To prevent the roughening of the hands the carbolic solution may be poured off just before the operation is begun, and the trays, etc. filled with boiled water. When the operation is terminated the instruments should be scrubbed with a nail-brush and carefully dried, especially in the joints and serrations or teeth of forceps, etc., in order to get rid of all blood, fragments of tissue, etc. This cleansing is quite as important as their disinfection prior to the operation. If the case has been a suppurating one, the instruments should be boiled after the operation, independently of the preparation for the next one.

Sponges.—Many surgeons have practically given up sponges and use small mops of sterilized or antiseptic gauze instead. These answer admirably, especially for the dry method of Landerer. In the abdomen, gauze pads about 8 or 10 inches square may replace the large flat elephant's-ear sponges to advantage. They are made of a number of folds of the ordinary gauze used for surgical dressings, loosely hemmed at the margins, and then sterilized or made aseptic by sublimate solution. The edges should not be cut, but should be folded over and hemmed so as not to have loose threads which might be left in the abdomen.

Marine sponges should be first placed in a bag and beaten for a long time in order to free them from the sand in their meshes. They should then be washed for some days in water which is frequently changed, and best in water which is slightly acidulated with hydrochloric acid. They must again be washed in pure water in order to remove the acid. Different methods may be followed in their disinfection: (1) They may be soaked for twenty-four hours or less in a solution of ordinary washing soda, a pound of the soda to a dozen

sponges, and the soda then be removed by washing in clean water. The sponges are next soaked for twenty-four hours in a 1 : 20 carbolic solution, and dried by moderate artificial heat. They are then well wrapped up and kept in a dry place. (2) After beating the sponges free from sand and washing them in the warm water, they should be soaked in a solution of potassium permanganate, half an ounce to the gallon, and if the pink color of the solution is lost more permanganate should be added. If this addition is necessary, the sponges should be taken out of the liquid, the permanganate dissolved, and the sponges put back, for if the permanganate is put in upon the sponges it discolors them in spots. They are then washed in warm water and dipped for a very few minutes into a solution of sulphite of sodium ʒx and hydrochloric acid fʒij to the gallon of water. If they are allowed to remain any length of time in this solution they will not only become bleached, but very much softened. They are then thoroughly washed for twenty-four hours, after which they are kept in glass jars in a carbolic solution, 1 : 40. (3) Borham's method is that adopted by Greig Smith in preference to others. The sponges after being cleansed are first soaked in a 1 per cent. solution of potassium permanganate (about 75 grains to the pint). The sponges, having next been washed repeatedly in boiled water, are placed in a gallon of water in which has been dissolved half a pound of sodium hyposulphite for a dozen sponges. Four ounces of oxalic acid are added, which bleaches the sponges and dissolves out any fibrin in their meshes. They should remain in this solution not more than ten minutes, and are finally placed in a carbolic solution.

Ligatures and Sutures.—For ligatures, silk and catgut are practically the two most employed. The silk may be either the plaited silk or, perhaps better, the Chinese twisted silk. Ballance and Edmunds have recently recommended for the ligation of arteries in continuity dentists' floss silk, which, where large vessels have to be tied, does not slip so easily as other kinds, on account of the entanglement of its fibers. For sutures either silkworm gut or silk is the best. Silver and other wire sutures, formerly so popular, are but little used nowadays.

The *silk* is made of different sizes appropriate to the vessels or pedicles to be tied. It may then be prepared by boiling after it has been wound on glass spools, which are thus disinfected at the same time. Another method consists in putting three or four spools into an ordinary test-tube the mouth of which has been stopped with ordinary jewellers' cotton. Absorbent cotton is not good, since it becomes of course very wet. The test-tube, thus prepared as for bacteriological use, is then placed in a sterilizer and exposed to steam heat for an hour or more. In order to carry these test-tubes they may be placed in the ordinary tin tubes in which plasters are dispensed, the tube having been, of course, properly cleansed, or holes of a suitable size and depth may be bored in a block of wood by an auger and stopped with rubber corks. Just before use the silk should be placed in a carbolic solution, 1 : 20, and alcohol, one-third of the former to two-thirds of the latter. Carbolic acid is better than sublimate, as the needles may be threaded and placed in the same tray. The alcohol is added so that if desired the catgut may be placed in the same tray with the silk, and not undergo softening, which very quickly occurs when the catgut is placed in plain watery solutions.

Silkworm gut is that used by anglers, and is purchased in bundles. Small round threads should be selected and the poor ones thrown away. The threads should be soaked in a carbolic solution for fifteen minutes before use. The danger of its breaking while being tied can be obviated by making the first knot a double one and tying the second one very lightly or not at all (Greig Smith).

Catgut also can be used for sutures, and especially for ligatures. Raw catgut, as ordinarily purchased commercially, has two objections: first, it has a considerable quantity of fat in it; and secondly, it is infected with germs from its very source, being made from the submucosa of the intestine of the sheep. It is best prepared by first soaking it in ether for twenty-four hours to remove the fat, then for another twenty-four hours in an alcoholic sublimate solution, 1 : 500, and then may be preserved in ether or in alcohol. Before the operation it should be soaked, as already mentioned, for a few minutes in carbolic solution, 1 : 20, and alcohol, one-third of the former to two-thirds of the latter. An excellent method of sterilizing catgut is by boiling it in alcohol. It can scarcely be used, however, outside of hospitals, as it requires special apparatus. If it is desired to make the catgut less absorbable, it can be chromicized in this manner: 200 parts of catgut by weight are added to carbolic acid 200 parts and water 2000 parts, with chromic acid 1 part. The catgut should lie in this preparation for twenty-four or forty-eight hours. It may then be preserved either in alcohol or in ether, as before. Catgut and silk may be kept in quantity in reel-holders, but these are generally objectionable on account of the great difficulty of preventing their being soiled and infected during an operation by the necessary contact with blood- or pus-covered fingers and scissors. Robb and Ghrisky have lately made a bacteriological study of the sutures removed in forty-five cases in which every antiseptic precaution had been followed, and without exception they found them infected with a greater or less number of bacteria. Silkworm gut was infected with far fewer germs than silk or catgut. Even silver wire was not exempt. Tension was a potent factor in causing the multiplication of the germs. Hence the greater safety of silkworm gut is proved bacteriologically as well as clinically, and the importance of approximating the wound-surfaces with the least possible tension is emphasized.

Halsted of Johns Hopkins Hospital has recently introduced a new method of preparing the submucosa from which catgut is made, and calls it *gut-wool.* It is used solely for the purpose of stopping excessive hemorrhage from bone. To manufacture the gut-wool the dried submucosa is moistened with absolute alcohol and cut into fine shreds with a tobacco-cutting machine. The wool is then preserved in an alcoholic solution of corrosive sublimate, 1 : 1000. To plug bone sutures or bleeding points in bone take a very small quantity of the wool in a sharp-pointed forceps and press it into the bone. This is an instantaneous and infallible method of arresting hemorrhage in bone.

Dressings.—Ordinary cheese-cloth, which is very cheap, is prepared in the following manner: The grease is removed and the gauze thus made absorbent by boiling it either with soft soap or soda, after which it is rinsed and dried. It may then be soaked in a solution of bichloride of mercury, 1 to 1000, or any other strength desired, with twice as much common salt as of sublimate. The object of the salt is to prevent the sublimate from turning into calomel. It can be kept either moist or dry in disinfected glass jars. Sterilized gauze is first made absorbent, as before, and then is boiled for ten or fifteen minutes, or it may be placed in a sterilizer and steamed for the same length of time. In order to make iodoform gauze, sterilized gauze is impregnated with a mixture of 3 drams of iodoform to 6 ounces of ordinary soapsuds made with castile soap. In using sublimate gauze it should be remembered that certain parts of the body —for instance, the recently shaven scalp and the scrotum—are liable to be pustulated by a 1 : 1000 gauze, and it should therefore be used of a strength of 1 : 2000 or 3000 on these parts. This can easily be done with sufficient accuracy extemporaneously by washing the ordinary sublimate gauze in sterilized

water, and then in a solution of sublimate of the desired strength. For making sublimate solutions the manufacturing chemists now supply tablets containing 7½ grains of bichloride of mercury and 37½ grains of tartaric acid, the object of the latter being to prevent the decomposition of the bichloride and the formation of the albuminate of mercury from the blood-serum. One of these tablets added to one pint of water makes a solution of 1 : 1000.

Sir Joseph Lister has recently introduced another dressing, made of the double cyanide of mercury and zinc. It is deficient in power as a germicide, but this objection can be obviated by dipping it in a 1 : 4000 sublimate solution before use, or incorporating this with it during its manufacture. Its inhibitory power is, however, very great. The double salt is very insoluble in the discharges of wounds, and hence is not easily washed out of the dressings, and it is non-volatile and non-irritating. Its manufacture involves considerable trouble, and it is perhaps as well to purchase it from reliable dealers. In fact, at the present day this industry has become so well established that a number of firms manufacture very reliable dressings of sublimate, carbolic acid, iodoform, and the double cyanide, and also of sublimated wood wool. All purchased dressings, however, should be tested from time to time bacteriologically, in order to determine whether they are absolutely germ-free.

All of these dressings should be applied in large quantities at the time of a primary dressing, when there will be considerable oozing. Later dressings may be done with smaller amounts. The dressings should be covered with rubber dam. This is the thin pure rubber tissue used by dentists in filling teeth. It can be bought by the yard, and should be always washed clean with soap and water, rinsed, and placed in a carbolic or bichloride solution before use. Its object is partly to prevent the discharges from the wound soaking through the dressings and soiling the patient's clothing, but more especially to prevent the access of bacteria to the wound by means of the dressings which have become moistened by the wound-fluids. It is far superior to the frequently used mackintosh in that it has no cloth tissue on either side. Dressings are best held in place by bandages made of gauze rolled on slender cylindrical sticks of wood to give stiffness to the roller. These bandages do not easily slip. Of course ordinary roller bandages may also be used. If pressure is desired at any point on the flaps, it can be made either by placing a moist antiseptic sponge underneath the dressing or by absorbent cotton, or, better, antiseptic wool, outside of it.

The Operation.—The surgeon should first of all see that absolutely everything is ready; not only that the patient has been properly prepared, the stomach and bowels attended to, the clothing ready for operation, instruments, dressings, rubber dam, bandages, and all the drugs and antiseptic solutions at hand, but that everything that can be needed, from the most important to the least, is within reach. During the operation every detail must be attended to "with a thoroughness as minute and definite as if that detail were the turning-point of success." The means for the prevention of shock have already been described in part, but still further we must remember that the time occupied by the operation and the duration of the anesthesia influence considerably the amount of shock. Hence speed without haste should be the rule for every operation. Of course the precautions should be taken to remove false teeth, tobacco, or other foreign bodies from the mouth. After the patient is etherized he is placed upon the operating table, and his clothing so arranged that if possible it shall not be soiled. The body will be protected by blankets, over which will be laid the sterilized or antiseptic towels or sheets.

The incision should always be sufficiently long. The question whether it shall be an inch or two longer or shorter, as far as healing is concerned, is of little matter at the present day, but it is of great importance that it shall be long enough to give ample room for the manipulations required. No feats of dextrous manipulation within narrow limits are allowable. Hemorrhage is arrested as vessels are divided by placing the fingers upon them until they can be clamped with the hemostatic forceps, and later ligatured if required. Heat and pressure by wads of gauze dipped in hot water at 110° to 120° F. will be most valuable aids, especially for arresting the bleeding from the smaller vessels and any general oozing.

Irrigation during an operation is often employed. Bichloride of mercury solution is the one in general use. The strength of it should vary according to the part to be irrigated. The skin can be irrigated with a solution as strong as 1 : 500, but when the surface is broken this is too strong, and 1 : 2000 is sufficient. If the peritoneal cavity is to be washed out, the strength must not be more than 1 : 10,000, or even milder, or plain boiled water may be used. If a joint or the bladder is to be irrigated, the strength should be 1 : 10,000. In sinuses, joints, etc. where poisoning may result from the retention of a solution, the usual 1 : 1000 solution can be used if its use be followed by the injection of plain boiled water sufficiently cooled.

Landerer's dry method of operating is adopted by many surgeons. In this, once the field of the operation, and therefore the wound, are aseptic, no fluid whatever is allowed to touch the wound. Mops or pledgets of gauze are packed in it as rapidly as the operation is completed at one part, and subsequently, when the last part has been packed, it will be found, if the wound be a large one, that the part first packed is perfectly bloodless and dry.

Drainage.—Before the edges of the wound are approximated the question of drainage is to be decided. The principles upon which this must be determined are mentioned in various parts of this work. We have here to do only with the practical methods which are most common and most efficient.

Carbolic acid and bichloride of mercury and other antiseptic solutions, while they prevent suppuration, irritate the tissues to a certain extent, so that provision must be made for the removal of serous exudation. Drainage-tubes should be brought out at the angle of the wound which will be lowest when the patient is recumbent, or through an opening in the lower flap; and the size of the tube should be adapted to the character of the wound itself.

Drainage in a wound can be secured by tubes made of rubber, of glass, of decalcified bone, or upon the principle of capillarity. The tubes should be cut the proper length, and holes made upon the sides at short intervals, and then the tube should be cut off nearly flush with the skin and held *in situ* by an aseptic safety-pin, or often better by a stitch through the skin and tube. The lower angle of the wound should not constrict the mouth of the tube by having the last suture too tight. If the tube projects much beyond the wound, instead of being flush with the surface, the projecting part is compressed or bent by the dressings, and it will fail to drain the wound. In a very long wound it is better to place two short drain-tubes, one at each end, rather than one very long one. The rubber tube may be removed upon the first or second day after operation unless more prolonged drainage be required by reason of prior suppuration, etc. If the wound has been made aseptic at the first dressing, there is no occasion for a tube to remain longer than the third day; it may often be removed sooner, as its usefulness is over when it has drained the primary abundant secretion. Its longer retention will tend to cause a persistent

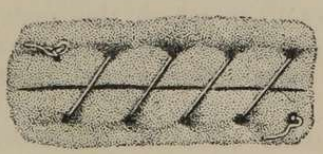
sinus. Glass tubes are used in abdominal cavities, but seldom in wounds of the soft parts. The decalcified-bone tubes are left in the wound, and are supposed to become absorbed in a few days after the object for which the tube was introduced is accomplished, a supposition which is often not realized. The capillary drainage is effected by strands of catgut or horsehair. A dozen strands a few inches in length are laid in the bottom of the wound, so as to project beyond the angle of the wound, but not beyond the dressing. In this respect the drainage by capillarity differs from that effected by tubes, which require to be cut off flush with the surface of the body. The strands should be carefully arranged parallel to one another, cut off squarely of the same length, and covered with protective so as to keep them moist, otherwise they will dry into a single mass and all capillarity be destroyed; and if at the end of the third day there is occasion still to continue some drainage, a few of the strands can be withdrawn from time to time. In some wounds the drainage by rubber tube and by strands of catgut or horsehair can be advantageously combined, both being inserted at the operation, the tube removed in twenty-four to forty-eight hours, and the horsehair later.

Many wounds, if the hemorrhage is entirely arrested and the wound absolutely aseptic and its walls in contact, may be entirely closed without drainage. This is certainly the ideal toward which the surgeon should strive, as a drainage-tube is always a possible means by which infection may occur. But the conditions stated must be first realized.

Methods of Suturing.—Sutures may be the continued or glover's, interrupted, quilled, twisted, hare-lip, button, etc.

In the *continued* or *glover's* suture the needle is introduced about one-quarter of an inch from the edge of the wound, and is carried first through one lip of the wound, and then through the other at a point one-quarter of an inch from the edge, and so on from one end of the wound to the other (Fig. 431). At the lower angle an opening sufficiently large to introduce a drainage-tube may be left if necessary. The tube must not be constricted, otherwise it will not afford free drainage.

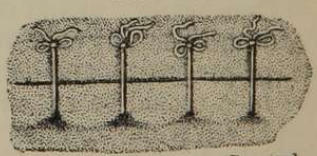
Fig. 431.



Continued or Glover's Suture (Bernard and Huette).

The *interrupted suture* (Fig. 432) is made by approximating the edges of the wound by introducing a suture in the manner already described, but the knot is tied and the ends cut off, and other fresh sutures are introduced in the same way. About three or four stitches to the inch are used, according to circumstances. The interrupted suture must not be tied too tightly, as tension will produce a stitch abscess; only that tightness which will bring the two edges of the wound into apposition is desirable. In removing the interrupted suture (which is the suture most commonly used) the stitch is lifted gently from the skin sufficiently to introduce one point of a pair of scissors, which should then cut the suture exactly at one of the points where it penetrates the skin. The skin on the opposite side of the wound is then supported by the blades of the scissors, one on each side of the stitch, while with the forceps it is withdrawn. Halsted of Baltimore has used and urged a subcutaneous stitch in which the needle is introduced on the under surface of the skin, emerging directly at its cut edge. It is made with silver wire, the ends being secured by simply bending them. The result is an almost invisible scar. This suture

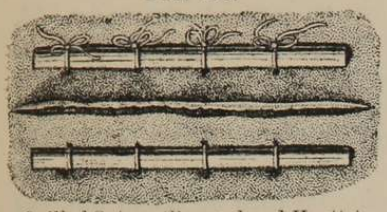
Fig. 432.



Interrupted Suture (Bernard and Huette).

is especially adapted to exposed parts, as the face. The object of this method is to avoid infection by the skin-coccus (staphylococcus epidermidis albus), which is constantly found in the epidermis, and may be carried through the stitch-wound by the suture if the latter is passed through the skin from without inward.

Fig. 433.

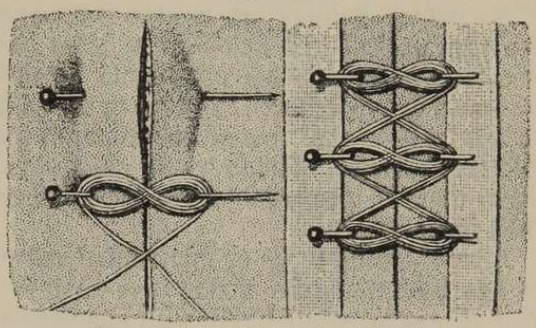


Quilled Suture (Bernard and Huette).

The *quilled suture* is indicated where there is considerable tension (Fig. 433). The needle is introduced half an inch from the edge of the wound, carrying a double thread, which is passed and then unthreaded. The quill is then caught in the loops upon one side of the wound, and the two free ends are tied around a corresponding piece of quill upon the opposite side. The length of the quill should exceed the length of the incision, so that the wound will be evenly and uniformly drawn in apposition.

The *twisted suture* is used in hare-lip cases. A steel pin is thrust through both lips of the wound at a distance of half an inch from the edge. The edges are then brought into accurate apposition; a silk thread is wound over the ends of the pin in an oval or figure-of-8 manner (Fig. 434).

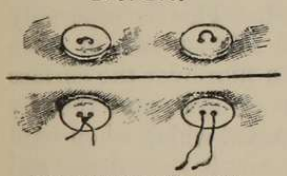
Fig. 434.



Twisted Suture (Bernard and Huette).

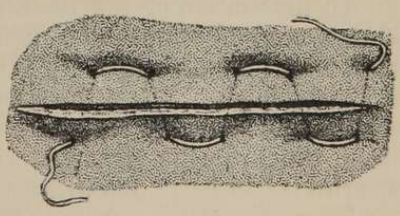
The *button suture* (Fig. 435) consists of two lead buttons, to one of which is attached a silver wire. The button is placed about two inches from the edge of the wound, and the wire is threaded to a needle which is passed through under the tissues and across the wound and out the other side at a point two inches from the edge of the wound. The second button is now placed at this point, and the silver wire is passed through the perforated centre and wound across the edges or wings of the buttons. The button suture is used where the wound is extensive and there is a tendency for it to gape from tension. After amputation of the breast the button suture is sometimes used with advantage as a deep or *relaxation suture* in addition to the sutures of the edges of the wound. Such sutures can be made extemporaneously also by perforated glass beads or other similar objects, the wire suture after passing through the beads being twisted on bits of disinfected wood, such as pieces of a match. Small pledgets of aseptic gauze can be substituted for the buttons, one being caught in the loop of the thread and the free ends tied over the opposite pledget. In all forms of this suture care must be taken that the tension is not too great, or it will favor suppuration.

Fig. 435.



Button Suture (Bryant).

Fig. 436.



The Quilted Suture (Bernard and Huette).

The *quilted suture* (Fig. 436) is often used to act as a sort of splint, and

to keep the edges of the wound quiet where there is a tendency for the lips to gape or to contract, as in the scrotal tissue, where the action of the cremaster prevents absolute quiet.

Subcutaneous or *Buried Sutures* are often necessary in deep wounds. In this case each layer of tissue beneath the skin must be sutured separately. A divided tendon must be sutured to its other end, the fiber of a muscle must be united to its other fibers; fasciæ, aponeuroses, nerves, and any other structures must be brought into contact each with its own divided part. Where we have to deal with deep wounds from aponeurotic and muscular tissue, as in the abdominal wall, buried sutures, either of catgut or silk, can be used. Different layers should be united each to its fellow, and especial care be taken that the aponeurotic structures of the abdominal wall are included in the sutures. As Treves has well stated, the *surfaces* of the wound, and not only the overlying *skin*, are to be approximated.

For details as to the sutures of nerves, tendons, muscles, and bones see the articles on the surgery of those structures.

Secondary Sutures are used in wounds which immediately after operation have been packed with iodoform or other antiseptic gauze to secure complete hemostasis or asepsis not obtainable by the usual methods. The packing is withdrawn in two or three days, when the sutures which may have been inserted and left long at the time of operation, or may be put in later, are tied in the customary manner. Union by first intention can frequently be secured in this way in wounds that would have been infected or distended by blood-clot if closed immediately.

After the continuous or interrupted sutures have been applied, if no drainage has been used, the wound may often be sealed by covering it with small strips of gauze painted over with iodoform collodion or with a mercurialized solution of collodion, 1 : 30,000.

If, although formal drainage is dispensed with, some oozing is to be expected, it would be better to use interrupted sutures at wide intervals, permitting of a slight escape of the fluids of the wound from between its edges.

A *dry method of dressing wounds* is often employed. This is especially adapted to small wounds. Iodoform, aristol, salicylate of bismuth, or some other innocuous but antiseptic powder which forms a thin film over the surface of the wound may be dusted upon it after it has been sutured, and thus by inspissating the blood and serum a dry aseptic crust is formed which when hard prevents putrefaction. As this film is exposed to the air, it soon dries, and the hard, firm crust prevents the entrance of particles of dust into the wound. Under this artificial scab the healing process rapidly progresses. The scab thus formed should not be removed, but allowed to fall off after the part is healed beneath it.

An illustration of the usefulness of this method may be found in the plan of treatment of compound fractures adopted by Treves in the London Hospital, and, following him, by White in the University and German Hospitals in Philadelphia. When the case is admitted to the hospital, the wound and surrounding parts are cleansed, but no attempt is made to arrest the oozing of blood, which, in the great majority of these cases, is still going on. Iodoform is sprinkled in large quantities and at short intervals over the wound and adjoining parts, and this is continued sometimes for two or three days. At the end of that time a scab has formed, beneath which cicatrization and repair take place aseptically. The infiltration of the muscles and connective tissue, which sometimes follows the sealing of the wound in compound fracture while

oozing is still going on, is thus avoided, and with the least possible disturbance of the parts. During the entire course of the case the affected limb, with the necessary fixation apparatus, is kept uncovered, as the atmosphere which surrounds such a part beneath the bed-clothes is much more likely to be septic than the general atmosphere of the ward. Results in a large number of cases justify confidence in this method.

Healing beneath a Moist Blood-clot.—This method of healing is adapted to those cases in which there has been a loss of substance in the soft parts and the edges of the wound cannot be brought into apposition. It is also applicable in cases of resection of joints and of compound fracture of the long bones, especially where there is slight separation of the fracture due to the loss of comminuted fragments. In operation for removal of necrosed bone it is also a method of repair that has many advantages. Schede has reintroduced this method, and to him is due the credit of perfecting the technique of a process of repair in cases in which the healing would never have taken place, or, if it had taken place, would have done so very imperfectly. The wound is thoroughly cleansed and made perfectly aseptic, and then blood is allowed to fill up the cavity. The blood-clot thus formed affords protection to the raw surfaces of the wound, and if the clot does not contract and desiccate on the one hand or undergo decomposition on the other, it will form a nidus for granulation-tissue which develops and finally cicatrizes. In order to utilize a blood-clot for the purpose of healing it is essential to keep the clot moist. To provide for this, a small strip of rubber tissue or protective is placed over the surface of the wound and made to overlap its edge. This fine rubber tissue should be rendered perfectly aseptic and immersed in carbolic acid before its application to the wounded surface. Over the protective a strip of iodoform gauze may be placed, and over the iodoform gauze is placed loosely an abundance of bichloride gauze, which provides ample drainage by absorbing from the wound all surplus serous and hemorrhagic discharges. The wounds that are best adapted for this process of healing are those in which the structures and tissues are highly vascular. Tendons, fasciæ, and other tissues possessing a low grade of vascularity are not suitable for it.

Open Wounds can be treated on the same aseptic principles that govern the surgeon in the management of closed wounds. If a wound is allowed to remain open, it can be kept aseptic if provision is made for free drainage and oxygen is admitted to the wounded surface. By free drainage is meant a provision to prevent any retention of discharges that may undergo putrefaction. A clean, healthy granulating surface is a barrier to the entrance of septic germs into the circulation. Frequent irrigation and the avoidance of the retention of discharges afford immunity from sepsis in any wound. The small amount of discharge from the granulation-tissue left after irrigation undergoes a sort of desiccation and concentration which renders the soil unsuitable for the growth of septic germs. Pasteur has demonstrated that germs will not multiply upon a surface bathed in a concentrated discharge. The free admission of oxygen to the open wound is in itself somewhat of a safeguard against putrefaction. Many of the special germs concerned in the development of putrefaction are often incapable of multiplication in the presence of oxygen.

After-treatment.—As soon as an operation is terminated the patient should be put to bed between blankets and surrounded, if necessary, with hot-water bottles or hot-water bags, great care being taken that the patient is not burned by them—an accident which has often produced serious consequences. The room should be darkened for the first few hours at least, and the utmost

quiet, both of mind and body, obtained. No visitors should be allowed, except perhaps either the husband or the wife. Very frequently for want of this direction friends, and especially a number of members of the family, may greatly disturb the patient by conversation. Not only should rest of the body as a whole be insisted upon, but also and especially rest of the part. For example, after an amputation of the breast the arm of that side should be secured to the trunk by a binder or bandage. After an operation on or near a joint the extremity should be placed upon a splint. In the early stages of union of wounds, the fine connective-tissue fibers, which are developed and bind the parts together, and the delicate slender vessels, should be preserved intact by absolute rest of the part.

The patient's comfort should be the chief object, and hence a change of position may be allowed, not by the active efforts of the patient, but by the aid of the nurse. All such little attentions as placing a pillow for proper support of the part, or relaxing a bandage, or the insertion of a little cotton at a point of undue pressure, or gentle friction applied to the back or extremities, suspension of an extremity, or its being placed on a double inclined plane,—all these means and the many others which will suggest themselves to a thoughtful nurse are to be employed for the comfort of the patient. Moreover, we must not forget that many patients are made uncomfortable by too heavy and too warm bed-clothing. That amount of clothing which is the most conducive to comfort is the best. For the treatment of shock external heat has already been mentioned as one of the most important means. Sometimes, again, irritation by mustard for a short time to the abdomen or to the extremities may be used. If the shock is due to great loss of blood, the foot of the bed should be raised and pillows and bolsters removed, thus favoring the access of blood to the brain by gravitation. Strychnia, digitalis, and atropia, one or all, may be used.

One of the most annoying post-operation symptoms is the *ether-vomiting*. This usually occurs, and often continues for two or three hours, and sometimes longer. If vomiting continue for over twelve to eighteen hours, some other cause than ether-nausea should be sought for, especially peritonitis if the operation has been an abdominal section. The best treatment for ether-vomiting is the administration of one-fourth of a grain of cocaïne every hour or two until four or five doses have been taken, with small doses of brandy and finely divided ice or champagne and ice. The ice is best pulverized by placing a small lump in a loop of a clean towel and striking it, as if it were a hammer, on a marble washstand. Very hot water will often arrest the vomiting better than ice. Mustard over the epigastrium is also found useful, and occasionally lavage of the stomach by the stomach-tube, which has been successfully employed in desperate cases of this character. The vomiting is usually accompanied by marked thirst. This can be best relieved by a rectal enema of six to eight ounces of warm water, to which may be added a little brandy or whiskey.

Any other than a trifling operation is usually followed by some pain. Since the introduction of antiseptics the amount of pain which patients suffer has been greatly diminished. It is no uncommon thing nowadays, after an amputation of an extremity or of a breast, to have the patient pass the entire period from the operation to complete convalescence with practically no pain. Occasionally, however, moderate, and sometimes severe, pain will be experienced; it is likely to occur if infection takes place. Formerly morphia was practically the only remedy that was used to relieve this pain, but it evidently had its disadvantages in the constipation, the furred tongue, and other digest-

ive disturbances which it induced. For severe pain morphia must still be employed in doses of $\frac{1}{8}$ to $\frac{1}{4}$ grain every hour or two, best given hypodermatically. But in most cases the moderate pain after an antiseptic operation, unless the remedy is contraindicated by great shock and a weak heart, can be controlled and sleep induced by small doses (5 or 10 grains) of almost any one of the antipyretics, which all act as analgesics. Antipyrine, antifebrin, phenacetin, acetanilide, etc. may be used. Opium is to be resorted to only if these fail. In operations on the abdomen the pain, tenderness, and other symptoms of a beginning peritonitis are best met, in the opinion of many surgeons, by repeated and frequent small doses of a saline aperient.

The *bladder* must be carefully attended to after an operation. Sometimes the patient will be able to urinate voluntarily, but in many cases the catheter must be used. This should be most carefully disinfected, as has already been described. As a rule, it need not be passed before the patient feels the need for it, from five to eight hours after the operation.

Food and Drink.—After any serious operation a patient may readily go a number of hours, and even two or three days, without food by the stomach. In operations on the stomach and intestines this should be a cardinal rule. No food whatever is required for from four to six hours after the operation, during which time the stomach may possibly right itself and retain small quantities. If there is difficulty in retaining it, the patient should be fed by rectal enemata of peptonized milk, beef-tea, etc. If given by the mouth, the food should be at first in quantities of not more than two or three ounces every two hours, the amount being increased and the intervals lengthened as the condition of the stomach will warrant. As a rule, the bowels, which have been thoroughly evacuated the morning before the operation, will not be opened the day after it; but on the second day, or certainly on the third day, they should be moved, either by an enema or by a gentle laxative. After the second or third day they should be carefully seen to either every day or every second day. Often after operations for hemorrhoids comfort will be attained better by daily evacuations, which prevent the feces from becoming hard and defecation painful. The surgeon should be careful to direct that until the patient is able to rise a bed-pan should be used, and on no account should he rise to use the commode, still less to go to the water-closet.

After the first or second day the patient's comfort is greatly increased by a daily sponge bath of hot water and alcohol, which should be done without any exposure of the person. Careful notes should be taken by the nurse, either on a printed blank or on one prepared extemporaneously by the surgeon.

Renewal of Dressings.—As a rule, the less frequently the dressings are disturbed the better it will be for the patient, since even the gentlest renewal is apt to cause some pain, and also since the handling of a wound always exposes it to the possibility of infection. So soon, however, as the wound-fluids have wet the dressings to their edge they must be reinforced, or, better still, renewed; in some cases this will be required within a few hours in consequence of the free oozing. In other cases even a number of days may elapse before the dressing is changed. If a drainage-tube has been inserted, the dressings should be changed in from twenty-four to forty-eight hours in order to take it out. Usually by the fifth or sixth day the sutures will cause a little tension and produce stitch-abscess unless they are removed. These abscesses are especially due to the skin-coccus, the *staphylococcus epidermidis albus* (Welch), which is constantly and normally found in the epidermis, and certainly cannot be removed by any of the present methods of disinfection of the skin. The renewal of dressings should be done with the same antiseptic

care as their first application: the hands of the surgeon and the nurse should be disinfected with care similar to that exercised at the time of operation. The instruments—usually a pair of scissors and forceps are all that are required—should be disinfected by being placed in a 1 : 20 carbolic solution for at least fifteen minutes, and the new clean dressings should be ready for application before the wound is uncovered. The bed-clothes should be turned down and covered with antiseptic or sterilized towels. If the wound is in the abdomen, the chest should be protected by a shawl also covered by a similar towel. Great care should be taken not to chill the patient. If they have to handle the body or bed-clothing, the binder or bandage, the surgeon and nurses should again disinfect their hands. Soiled dressings having been removed, the wound may be gently washed with an antiseptic solution, and after such attention to the wound as seems necessary the dry clean dressings, followed by the binder or bandage, should be applied. It is very important to change the position of the patient from time to time, to prevent bed-sores.

Bed-rests are often of great service during convalescence. They should, however, be employed with judgment, as it is sometimes dangerous to allow a patient to assume the upright position even in bed unless the heart's action is sufficiently strong. One which enables a patient gradually to sit up after a serious surgical operation and during the repair of a wound hastens recovery.

Air-cushions may serve as useful adjuvants by contributing to the comfort of a patient during convalescence. These may be used to remove pressure from parts which have shown a tendency to bed-sore formation, or they may be employed to rest extremities upon, or to make uniform and equable pressure upon certain parts of the body.

Water-cushions are often found to contribute to the comfort of a patient. They can be used to afford support to the back, or can be filled with hot water and serve as a conductor of heat to a part. Care should be exercised lest the water be too hot and thus burn a patient who may be in shock after an injury.

Single and double inclined planes are indicated when it is necessary to place one of the extremities in a position of flexion. In compound fracture of the leg in which there is a tendency for the fragment to protrude through the wound the double inclined plane relaxes the muscles and prevents the accident. A single inclined plane is indicated in a fracture of the patella or a wound of the quadriceps extensor muscle of the thigh, or in a case of cellulitis of the forearm where elevation, compression, and fixation of the part are simultaneously required.

Suspension apparatus, especially for the lower extremities, is necessary where a certain amount of movement of the body in bed must be allowed, while at the same time it is necessary to secure physiological rest to the wounded part itself.

Splints are often a necessity in wound-treatment. They serve to secure absolute rest to the part until healing takes place. Whatever material is employed for the splint, it should be carefully and evenly padded with absorbent cotton. If the padding becomes stained by the discharges, a new one should be substituted, as it might be the means of carrying infection to a wound.

Complications after Operation.—The most important danger is that of septic inflammation. If this does not occur, even the most serious wounds should run an aseptic course. There will usually be a post-operation rise of temperature to 100°, or occasionally to 101°, which will persist for from twenty-four to forty-eight hours. If the temperature rises after this latter time, sepsis should be suspected and the dressing be removed and the wound inspected. If sepsis has occurred, the wound should be disinfected through the drainage-

tube if one has been used, or in some cases it may be necessary to reopen it by removing the stitches, and follow this by disinfection. If hemorrhage has occurred and any considerable clot has formed, evinced by bloody oozing, by swelling and tension, and by a rise of temperature to 101° or over, the probabilities are that the clot is too large to be absorbed. One, two, or more stitches should be removed and the clot completely evacuated, and any bleeding vessels secured, followed by a redisinfection with scrupulous care. If this is done within from twenty-four to forty-eight hours, very frequently the case will still run an aseptic course. If in an abdominal case peritonitis arises, the saline treatment should be instituted at once. Sometimes the bowels become greatly distended with flatus, in which case great comfort may be obtained from inserting a soft catheter or rectal tube, which may be held in place and secured from loss within the bowels by a moderately long thread tied to its extremity. If the distention does not yield, a saline laxative in repeated doses, or a turpentine enema, will usually relieve it.

Not uncommonly, especially in hospital patients, delirium tremens will break out: this must be treated in accordance with the principles already laid down in connection with that affection. Occasionally insanity follows surgical operations, especially those about the head, uterus, or ovaries. The attack may often be only temporary, but in some cases it is more or less permanent.

Causes of Death after Surgical Operations.—This may be due to hemorrhage, either primary or secondary; to the administration of the anesthetic, directly or indirectly, as, for, example, by choking from the entrance of vomited matter into the trachea; to shock of the operation, due in part to hemorrhage as well as narcosis, and also to the traumatism calling for the operation; to entrance of air into the veins; to sepsis from incomplete or imperfect antiseptic technique; to shock, either primary or secondary, from some organic disease of one of the vital organs of the body; to tetanus; to persistent vomiting; to delirium tremens; to the formation of emboli or thrombi; to the development of some intercurrent disease, as pneumonia, peritonitis, bronchitis, or some other affection which may be indirectly or directly attributed to the operation itself; to œdema glottidis, caused by an inflammation of the surrounding tissues in the neck; to an extension of an inflammation from one organ or tissue to another, as a surgical kidney from a cystitis the result of an operation for removal of a calculus; to perforation of the bowel, owing to a slough caused by tearing up adhesions during a laparotomy, or to the formation of a slough produced by adhesive inflammation between the intestine and bladder, for example, when a fistulous communication was established; or to over-stimulation of the heart in an attempt to bring about reaction after operation.

CHAPTER II.

ANESTHESIA.

Anesthetics have contributed much to the present success of surgery. The first recorded instance of a surgical operation having been performed while the patient was under the influence of anesthesia is the removal of a tumor from the neck by Dr. Crawford W. Long of Athens, Ga., in 1842. No further attempt, however, was made to introduce an anesthetic

until 1844, when Dr. Horace Wells, a dentist of Hartford, Conn., first inhaled nitrous-oxide gas, and had a tooth extracted without any sensation. Without doubt, the merit of introducing ether as an anesthetic belongs to Dr. Morton, who in 1846, at the suggestion of Dr. Jackson, a chemist, selected this agent for the purpose of extracting teeth. Dr. John C. Warren, the senior surgeon of the Massachusetts General Hospital in Boston, was applied to by Dr. Morton in the autumn of 1846, who informed him that he had discovered a means of preventing pain in dental operations, and wished to have an opportunity to try it in a surgical operation. The first operation was performed by Dr. Warren at the hospital on October 16, 1846, and consisted in the removal of a vascular tumor of the neck from a young man in the public operating room. Dr. Morton administered the ether. In a few months anesthesia, hitherto a dream, had become a reality throughout the civilized world. In 1847, Prof. James Y. Simpson of Edinburgh first introduced chloroform into surgical practice.

Anesthetics act by producing a paralysis of the cerebral and spinal nerve-centers. There is first a stage of cerebral excitement, followed by a stage of cerebral insensibility, then a loss of voluntary movement, followed by a loss of reflex action. Consciousness is lost before the paralysis of the muscles supervenes, and a patient is said to be fully anesthetized when the nerve-centers are paralyzed, with the exception of those presiding over the respiration and circulation.

ETHER is chemically the oxide of ethyl, with the formula $(C_2H_5)_2O$. It is a highly volatile and clear liquid, with a pungent odor, a sharp taste, and a specific gravity of 723 (at 54.5° F.), and boils at 95° F. It is highly inflammable and explosive. This fact should always be borne in mind, because during an operation a lighted candle or gas-jet brought near the ether may cause a serious explosion. Ether vapor, being heavier than air, always falls; hence if a light has to be used, it should be held *above* the ether to avoid the danger of such an explosion. If an explosion occurs, the patient's face should instantly be covered with a towel or pillow to prevent burning; the inhaler may be thrown upon the floor, but *never* the ether-can or bottle, for fear of the spilling of the ether and its catching fire.

Ether is prepared by the action of sulphuric acid upon strong alcohol heated to a temperature of 260° to 300° F. A simple test as to the purity of ether is to add a little oil of copaiba to it, when the mixture should remain clear; if an emulsion forms, it indicates impurity of the article from the presence of alcohol or water.

There are some *contraindications to the use of ether* as an anesthetic. In cases of renal disease ether is generally thought to be unsafe, owing to the danger of suppression of the urine and shock, although the opposite opinion is held by some surgeons. In atheroma of the vessels it is not expedient to use ether, owing to the vascular excitement incident to the primary stage, which might result in rupture of the vessels from increased tension. In patients suffering from emphysema, asthma, or chronic bronchitis ether is unsuitable, owing to its irritation of the pulmonary and bronchial organs. Ether is also contraindicated in serious and prolonged operations about the face and mouth where the patient cannot be kept constantly breathing the vapor. Ether can be safely employed when it is necessary to use the actual cautery or a lighted candle near the face of the patient by suspending its administration for a few moments, and fanning away its vapor before using the cautery.

In *administering ether* by a cone or by some inhaler the first few inhalations should be with a very small amount of ether and largely diluted with air,

because pure ether vapor irritates the mucous membrane and causes a spasm of the larynx. After a few inhalations the patient is bewildered, the face flushed, the respiration rapid, and the pulse at first slightly accelerated and somewhat stimulated. Then follows the period of "*primary anesthesia*," which continues for a brief time, and during which short operations, such as opening an abscess, dilating the sphincter, etc., may be done without pain and with almost instantaneous recovery. If during the earlier part of the administration the patient is repeatedly directed to hold his arm up, its fall is a good indication of the induction of this stage. Many surgeons, however, consider this a dangerous practice.

A period of excitement soon supervenes, and it is often necessary at this period to restrain the patient. After the stage of excitement the patient passes into a state of muscular relaxation; the respirations are regular, accompanied often by snoring, and attended by a considerable secretion of mucus in the mouth. The face is flushed and the skin soon becomes moist. During the period of muscular rigidity which precedes that of relaxation the breathing sometimes ceases, and artificial respiration must be resorted to at once.

While administering ether the fact must always be borne in mind that its vapor commonly kills by asphyxia, and not by syncope; consequently, the pulse usually keeps up long after the patient has ceased to breathe, although in rare cases the failure of the heart is primary, the patient dying of syncope. Hence, though the pulse is to be watched, the respiration should be the principal object of solicitude. The symptoms of asphyxia come on gradually, and thus a warning is given, and the first appearance of dangerous symptoms must be met with prompt and suitable remedies. There are certain patients who take ether with great difficulty, and in whom its administration is attended with some danger. Patients with cardiac obstruction and sluggish circulation are very apt to take ether badly. If the face is florid or there is much capillary stasis, the administration of ether is attended with especial difficulty.

The hypodermatic injection of $\frac{1}{6}$ of a grain of morphine with $\frac{1}{120}$ of a grain of sulphate of atropine has been suggested as a valuable prophylactic during etherization.

CHLOROFORM (formula $CHCl_3$) is a clear liquid, with a specific gravity of 1.497 at 62.5° F., with a sweetish taste and an ethereal odor. The drug should not be allowed to stand exposed to the light, since the article thus becomes impure by splitting up into hydrochloric acid and chlorine.

In *administering chloroform* a towel may be placed over the patient's mouth and be kept moistened by chloroform drop by drop, or about a half teaspoonful should be poured upon a napkin and held about an inch from the face, but never allowed to touch it, on account of its irritant action on the skin. The patient should be instructed to close the eyes, since the vapor may inflame the conjunctivæ. A little vaseline may be smeared over the face to prevent erythema of the skin. After the patient has inhaled the chloroform a few minutes, consciousness is lost, the conjunctivæ become insensitive, and the breathing assumes a stertorous character. During the inhalation the napkin must be kept at least one inch from the patient's face, not only because if held nearer than this the vapor might act as a vesicant, but also and especially because experiment has shown that the vapor is inhaled under the condition just stated in the strength of about 5 per cent. admixture with the air, which is a proper proportion. The vapor must not be given too suddenly nor continued too long without allowing fresh air to be inspired. The patient should be always placed in the recumbent posture, and never allowed under any circumstances to sit up erect. Before the patient is fully anesthetized convulsive movements often take place and

the face becomes cyanosed. It is best in such case not to struggle with the patient, but to discontinue the inhalation until the cyanosis has disappeared, when the napkin can be replaced over the face. Occasionally, without convulsive movements or lividity of the face, the patient passes quickly into an unconscious state. The pupils should be closely watched to ascertain if they respond to light or if they are dilated. Failure of the pupils to respond to light, or their wide dilatation, is a sign of approaching danger, and the inhalation should be at once discontinued, the head lowered, the tongue drawn well out of the mouth, the heart stimulated, and artificial respiration begun. The loud stertor indicating the closure of the larynx by the epiglottis is a sign of danger, and must not be mistaken for snoring, in which a patient often indulges while profoundly under the influence of an anesthetic.

In beginning anew to place the chloroform over the face of a patient upon whom its use has been discontinued on account of some serious signs, the vapor should be carefully and slowly given, otherwise fatal syncope may follow in a heart already affected by a previous overdose. During the entire period of taking chloroform the finger should be kept over the temporal artery, to detect immediately the slightest change in its character or volume. Every respiration should be watched. It is not enough to watch the movements of the chest, because the glottis may be closed and the chest-wall move, and yet but little air enter the lungs. The hand may be placed over the mouth and the current of air recognized. In case the glottis is closed and the vapor has filled the pharynx, the patient becomes asphyxiated, and as soon as the glottis is open a condensed volume of vapor instead of fresh air is drawn into the lungs. If the patient is suffering from a weak and feeble heart, this sudden overdose may cause a fatal termination. A patient may die either on account of asphyxia or from heart-failure. The asphyxia may be due to the presence of a foreign body in the larynx from vomited material, or to a too condensed form of vapor which the patient has been allowed to inhale. Heart-failure is a frequent cause of death during the administration of chloroform. The face becomes pale, the finger-nails turn blue, the pupils become dilated, the pulse flickers, and the heart's action is arrested. As a rule, this accident occurs only in a heart which has undergone fatty degeneration or in which mitral or aortic valvular lesions exist. The respiration often keeps up even after the heart ceases to beat. Hence in giving chloroform the great importance of watching especially the pulse in addition to the breathing. Death may occur from syncope during the first few inhalations, or it may occur at the end of the period of anesthesia, but under these circumstances some warning of impending danger is given by the gradual onset of the symptoms.

Of course in giving any anesthetic it is highly important that the lungs as well as the heart and the kidneys should be sound. The anesthetic is probably never eliminated entirely by the lungs, but only with the aid of the excretory organs generally. If the lungs have a smaller area than usual on account of disease, just so much more strain is thrown on the kidneys, and if, in addition, the latter are contracted or fatty, the danger is greatly increased, especially if ether is used. Chloroform usually kills by its depressing action on the heart, and it seems highly probable that it often does this by the property which it has been shown to have, of destroying the contractile power of the cardiac muscle when it reaches it in a sufficiently concentrated form. Various circumstances may greatly affect the degree of its concentration in the lungs and the circulation, and thus increase or decrease the danger of its employment. Of these the most important are those connected with the character of the respiration of the patient and the circulation through the lungs.

For example, a given quantity of chloroform, say one dram, will exert its greatest effect when the respiration is deep and quick, because the vapor is then carried, in a given period of time, in larger quantity into the air-spaces of the lungs. If, at the same time, the patient, being only partially anesthetized, stops suddenly after breathing deeply—*i. e.* closes his glottis and strains—he increases the rapidity of absorption of the chloroform vapor into the blood; or if the movement of blood through the lungs is exceptionally slow, as shown by a dusky or congested appearance of the face, the opportunity for absorption will likewise be greater, and the blood will reach the heart overcharged with chloroform, and possibly produce its poisonous effect.

A combination of these conditions, therefore, should put the anesthetizer, especially one who employs chloroform, on his guard. During the preliminary stages of chloroformization at least it may be said that a patient who is suffering from shock after injury or accident, who is only partially anesthetized, whose face is dusky or congested, and who is struggling against the anesthetic, is in the greatest danger. Many deaths have occurred from chloroform under these circumstances and in this *first* stage, or so-called "stage of excitement."

The *second* stage is the period of true anesthesia, during which consciousness and sensibility are abolished, the muscles partly relaxed, the pulse weak, the breathing often shallow and feeble: it is during this stage that operations should be performed, and great care observed to limit the quantity of chloroform used to the least amount necessary to continue the condition without causing it to pass into the *third* stage, or that of dangerous narcosis, in which there are increasing weakness of the pulse, stertorous breathing, complete abolition of the reflexes, and other indications of profound involvement of the nerve-centers. This is still more dangerous than either of the other stages. There may be no premonitory symptoms of danger, or it may be indicated by either great paleness or congestion of the face or by marked irregularity and failure of the pulse.

It seems probable that the position of the patient during the administration of chloroform has something to do in increasing or diminishing the risks of respiratory or cardiac failure. It is said that during gynecological and obstetric operations, in which the patients are kept lying on the left side, the pulse and respiration have been more satisfactory during anesthesia from chloroform than when the patients have taken it in the dorsal position. It may be that the view which attributes special safety to the drug in obstetrical cases took its origin in the fact that the customary obstetrical position in England and in this country is upon the left side. Buxton thinks that the influence of position is unquestionably important, and is due to the fact that the condition of the heart, lungs, tongue, and larynx is more nearly correct physically and physiologically when a patient is placed in the left lateral position instead of on the back. In his opinion, the difference in the condition of the pulse and respiration of patients chloroformed in the dorsal and lateral positions has been so striking as gradually to force on one the lesson of placing every patient, where it is possible, on the left side while chloroforming him.

Poisoning from Ether and Chloroform.—In his address before the Berlin Congress of 1890, Dr. H. C. Wood called attention to the value of *forced artificial respiration*, and to its superiority to the ordinary plans as practised upon the human being. He stated that he had repeatedly taken dogs in which both respiratory and heart movements had been absolutely arrested by chloroform or by ether, and had restored them to life by pumping air in and out of the lungs. He further called attention to the fact that Dr. Fell of Buffalo had demonstrated the extraordinary efficacy in man of forced artificial respiration

in severe morphine-poisoning, so that the methods of the physiological laboratory must be considered as applicable to human beings. Dr. Fell's apparatus consists of a pair of foot-bellows, by which air is forced into a receiving chamber, which is connected with an apparatus for warming the air, and a valve which can be opened and shut by a movement of the finger. This valve, in turn, leads to a trachea-tube which is inserted into the trachea of the narcotized subject. When the valve is opened, the air rushes through the chamber into the lungs and expands them; the finger is lifted, the valve shuts, the lungs contract, and so the respiration goes on. Experiments upon the dead body convinced Dr. Wood that the trachea-tube is not necessary, and that a closely-fitting face-mask, such as is employed for the inhalation of nitrous oxide, will suffice in most if not all cases, and that an intubation-tube makes a good substitute for the trachea-tube. All the apparatus that Dr. Wood believes necessary is a pair of bellows of proper size, a few feet of India-rubber tubing, a face-mask, and two sizes of intubation-tubes (in case the face-mask should not suffice); there should also be set in the India-rubber tubing a metal tube with an opening similar to that commonly found in the tracheal canula of the physiological laboratory, so that the operator can allow the escape of any excess of air thrown by the bellows.

In using this apparatus the mask should be first tried, care being exercised to see that by a thread passed through it the tongue is well drawn forward and held in place, so that the epiglottis is kept up. If the lungs do not fully expand, the intubation-tube may be employed. The lungs should be thoroughly but slowly expanded by each stroke of the bellows, and a respiratory rate of about sixteen to twenty a minute be steadily maintained. It is essential to free the lungs and blood as rapidly as possible of chloroform by quickly changing the residual air of the lungs; but of course due care must be exercised that no force sufficient to rupture the air-vesicles be employed. When the symptoms are protracted and the body temperature fails, external warmth must be used, and the temperature of the room, unless the air entering the lungs be artificially heated, should not be less than 85° F.

Nitrous-Oxide Gas (formula N_2O) consists of nitrogen and oxygen in chemical union. The gas is made from nitrate of ammonium, which is heated in a glass retort until at 226° F. the salt melts, and at 460° F. it gives off the gas. This gas is stored for use in gasometers or in steel cylinders in which it has been liquefied by pressure. This is the best form for surgical use. On turning a key the gas escapes into a rubber bag (which comes with the apparatus), in which it is instantly vaporized and from which it is inhaled. When the gas is administered it enters the blood by diffusion through the thin walls of the air-cells in the lungs. The physiological effects are diminution in the number of the respirations, and the breathing also becomes shallow. If the gas is pushed to a dangerous dose, the effect is entire cessation of respiration. The heart, however, pulsates until some time after breathing has ceased. It is therefore of the greatest importance to watch carefully the respirations when this anesthetic is administered.

The duration of unconsciousness is about one minute; hence, while this gas is the safest of all anesthetics, its great drawback is the short interval of time during which anesthesia continues. Nitrous oxide can be administered, however, by one accustomed to giving it so that an operation occupying considerable time can be performed.

In administering the gas a cork or a piece of wood with a long safety-string attached to it is placed between the molar teeth. The mouth-piece is then placed over the face, the nostrils are closed by the thumb and finger, and the

patient begins to inhale the gas. When the lungs are filled there is a slight cyanosis visible about the face and ears and the tips of the fingers. In a few seconds later the patient begins to lose consciousness. During this time the room should be kept quiet, and no loud talking indulged in, as this is apt to disturb the patient and bring him back to consciousness. Within one minute from the inhalation the pupils dilate, the face loses all its expression, and strabismus is observed. In a very short time deep anesthesia supervenes, accompanied by stertorous breathing and muscular twitchings: the conjunctivæ become insensitive to touch, and the eyeball itself oscillates. The respirations soon become slower and shallow. The pulse at this stage should be watched, and if there is any change the inhalation of the gas should be immediately discontinued. The stertor and cyanosis are the signs indicating that the patient is anesthetized. The cessation of stertor, the disappearance of the cyanosis, and the absence of convulsive movements indicate the return to consciousness, which is sometimes ushered in by a shriek or cry. During the stage of anesthesia produced by nitrous-oxide gas there are no emergencies which are peculiar to this anesthetic, and none which are not fully covered by the rules laid down for the management of accidents during the administration of any anesthetic.

Rules for Giving Ether and Chloroform.—The patient should not eat any solid food for four hours before taking an anesthetic, nor any fluid food less than two hours before the operation. He may take some brandy and cracked ice ten minutes before inhaling the anesthetic.

The anesthetizer should always listen to the patient's heart, and at the same time assure the patient that this act is a part of the routine treatment in giving an anesthetic. If he is adroit, he can turn this to good advantage by assuring the patient that his heart is free from any disease.

The patient should always assume the recumbent position, which facilitates the circulation between the heart and the brain. Syncope is more likely to occur when the patient is in the sitting posture.

All articles of dress should be loosened, so as to have nothing to impede or constrict the respiration and the circulation, especially about the neck and abdomen.

The urine should always be examined, especially before ether is given.

In giving chloroform apply vaseline over the face to prevent irritation and excoriation of the skin by the vapor. The eyes must be closed, so that a conjunctivitis will not be produced.

False teeth must be removed, and tobacco or any other foreign body in the mouth taken out, lest it might become loose and fall back into the pharynx or larynx.

In applying the towel or inhaler to the mouth allow at first a free admixture of air with the vapor. Assure the patient that, though the first few inhalations are disagreeable, they are free from danger.

Instruct him to take a few full, deep inspirations in quick succession and count out loud up to fifty.

Watch the number and character of the respirations, and also feel every pulsation of the temporal artery from the beginning to the end. Clear the mouth and throat from mucus whenever it seems to impede the free entrance of air into the larynx. If mucus accumulates to any serious extent in the bronchial tubes, inversion of the patient will get rid of it.

When the eyelids can be raised without resistance and the cornea is insensitive, the patient is usually fully anesthetized. Do not begin an operation until the patient is entirely under the influence of the anesthetic, as it is dangerous to operate during partial anesthesia.

If vomiting occurs, turn the patient's head well to one side, open the mouth widely, and clear the throat and pharynx.

Under no circumstances should an anesthetic be given unless the administrator has tongue forceps, a mouth-gag, the necessary cardiac stimulants, and a hypodermatic syringe at hand. Tracheotomy instruments, the battery, and an apparatus for forced artificial respiration should always be within reach in a hospital.

Mortality.—It is not surprising that any drug which is capable of depriving a patient of consciousness and of rendering him insensible to pain is not entirely devoid of danger. Death from an anesthetic can often be traced to some carelessness. When carefully watched and administered properly there is, as a rule, but little danger. Sometimes, however, even with the best of care, sudden death will occur.

It is very difficult to give any accurate statistics as regards the mortality of anesthetics. It has been stated that chloroform kills one patient in every ten thousand; sulphuric ether, one in every twenty-six thousand; and nitrous-oxide gas, one in every one hundred and fifty thousand. If the anesthetic is restricted to one of the three just mentioned, the mortality is one person to every sixty thousand persons anesthetized. This represents only an approximate danger, but in careful hands and with every necessary preparation there is practically very little danger. Some deaths have resulted from the cases having needlessly been anesthetized in the sitting posture, often by incompetent persons, and without the proper means at hand to meet the sudden emergencies that may arise. Every surgeon should observe the above rules, and should inform himself in detail in regard to every patient before an anesthetic is administered.

ACCIDENTS OCCURRING DURING THE ADMINISTRATION OF AN ANESTHETIC.

Death may occur suddenly from paralysis of the heart. This accident is likely to happen when the vapor is administered in too concentrated a form to a patient suffering from a fatty or enlarged heart. The respirations continue after the heart has ceased to beat. In sudden syncope produced by an overdose of the anesthetic the patient's head should be immediately lowered almost to the floor.

Death may occur by asphyxia due to a falling back of the tongue over the epiglottis. The tongue in this case should be forcibly drawn well out of the mouth. Death may also occur by a tetanic fixation or by relaxation of the respiratory muscles. In the two latter conditions the heart pulsates while the respirations have ceased. Artificial respiration should be kept up, and nitrite of amyl administered by inhalation in three-drop doses.

Death, again, may occur from coma on account of a violent congestion of the brain. This accident is more likely to arise in patients addicted to the alcoholic habit or in cases of renal disease or in epileptics.

Death may also be caused by entrance of vomited material into the larynx and trachea.

Finally, death may occur from a combination of the causes already mentioned, associated with traumatic or surgical shock. In exceedingly nervous patients tympanites of the stomach often irritates the pneumogastric nerve and enfeebles the heart's action. Removal of the gas in the stomach is to be secured if possible, in order to avoid danger.

When any of these conditions—which are likely to occur during anesthesia from chloroform, but may also be produced by ether and other anesthetic

agents—are threatened, the duty of the anesthetizer should be the same in every case. He should promptly take the following precautions:

1. Remove the anesthetic, and secure a plentiful supply of fresh air about the head and face of the patient.

2. Place the fingers back of the angles of the inferior maxilla and press it strongly forward, thus carrying with it the tongue.

3. Seize the tongue with forceps and draw it forward.

4. Lower the head of the patient, and, if the case is grave, raise the lower limbs, pelvis, and trunk higher than the head and shoulders.

5. Use forced artificial respiration, or, if the apparatus for this is not at hand, then begin the movements of artificial respiration, catching the arms at the elbows and carrying them outward and upward until they almost meet in a line above the head, then bringing them down again until they touch the anterior surface of the chest: at each movement moderate pressure should be made upon the lower portion of the chest. These motions should be repeated not oftener than sixteen or eighteen times per minute.

6. Dash alternately hot and cold water or ether on the front of the chest and abdomen.

7. Give hypodermatic injections of strychnine, tincture of digitalis, or nitroglycerin.

8. Rub the extremities strongly toward the heart.

9. Compress the abdominal aorta.

The last two methods are intended to keep the blood in the region of the heart and great nerve-centers, where, at least during the period of shock, its presence is vitally important.

10. Faradize the diaphragm through the phrenic nerve, placing one pole on the pit of the stomach and the other over the base of the neck at the external border of the sterno-mastoid muscle.

11. Small lumps of ice, or "ice suppositories," inserted into the rectum, will sometimes by reflex action bring about deep breathing.

12. As soon as the power of swallowing returns, use diffusible cardiac stimulants—alcohol and ammonia, etc.

Choice of an Anesthetic.—The general conclusions may be formulated as follows:

1. As a rule, ether, as the safest of the more powerful anesthetics, is to be preferred; the lessened risk to life more than counterbalances its minor disadvantages.

2. Chloroform may be employed when ether has failed or cannot be procured, or when there is a distinct record of serious trouble during a previous etherization. It is possibly safer in children than in adults, and it is said to be exceptionally adapted for administration in obstetrical cases. It has some distinct advantages over ether in cases of stenosis of the larynx or trachea, and may be considered in those cases of emergency in which an operation has to be performed a short time after a solid meal. As secondary indications for its employment the following may be mentioned: (*a*) protracted operations about the mouth, jaws, nose, or pharynx which necessitate the mouth and nose being uncovered; (*b*) operations calling for the employment of the actual cautery in the vicinity of the mouth, though ether may be used as above directed; (*c*) severe bronchitis, emphysema, or asthma; (*d*) extensive renal disease; (*e*) marked atheroma.

3. Nitrous oxide should be employed in operations which can be completed in from two to five minutes.

4. Methylene, methylene ether, and the various anesthetic mixtures, such

as the *A. C. E. mixture* (*A*lcohol one part, *C*hloroform two parts, and *E*ther three parts) are not so safe as ether alone, and have no decided advantages to compensate for the increased risk.

Local Anesthesia.—It often is necessary to perform certain minor operations where it is undesirable to administer a general anesthetic. The opening of a felon or an abscess, paracentesis thoracis, the removal of a toe-nail or a wart, the extraction of a splinter, are some of the minor operations where local anesthesia is most valuable.

There are several ways to produce local anesthesia. One of the simplest is to place over the part to be incised a small muslin bag containing some ice pounded very fine, with salt, which must be kept in contact with the skin for two or three minutes or until the skin is blanched. Another way is by spraying pure ether or rhigolene over the part by a hand-atomizer. Recently the spray of chloride of ethyl has been employed to advantage. It comes in small glass tubes. The tip is broken off and the fine jet of the volatile fluid is directed upon the part and quickly chills or even freezes it. In certain tissues, among which may be mentioned the scrotum, a slough may result from local anesthesia; judgment, therefore, must be exercised in its employment.

Ethyl Chloride is a local anesthetic which possesses superior advantages. It is made by the action of either hydrochloric acid or phosphorous chloride upon alcohol. The great volatility has been overcome by the use of glass bulbs upon one end of which is a capillary orifice to which is attached a copper screw thread for the cap. The bulbs contain enough of the ethyl chloride to produce anesthesia in at least a dozen cases. The action is very rapid, and it is said to produce no local injury or any constitutional danger. For such minor operations as opening abscesses or carbuncles, removal of splinters, extraction of teeth, removal of small subcutaneous tumors and ingrowing toe-nails, this local anesthetic is of great value. The thermocautery can be applied to a surface upon which this local anesthetic is applied, provided only the cautery iron does not approach the jet of spray and a sufficient time has elapsed to permit of evaporation, which requires but a few seconds. A little vaseline smeared over the surface of the skin which is to be anesthetized will prevent the transient redness. In order to produce local anesthesia the bulb should be held in the palm of the surgeon's hand, and then the cap unscrewed and the jet of spray directed to the spot, with the nozzle about six inches from the skin. The integument almost instantly becomes red, which is at once followed by a white color, which is indicative of insensibility. The effect continues about two minutes. The action of the drug can be hastened by blowing on the skin upon which the jet falls.

In dentistry a special bulb is prepared, and this jet is directed to the gum, which has been previously dried and over which some vaseline has been smeared. The rest of the gum and the teeth should be protected by a piece of linen.

The Hydrochlorate of Cocaïne, as suggested by Dr. Kohler, is another means of producing insensibility to pain. It can be best employed in parts where the circulation can be confined within a limited area. In incision of a felon, for example, a stout ligature should be placed around the finger, the cocaïne injected into the skin, and the drug allowed to remain in the finger, the blood of which is thus cut off from the general circulation by the ligature. The use of the ether spray as a preliminary measure to the hypodermatic injection will make the operation absolutely painless. In operations upon mucous surfaces the cocaïne is found to possess remarkable anesthetic properties. The solution need only be applied to the mucous membrane by a small swab of cot-

ton. Insensibility follows in about three to five minutes, and continues for from fifteen to twenty minutes. Operations of considerable magnitude have sometimes been done under cocaïne, using it first by hypodermatic injection, and then dropping it in the wound from time to time.

The drug must be used with caution, especially about the head, as not a few alarming cases of syncope, delirium, and paralysis or tetanic fixation of the respiratory muscles have been observed. In those mild cases of cocaïne-poisoning which are characterized merely by pallor, tremor, restlessness, and weak pulse, stimulants and recumbency are all that will be required. In severe cases death may occur in two modes—by paralysis of the respiratory center and by tetanic fixation of the respiratory muscles (Mosso). In those which manifest respiratory failure the hypodermatic use of strychnia is attended with the best results. In those cases in which tetanic fixation of the chest-muscles occurs (as a part usually of general convulsions) chloral by enema is of great value. In convulsive cases inhalations of amyl nitrite or hypodermatics of nitro-glycerin are to be employed. When delirium is violent, if the heart be not very weak, chloral can be used, or hyoscine in small doses hypodermatically. The patient when very delirious will require to be restrained. The bladder should be emptied and the action of the kidneys stimulated. The subsequent tendency to sleeplessness is to be antagonized by a hypnotic.

CHAPTER III.

PLASTIC SURGERY.

General Principles.—This branch of surgery includes all operations for the repair of deficiencies of embryonal development, as hare-lip or exstrophy of the bladder, for the replacement of parts lost by accident or disease, as lupous or syphilitic destruction of the nose, and for the restoration of the function of parts restrained by cicatricial contraction from injury or disease, as eyelids bound down by scars, a joint fixed by the cicatrices left by a deep burn, etc. The tissues employed are commonly those obtained from other portions of the patient's body, or they may be transferred from a donor. The termination "plasty" is often appended to the name of the organ or part to be repaired or replaced, and the word thus formed becomes synonymous with such restoration, as "cheiloplasty," the formation of a lip. Retrenchment of abnormally large noses or ears belongs to this branch of surgery.

Although bone, muscle, nerve, periosteum, and mucous membrane have all been used in certain plastic operations, the skin with its subcutaneous tissue is that most frequently employed. With the exception of bone and nerve, the portions of tissue used must be about one-third larger than the defect to be repaired, since they are sure to shrink both immediately and for many weeks subsequently. Flaps should have their pedicles as broad as possible, fashioned with curved outlines, thus admitting of greater stretching; they should include the larger vessels of the parts, with which their long axis should coincide; and they should never be subjected to either tension or torsion if these can possibly be avoided; indeed, when a choice exists between a simple operation involving one or both of these procedures and another more difficult and elaborate, the latter should be chosen.

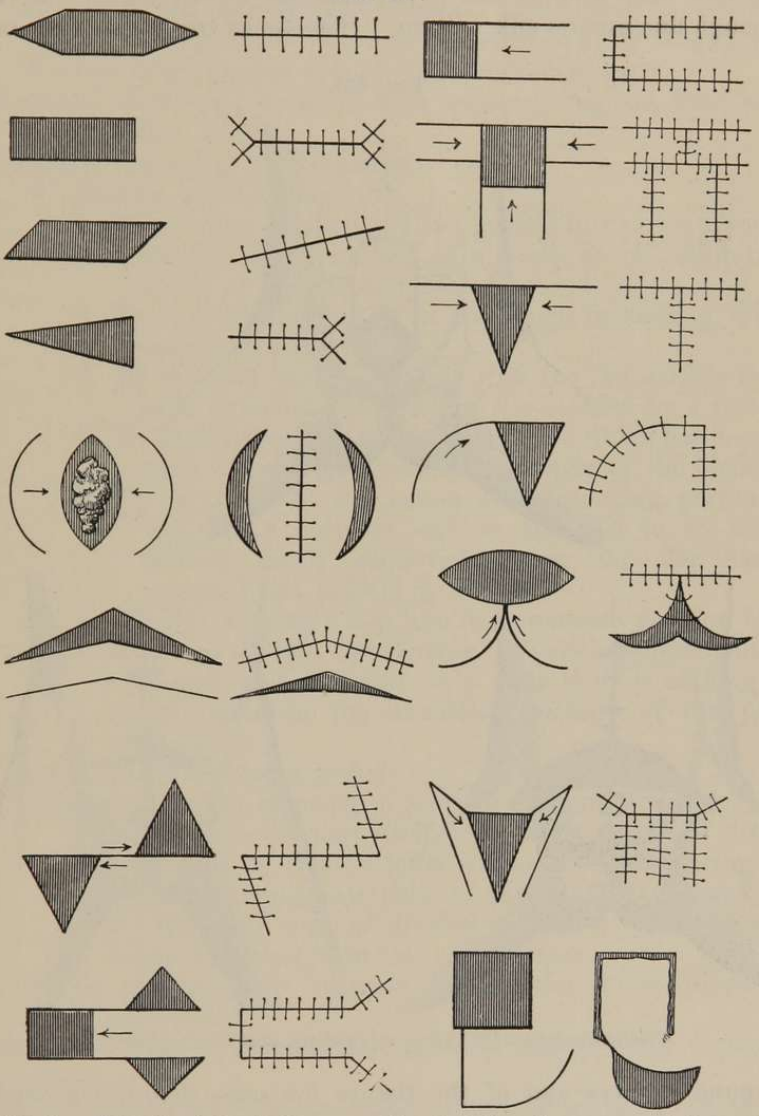
Favorable and Unfavorable Conditions.—As syphilis and lupus are frequently the causes of deformities which require plastic operations, it is absolutely essential in the first disease that some months shall have elapsed since any manifestations of syphilis were detectable, and that the patient shall have been treated for a prolonged period with antisyphilitic remedies; while in a patient who has suffered from lupus it is imperative that all the diseased tissue shall have been long since destroyed, as shown by a perfectly sound cicatrix which has remained healthy for some months. Hare-lip or cleft-palate operations must never be attempted when there is any disturbance of either the gastro-intestinal or respiratory mucous membranes, for manifest reasons over and above the distinctly increased risk to life. Rigid asepsis is far better than antisepsis, and is essential if Thiersch's method of skin-grafting has to be employed to fill up the gaps left by deficient flaps or to close the surfaces from which these have been dissected.

The *first step* in any plastic operation must consist in the proper freshening of the edges of the parts to be apposed or of the surfaces to which flaps are to be transferred. This may be incidentally done when removing cicatricial tissue, loosening up the bound-down alar cartilages of a partially destroyed nose, or the surface may have to be specially freshened, as in the case of hare-lip. The largest attainable raw surface must be secured wherever merely the edges of flaps are to be apposed, provided that this does not entail such destruction of tissue as will add a worse evil—viz. tension of flaps from lack of tissue, as in cleft palate; but the same end can often be secured without any removal of tissue—or at least with very little—by *splitting* the edge of the cleft on one side

and removing a strip of tissue on the other. It is rarely advisable to freshen both surfaces by splitting, because proper coaptation will then be difficult.

The *second step* must be the arrest of hemorrhage, otherwise primary union may fail from the interposition of a clot. This should be done either before

FIG. 437.

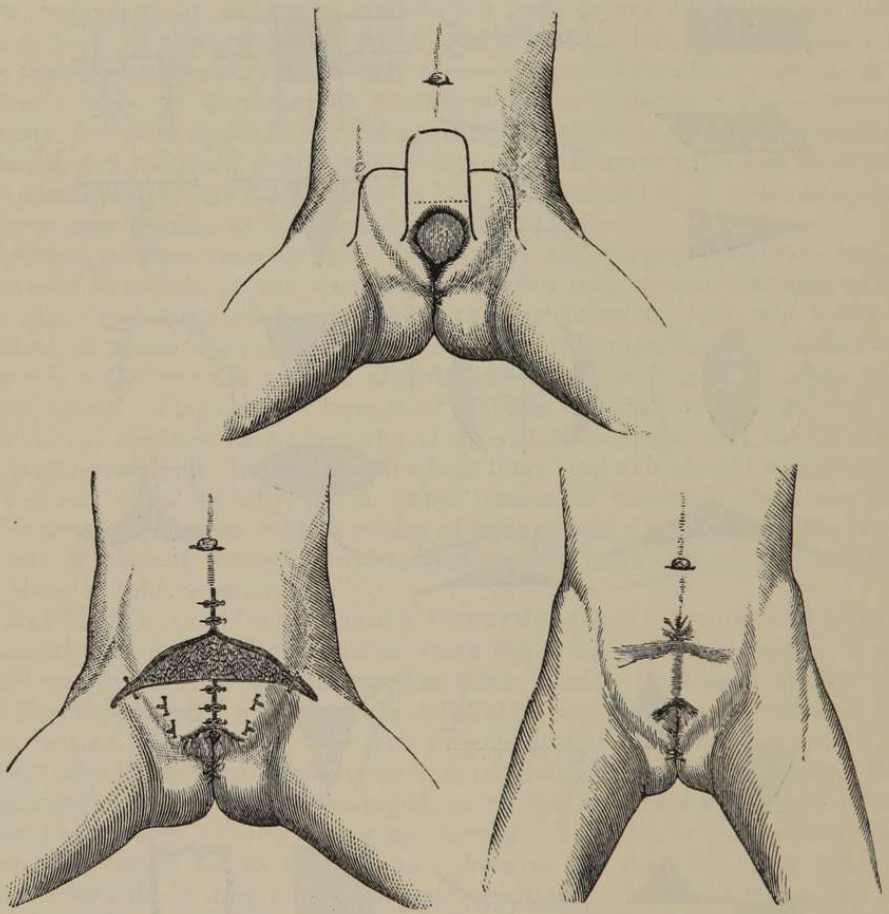


Diagrams of Various Methods of Plastic Surgery. The shaded portions represent the parts removed. The arrows indicate the direction in which the flaps are displaced. The second and fourth columns show the results of the operations represented in the first and third (Esmarch and Kowalzig).

coaptation or by using such methods of suturing as will secure this arrest after closing the wound: this is peculiarly necessary when transplanting mucous membrane. The *third step* is to adjust the parts with so little tension that the sutures merely retain, but do not pull, the parts together: this is the secret of success in operations for cleft palate. The *fourth step* is, when flaps from other parts have been employed, to close the gap left by their transplantation. The *fifth step* is to dress either aseptically or antiseptically in such a way as to avoid motion or frequent handling of the parts.

Where the repair of the defect or the overcoming of a deformity requires a series of operations, as often happens, sufficient time should be allowed for all shrinkage and readjustment of parts to have taken place before any further operation is attempted. Sutures which it is desired should last for many days must be of wire, or preferably of silk, both as fine as will hold. Where extensive and deep wounds are to be apposed, buried sutures of catgut are best, although fine aseptic silk will do. Sometimes coaptation with immobility

FIG. 438



Plastic Operation for Extroversion of the Bladder (Ashhurst).

of the wound-surfaces and of the tissues for some distance around is best secured by the "splinting" action of hare-lip pins with figure-of-8 ligatures. An admirable means of removing tension from the wound-edges so that the superficial sutures shall merely hold the margins together is the "relaxation suture" in some one of its forms. Catgut is unreliable, and should be used only in the form of "buried sutures," or perhaps in between silk sutures.

CLASSIFICATION OF METHODS.—Deformities and lesions are repaired by one of four methods—viz. (1) approximation of parts; (2) interpolation of flaps derived from contiguous or distant parts, a pedicle being left; (3) transplantation of flaps without pedicle; (4) retrenchment of redundant parts. Roberts' table, which is here reproduced, slightly condensed, gives an admirable epitome of the whole subject:

METHODS USED IN PLASTIC SURGERY.

DISPLACEMENT—stretching or sliding of tissues.

I. *Simple approximation after freshening the edges*, as in hare-lip, vesico-vaginal fistulæ, etc.

II. *Sliding into position after transferring tension to adjoining localities*, as in V-shaped incisions for ectropion and cicatricial contraction of joints after burns, and in linear incisions to allow stretching of skin to cover large wounds and to relax contracted parts.

INTERPOLATION—borrowing material from adjacent regions, from a limb, or from another person.

I. *Transferring a flap with a pedicle.*

A. Putting in place at once:

1. By rotating the flap and the pedicle in its own plane through one-fourth or one-half of a circle, as in making an upper eyelid or a nose from the forehead.
2. By twisting the flap on its pedicle, as in making the side of nose from a lip.
3. By everting the flap entirely with the raw surface uppermost, as in covering exstrophy of the bladder by a scrotal flap.
4. By superimposing one flap on another which has been everted, as in Wood's operation for exstrophy of the bladder.
5. By carrying the flap across an intervening portion of skin, and fixing only its end to the part to be repaired—a method rarely employed; when the flap has become attached the pedicle is severed.

B. Gradually carrying a flap into its permanent position by a series of partial sliding, transferring, or twisting operations—seldom employed, and advisable only when there is nothing but cicatricial tissue in the immediate vicinity of the part to be repaired.

II. *Transplanting without a pedicle.*

(*a*) By accurately suturing in position portions of tissues recently removed from the part itself, from other regions of the patient's own body, or from a lower animal; *e. g.* replacing the bone after trephining, interpolating pieces of nerve-trunks between the freshened ends of divided nerves in secondary operations where there has been loss of substance.

(*b*) By skin-grafting in some one of the forms presently to be described.*

RETRENCHMENT—removing redundant material and causing cicatricial contraction.

I. By cutting out elliptical or semi-elliptical pieces of tissue, as in ptosis, cystocele, etc.

II. By cutting out triangular or wedge-shaped portions of tissue, as in closing the vaginal aperture, decreasing the size of a lip, nose, etc.

REVERDIN'S METHOD OF SKIN-GRAFTING.—Strictly speaking, the term "epidermic grafting," by which Reverdin originally designated the procedure, is the only correct one, since "the epidermis by itself, but the living epidermis, that of the deep layer, is alone necessary for the success of the graft." For success the general health of the patient must be good and the granulations of

* Readjustment of recently severed finger-tips, nose, etc. is sometimes incorrectly classed among the plastic operations.

the ulcer healthy; moreover, when possible, complete asepsis should be secured and maintained, because all antiseptics endanger the vitality of the grafts. If antiseptics are requisite to secure asepsis of a freely suppurating ulcer, they must be thoroughly removed by prolonged douching with sterilized normal salt solution (6 : 1000). Small grafts about the size of a large pin's head will do quite as well as large ones, and are far less painful to obtain from the donor. When procured from another individual, it is imperative that all possibility of specific trouble be excluded, and that the donor be young.

Amputated limbs—even the skin of recent cadavers has been used—may supply the grafts, since Martin has shown that after many hours of exposure in the open air at a temperature of nearly 32° F. grafts could be successfully applied, but that at such temperatures as 82° F. exposure of from six to seven hours destroyed their vitality, so that the limb of a healthy individual amputated for some accident may be utilized for grafting purposes for at least twenty-four hours if kept cool—in a refrigerator, for instance. The skin of any of the lower animals may be employed, especially that covering the abdomen of the frog. In most instances some other portion of the patient's own skin must be utilized. Much difference of opinion seems to exist as to whether grafts from the skin of a black transferred to a white patient will remain pigmented, and *vice versâ*, so that it will be better always to graft blacks from blacks and whites from whites.

Method of Performing the Operation.—Having rendered the ulcer, the neighboring skin, and the part from which the grafts are to be taken aseptic, the point of an ordinary (aseptic) sewing needle should be thrust under the epidermis, the skin elevated, and the graft shaved off by a sharp scalpel or cut off with a pair of small curved scissors. To ensure obtaining the deeper, active epithelial layers, a small portion of the derm should always be removed. The graft must then be gently deposited, cut surface downward, upon the granulations by means of the needle, avoiding any pressure such as will induce bleeding. Having placed as many grafts as desired, very narrow strips of protective or of thin pure rubber or gutta-percha tissue should be applied over the grafts, extending for a couple of inches on each side of the ulcer, interlaced in such a manner as to ensure retention of the grafts and at the same time allow of free escape of any serous or purulent secretions. Over the protective a compress wet with the salt solution must be applied. Next a piece of oiled silk or protective must follow, then a pad of absorbent cotton and a gently applied bandage; sometimes a light plaster-of-Paris or silicate-of-sodium bandage is advisable, especially on the limbs of children when the grafting is done near the joints. In from twenty-four to forty-eight hours all dressings but the lattice-work of protective should be removed, the parts gently irrigated with warm salt solution, and a dressing identical with the primary one applied, repeating this procedure from time to time, and at the end of a week removing the protective strips next the grafts and reapplying if necessary. In many instances the grafts shed their cuticle, which floats off in the discharges, the operation apparently having failed from loss of the entire graft, but at the next dressing commencing growth of epidermis will often be shown by bluish-white spots, not only where the grafts were supposed to have taken, but also where they were thought to have been shed. As the grafts extend eccentrically, each capable only of producing an area of about half an inch of cicatrix, and stimulating to healing the contiguous sluggish borders of the sore, they should be placed about half an inch from one another and from the borders of the ulcer, or, when this is irregular in outline, rows of grafts should be placed so as to cut the surface up into triangles and irregular figures, which if

skilfully planned will diminish the extent of surface each graft must cover, and consequently their number and the pain incident to their removal. If one grafting will not suffice, the operation should be repeated. The spots from which the grafts have been taken are best treated by dusting them over with sterilized iodoform and covering them with dry absorbent cotton and a bandage, the dressing not to be removed for about ten days.

Unfortunately, but little diminution of the cicatricial contraction is effected by Reverdin's method, and, while healing is more rapidly secured, too often an almost equally rapid breaking down of the new cicatrix results, either from no recognizable cause or from causes which would be inadequate to produce such a result in a scar formed by the ordinary processes of healing.

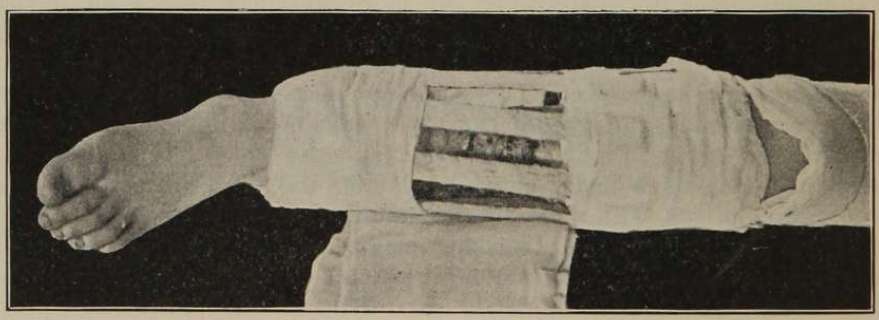
Thiersch's Method of Skin-grafting.—Thiersch contends that healing of a granulating surface results, first, from a conversion of the soft, vascular granulation papillæ—by contraction of some of their elements which have developed into young connective-tissue cells—into "dry cicatricial papillæ," actually approximating the surrounding tissues, thus diminishing the area to be covered by epidermis; and, secondly, by the covering of these papillæ by epidermic cells. Contraction having gone on as far as the laxity of the tissues will admit, and the capacity for developing new epidermic cells by the margins of the wound being limited, the granulations of the unhealed central portion remain stationary—*i. e.* vascular and soft: few if any of their component cells having undergone development into connective tissue, the maximum of contraction has not yet been attained, but will be promptly reached if they are covered in with epidermis. Moreover, any trivial mechanical or vascular irritation will give rise to exudation from the soft subjacent papillæ, resulting in separation of the newly-formed skin. Still further, microscopically two layers of granulation-tissue are discernible, the more superficial possessing vertically disposed capillaries, the deeper containing a horizontal network of vessels, from which the former spring, coursing through a structure more or less dense according to its age—*i. e.* stage of conversion into connective tissue. A free removal of this upper, soft layer of granulations, yet capable of full contraction, must be effected to prevent cicatricial distortion and the risk of separation of the epidermis, these evils being avoided by laying the grafts directly upon the layer of granulations with horizontally disposed capillaries, to which layer the transplanted portions will become firmly adherent, and will remain so, undisturbed by cicatricial contraction.

Favorable and Unfavorable Conditions.—Syphilis may prevent the grafts from taking. The best results are attained when the granulations are about six weeks old, are firm, and have reached this condition by repeated cauterization and compression. Most careful disinfection of the hands, instruments, and parts, with subsequent removal of all antiseptics, is essential, as is complete arrest of hemorrhage. The salt solution should be freshly sterilized. All portions of the wound must be covered with the grafts if possible, and they in turn with the protective strips. After the second or third day, daily dressings, with free irrigation, are imperative. Grafts applied to loose connective tissue, to fascia, or to periosteum do not succeed so well as on freshened granulations, while on glandular and muscular tissues the results are only fair. On cancellous bone or tendons the results are not permanent, while grafts will not even primarily adhere to compact bone.

Method of Operating.—Complete asepsis having been secured, as before indicated, and all antiseptics washed away with the salt solution, the soft granulations are to be scraped away with the sharp spoon, including a small portion of the newly-healed margins if they do not appear healthy, and the bleeding

surface irrigated, covered with protective, and compressed for a few minutes to check all oozing. Any portion of skin relatively free from underlying fat —that of the arm or thigh—having been previously sterilized and shaved, is put upon the stretch by one hand while with the other a long wide razor or microscopic section-knife is applied flatwise, and the upper layers of the skin removed by a to-and-fro movement of the knife, which is kept flooded with the salt solution. Mixter of Boston has devised an excellent apparatus which facilitates the cutting of these long grafts, and McBurney some hooks for lifting and stretching the skin. Each graft should be as broad and long as possible, and be immediately laid upon the prepared surface, upon which it is floated from the knife by salt solution. A probe may be used to facilitate this manœuver, drawing the edge of the graft on to the wound-surface while slipping the blade away. Subsequent correction of position may be effected by the probe or by a camel's-hair brush. Each graft must be gently pressed into place with a spatula, and must be in contact with its neighbor, better slightly overlapping its fellow and the margins of the wound, otherwise separation of the grafts is apt to occur, commencing at the edges, or a spreading ulcerative destruction is liable to set in. Skin from the abdomen or back of a living frog may be substituted for or used to supplement human grafts: indeed, the hairless skin of the young of any of the lower animals will do. The dressing should consist of the lattice-work of protective strips, a compress moistened with salt solution and covered in with protective, outside dry cotton, and possibly the fixed dressing described for ordinary epidemic grafting. Mayer has recently devised a better method (Fig. 439). The limb is encircled by two collars of sterilized gauze wet with the

FIG. 439.



Mayer's Dressing for Thiersch's Method of Skin-grafting (from original photograph by J. M. Bertolet).

salt solution, one above and the other below the site of the grafts. These collars should be an inch or more thick. Strips of sterilized wood covered with gauze and long enough to reach from one collar to the other are laid in place and fixed by gauze bandages. Over this "cage" are placed several gauze pads wet with the salt solution. The whole dressing is then covered with rubber dam and a bandage. A hot-water bag keeps the grafts in a warm, moist chamber untouched by any dressing which might displace them. The outer gauze dressing need only be wet once daily. After a few days, when the grafts have taken, the whole dressing is removed and borated albolene ointment is applied. When employed as an adjunct of a plastic operation, having checked all hemorrhage by compression, the epidermic strips must be placed and dressed as just directed, and will usually unite with the subjacent tissues. Blood beneath a graft, indicated by a bluish tint, although endangering the vitality of the graft, does not necessarily cause its loss. A pink tint

at the close of a few days usually indicates success, while if the grafts be at this time of a dead white they will probably exfoliate, although only the outer layers may float away, while the deeper, active ones remain. Sometimes the grafts are perforated by the granulations, and disappear for a time to reappear as epidermic islets later on. The surfaces from which the grafts have been removed must be dusted with sterilized iodoform, and dry cotton bandaged on, this dressing to be left on for about ten days; or they may be dressed precisely like the grafts themselves.

Transplantation of Mucous Membrane.—Where this measure is demanded, the practical impossibility of maintaining asepsis and immobility of the parts—in operations upon the mouth and urethra, for instance—renders success less probable than in skin-grafting, yet Wölfler has resected the cicatricial tissue of urethral strictures, and, suturing in position a circular graft of mucous membrane, has found it adhere and form a constituent part of the new urethra. The material for the grafts—consisting of the whole thickness of the membrane—may be obtained from other portions of the mouth if the oral cavity be concerned or if the conjunctiva or urethra needs repairing, or the grafts may be taken from the rectum; again, the conjunctiva of the rabbit, the mucous membrane of the frog's stomach, of the œsophagus of the pigeon or rabbit, and of the rabbit's bladder, may be used.

Operation.—The same aseptic preliminaries, freshening of surfaces, loosening of cicatricial tissues, and after-dressings are requisite as for skin-grafting, except such modifications as special parts like the eye, urethra, or mouth require. The best results have been obtained when the grafts have been taken from young subjects and placed on wounds from *three to four days old:* the whole thickness of the membrane must be employed, and the grafts must, when possible, completely fill the gap left by removal of tissue or section of cicatrices. Great care must be exercised in the application of sutures, because they are in most instances the only means of securing immobility, notably in the mouth and urethra.

Operations on Muscles, Nerves, and Bones.—The same asepsis of the field of operation and of the graft, thorough hemostasis, and securing contact of the new with the freshened surfaces of the old tissues are requisite.

Muscles but rarely require plastic operations, and then commonly only freshening with careful adjustment by numerous buried sutures of stout catgut, which should include considerable tissue, to prevent cutting out; separate suture of the sheath is advisable if the muscle possess a distinct one. Fixation of the parts in such a position as will secure relaxation of the muscle is requisite throughout the after-treatment; and this has sometimes to be specially provided for by partial sections of the muscle above or below, combined with careful stretching. Although muscle-grafts have been successfully employed, any necessity for such a measure must be excessively rare. When employed, the grafts must be very much larger than the gap to be repaired, and must be carefully fixed in position by buried animal sutures. When a contracted muscle requires lengthening, as in torticollis, this can usually be effected by open incision with fixation by numerous heavy catgut *sutures à distance*, which will serve as "a scaffolding for the new connective-tissue cells," which will infiltrate them and be converted into tendon-like tissue.

Nerves.—After the usual aseptic preliminaries, the part having been rendered bloodless, the nerve should be exposed, and the ends freshened, and united by fine silk or catgut sutures passed with a round needle, which should transfix each end about one-fourth of an inch from the free edge; from two to four

sutures will be required, and where there is a distinct sheath this had better be separately secured by a couple of stitches. If the nerve-ends cannot be readily approximated, careful but thorough stretching of both the proximal and distal portions of the nerve will often secure this end, but if not, a nerve freshly removed from some lower animal or from a recently amputated limb should be carefully sutured in position. Either stretching the nerve or inserting a graft is better than the interposition of a decalcified bone drainage-tube or a bundle of catgut threads, as has been advised.

Bone-grafting.—The method depends somewhat upon whether the skull bones are concerned or one of the long bones. Thus, when trephining the bone the button or fragments removed must be at once transferred to a warm (100°–105° F.) aseptic salt solution, and kept at that temperature until replaced. If the operation is for accident, any foreign matter must be removed, even to paring with the bone chisel, and disinfection effected by weak solutions of mercuric bichloride before placing in the warm aseptic solution. When but little aseptic bone can be saved, the fragments may be laid on an aseptic surface, minced into fragments with a chisel, and scattered over the dura.

If a defect in a long bone, the continuity of which has not been destroyed, requires repair, after exceptional precautions to render the part aseptic, properly shaped bone-grafts from a recently amputated limb or removed from a living animal must be placed *in situ*, or bone chips may be packed in so as to fill up the gap. When non-union results after compound fracture with shortening from loss of bone, after preparing a longitudinal sulcus in the tissues between the ends of the bones—which must be carefully freshened—bone-grafts, either human or from the lower animals, may be secured in position: success has, as yet, been rarely attained. Shifting of bone has been done by dividing a strip of the hard palate, covered with its soft parts, parallel to the fissure in cleft palate, but leaving unsevered the bony attachments in front, and partially fracturing the pedicle, drawing the bony flaps together with sutures; or, when forming a new nose, turning down with the skin and periosteum the outer table of the frontal bone split off with a chisel after cutting a groove around the part to be removed.

A modification of **bone-grafting** has been suggested by Senn, whereby aseptic bone-cavities and defects left by trephining may be filled—in the first case by chips, and in the second by decalcified-bone plates carefully fashioned to fit the opening.

Method of Preparing Decalcified Bone.—Select the compact layer of the fresh tibia or femur of the ox, remove all periosteum and medullary tissue, divide into longitudinal strips about one-eighth of an inch wide, and immerse in a relatively large quantity of 10–15 per cent. watery solution of hydrochloric acid, which must be renewed daily for from one to two weeks: then wash thoroughly in water or a weak solution of caustic potash, cut into small chips, soak for forty-eight hours in 1 : 1000 mercuric bichloride solution, remove and store in a saturated solution of iodoform in ether. When about to be used, wrap in aseptic gauze, dissolve out the excess of ether and iodoform with alcohol, and put in 1 : 2000 mercuric bichloride solution until required, when careful drying with iodoform gauze should precede their implantation. For cranial defects large plates must be sawn out of the compact tissue and decalcified, as already described.

Operation.—Having cleansed, sterilized, and dusted the cavity with iodoform, it is to be carefully packed with chips until filled, a capillary drain introduced at the most dependent part, and the periosteum and soft parts united by

buried catgut sutures: if a defect of the soft parts exists, an iodoform gauze tampon may be employed to keep the chips in position. When an opening in the skull is to be filled, the plate or plates should accurately fill the gap, but must be perforated in numerous places to allow the wound-secretions to escape. It is alleged that ordinary bone-grafts undergo decalcification, and are only then infiltrated with bone-forming cells, thus merely acting as a scaffolding, for which purpose decalcified bone will do equally well, requires no decalcification, and is not only aseptic, but actively antiseptic.

CHAPTER IV.

LIGATION OF ARTERIES.

THE LIGATION OF ARTERIES requires a precise knowledge of anatomy, which can be acquired only in the dissecting-room. The technique of the operative work must be learned by practice upon the cadaver. The region in which the vessel is situated should be thoroughly prepared for an aseptic operation. (See p. 1100.)

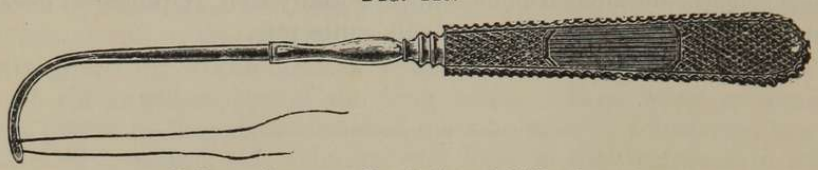
The INCISION should vary in length from two to four inches. It should be made from left to right, and from above downward, and at an angle of five degrees over the course of the vessel. The integument lying over the vessels should be held firmly between the middle finger and the thumb of the left hand of the surgeon. The skin must not be stretched or pulled aside, otherwise the incision will not be over the underlying vessel. The knife should be held between the thumb and index finger of the right hand of the surgeon. When, however, the incision has been made through the superficial tissues, the knife may be held for the deeper dissection in the same manner as a pen. When the vessel is reached, the handle of the scalpel, an Allis' dry dissector, or the index finger may be used to tear and gently push aside the loose connective tissue surrounding the artery. The depth of the skin-incision should be the same from the beginning to the end, and not terminate obliquely at either extremity. After cutting through the skin, the fascia should be raised and a small opening made, through which a director is passed with the point constantly turned upward. The fascia is slit along the entire length of the wound. Instead of a director, two pair of thumb forceps can be used in the following manner: The surgeon seizes with the forceps the fascia at a certain point, and the assistant grasps the fascia at a point directly opposite; then both the surgeon and the assistant together lift up the fascia from the wound, and the operator cuts between the two forceps. The surgeon then releases the hold upon the tissue with the forceps, and the assistant follows his example, and the same procedure is repeated. In this manner no structure of importance can be cut when the fascia is lifted up from the wound.

The retractor should first be placed in the wound by the surgeon, and when properly adjusted he requests the assistant to hold it *in situ* just as he has placed it. Two retractors are used, and in this way the wound is kept well open, so that light enters into its depth.

The SHEATH of the artery is now reached, and great care must be used in opening it. It should be seized by a pair of forceps upon the side opposite the accompanying vein, lest that vessel be injured. A small aperture is cut or

torn in the sheath only large enough to admit the point of an aneurysm needle. It is important to remember that the sheath should be disturbed as little as possible, because the vasa vasorum lie in it. Any unnecessary disturbance might be a cause of secondary hemorrhage. In passing the aneurysm needle (Figs. 440, 441) around the artery it should be always passed away from the

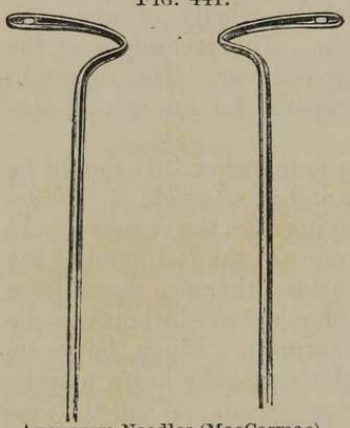
FIG. 440.



Ordinary Aneurysm Needle threaded (MacCormac).

vein—*i. e.* inserted first between the artery and vein. The nerve must not be included in the ligature. When the needle has been passed around the artery the vessel must not be lifted up from its bed, as this act would be likely to set up some cellular inflammation. Before the ligature is finally tightened an examination should be made to ascertain if any tissue besides the artery itself is included in the ligature. The two thumbs can be placed on top of the artery and the ligature lifted by the two hands, so that the artery is occluded by simultaneous pressure produced by the thumbs above and the ligature below. An assistant should now ascertain if pulsation is lost in the vessel upon its distal side. The ligature is tied with a reef knot in the manner shown in Fig. 442.

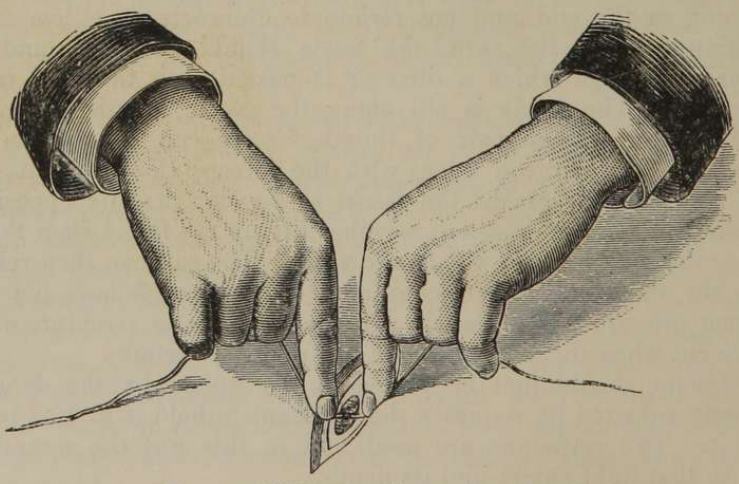
FIG. 441.



Aneurysm Needles (MacCormac).

The INDICATIONS for the ligation of arteries are—1, *hemorrhage;* 2, *aneurysm;* 3, *arrest* of

FIG. 442.



Manner of Tightening Ligature (MacCormac).

malignant growths and control of acute inflammations. (For the discussion

of these special indications and the contraindications the reader is referred to each subject.)

LIGATION OF SPECIAL ARTERIES.

The INNOMINATE ARTERY (Pls. XXV and XXVI) arises from the arch of the aorta upon the right side, and at the sterno-clavicular articulation divides into the right primitive carotid and right subclavian arteries. The artery begins at a point about the middle of the manubrium and ascends to the upper edge of the clavicle. As the clavicle is movable, the termination of the artery may be slightly above or below the bone. The incision should be made along the anterior margin of the sterno-cleido-mastoid muscle down to the sternal notch. An incision at an angle to this should be made outward along the upper border of the clavicle. The inner attachment of the sterno-cleido-mastoid muscle is now divided in order to allow of more room to reach the vessel. After tearing with the fingers the loose areolar tissue, the surgeon must look out for the anterior jugular vein, and secure it between two ligatures or else draw it out of the way with a blunt hook. The sterno-hyoid and sterno-thyroid muscles must be divided. The pericardial cervical fascia is now divided on a director, and the inferior thyroid vein must be ligatured or drawn to one side. The bifurcation of the innominate can now be felt, and the needle passed from below upward so as to avoid wounding the pleura and the innominate vein. The internal jugular vein must be carefully guarded, and also the innominate vein which occasionally overlaps the artery. The pneumogastric nerve and the phrenic must be held out of the way in passing the ligature. Only two patients out of twenty-four have survived the operation. Banks's patient lived fifteen weeks, and Smyth's (of New Orleans), the first successful case, lived ten years.

FIG. 443.

Position of the lines of incision for ligation of temporal, facial, lingual, common carotid (above the omo-hyoid), subclavian, axillary (first portion), and internal mammary arteries (MacCormac).

The COMMON CAROTID (Pls. XXV and XXVI) is formed by a bifurcation of the innominate upon the right side and from the arch of the aorta upon the left. The artery extends from the sterno-clavicular articulation to the superior border of the thyroid cartilage. It runs for the most part just under the internal border of the sterno-cleido-mastoid muscle. Its course is marked by a *line* from the sterno-clavicular articulation to a point midway between the angle of the jaw and the mastoid process. It lies in two triangles of the neck, the superior and inferior carotid triangles. The superior carotid triangle, or the *triangle of election*, is bounded *behind* by the sterno-cleido-mastoid, *in front* by the anterior belly of the omo-hyoid, and *above* by the posterior belly of the digas-

tric. The inferior carotid triangle, or the *triangle of necessity*, is bounded *in front* by the median line, *above* by the anterior belly of the omo-hyoid, and *below* by the sterno-cleido-mastoid.

The internal jugular vein is upon the outer side. Upon the right side, at the root of the neck, the vein is separated from the carotid artery, forming two legs of a triangle the base of which is formed by the subclavian artery. The common carotid is ligated about the middle of its course, either just *above* or just *below* the tendon of *the omo-hyoid* muscle (Fig. 443). In studying the anatomy of the neck it is necessary to remember that the primitive carotid terminates at the upper border of the thyroid cartilage, and is slightly overlapped by the sterno-cleido-mastoid; that the point of election for ligating the artery is on a level with the cricoid cartilage; that the omo-hyoid tendon crosses in front of the carotid artery and upon a level with the cricoid cartilage; that the inferior thyroid artery crosses behind the carotid upon this same level; and that the pneumogastric nerve lies on a plane behind the artery, between it and the internal jugular vein, upon its outer side.

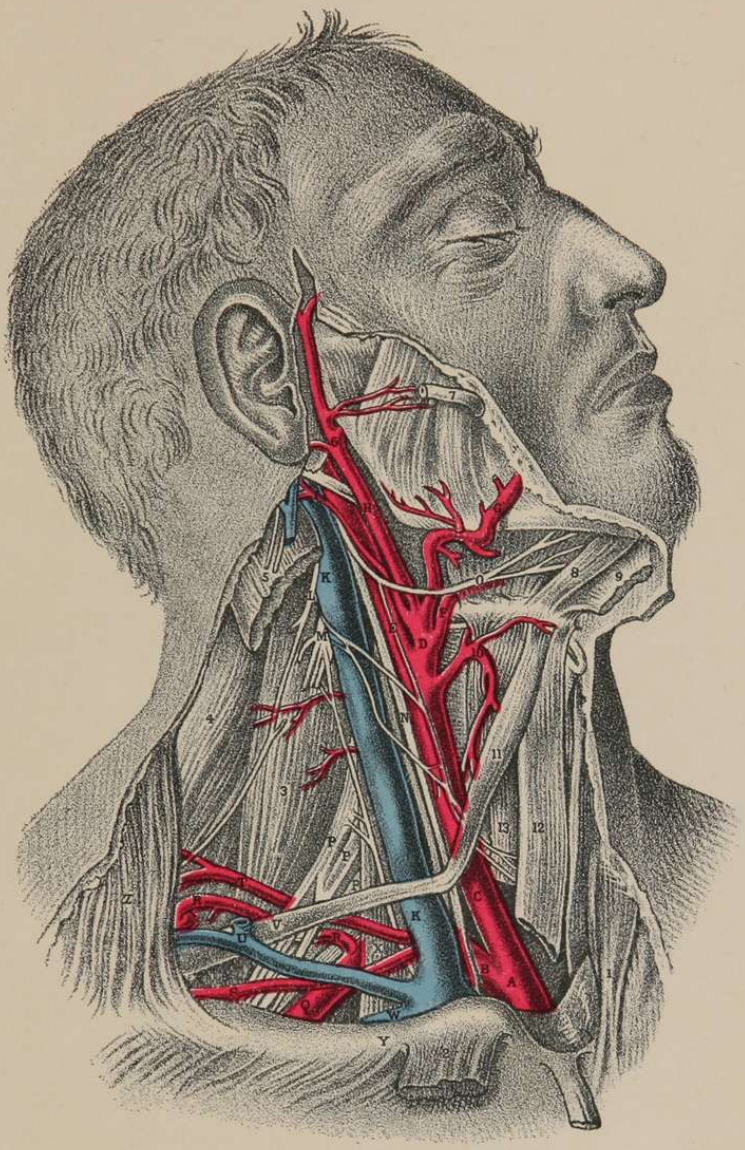
In ligating the artery the patient's head should be turned to the opposite side. The **surface guide** is the anterior margin of the sterno-cleido-mastoid muscle, and the **deep muscular guide** is the tendon of the omo-hyoid muscle. An incision (Fig. 443) about three inches long should be made parallel to the anterior edge of the sterno-cleido-mastoid muscle. The center of this incision should be opposite to the cricoid cartilage. The skin and the two layers of the superficial fascia between which is the platysma myoides should be divided. The deep fascia attached to the border of the sterno-cleido-mastoid muscle is next divided upon a grooved director. The tendon of the omo-hyoid muscle will now be exposed. The tendon must be loosened, so that it can be pulled down or raised upward in the wound by a blunt hook, according as the ligature is to be applied to the carotid above or below the muscle. The index finger of the surgeon should be introduced into the wound for the purpose of exploring the different structures. The sheath of the carotid artery should be opened upon its inner side, so as to avoid wounding the internal jugular vein, which might overlap the artery during a deep inspiration.

The needle should be passed from without inward, so as to direct its point between the two vessels and away from the vein. There are some important structures that the surgeon must avoid wounding in passing the needle around the carotid artery. In front there are three: the descendens noni nerve, the sterno-mastoid artery, and the lobe of the thyroid gland. Behind there are also three: the pneumogastric nerve, the sympathetic nerve, and the inferior thyroid artery. Upon the outer side there is one, the internal jugular vein; and upon the inner side, likewise one, the lobe of the thyroid gland.

The **Collateral Circulation** is established in the following manner:

1. *Internal carotid* of one side with the *internal carotid* of the opposite side, through the circle of Willis.
2. *Vertebral artery* of one side with the *vertebral artery* of the opposite side, through the circle of Willis.
3. *Superior thyroid* of one side with the *inferior thyroid* from the subclavian of the same side.
4. *Arteria princeps cervicis* from the occipital with the *profunda cervicis* from the superior intercostal of the same side.
5. *Ophthalmic*, from the internal carotid with the *angular* from the facial of the same side.
6. *Superior thyroid*, *lingual*, and *facial* with corresponding arteries from the opposite side.

PLATE XXV.



(Maclise.)

A, innominate artery at point of bifurcation; B, subclavian artery, crossed by vagus nerve; C, common carotid artery, with vagus nerve at outer side, and descendens noni nerve on it; D, external carotid artery; E, internal carotid artery, with descendens noni nerve on it; F, lingual artery, passing under the fibers of the hyoglossus muscle; G, facial artery; H, temporo-maxillary artery; I, occipital artery, crossing internal carotid artery and jugular vein; K, internal jugular vein, crossed by branches of cervical plexus, which join descendens noni nerve; L, spinal accessory nerve, which pierces sterno-mastoid muscle, to be distributed to it and trapezius; M, cervical plexus of nerves, giving off the phrenic nerve to descend the neck on the outer side of the internal jugular vein and over the scalenus muscle; N, vagus nerve, between carotid artery and internal jugular vein; O, ninth or hypoglossal nerve, distributed to muscles of tongue; P, P, cords of brachial plexus of nerves; Q, subclavian artery in connection with brachial plexus of nerves; R, R, post-scapular artery; S, transversalis humeri artery; T, transversalis colli artery; U, union of post-scapular and external jugular veins; V, posterior half of omo-hyoid muscle; W, part of subclavian vein, seen above the clavicle; X, scalenus muscle, separating subclavian artery from vein; Y, clavicle; Z, trapezius muscle; 1, sternal origin of sterno-mastoid muscle of left side; 2, clavicular origin of sterno-mastoid muscle of right side; 3, scalenus posticus muscle; 4, splenius muscle; 5, mastoid insertion of sterno-mastoid muscle; 6, internal maxillary artery; 7, parotid duct; 8, genio-hyoid muscle; 9, mylo-hyoid muscle, cut and turned aside; 10, superior thyroid artery; 11, anterior half of omo-hyoid muscle; 12, sterno-hyoid muscle, cut; 13, sterno-thyroid muscle, cut.

The Internal Carotid (Pl. XXV) begins at the bifurcation of the primitive carotid, upon a level with the superior border of the thyroid cartilage, passes upward, and enters the skull through the carotid foramen in the petrous portion of the temporal bone. As the vessel ascends in the neck it lies in front of the transverse processes of the upper three cervical vertebræ. At the beginning the internal carotid lies behind and a little external to the external carotid artery. The **surface guide** is the sterno-cleido-mastoid.

The incision for ligature of the internal carotid artery is practically identical with that to be described for securing the external carotid. Having divided the integument, the two layers of the superficial fascia between which lies the platysma myoides, and the deep fascia attached to the anterior border of the sterno-cleido-mastoid muscle, the posterior belly of the digastric muscle and the stylo-hyoid muscle are brought into view. The superior thyroid, lingual, and facial veins, and also some lymphatic glands, are to be carefully avoided. The hypoglossal nerve will be seen crossing the external carotid artery. The muscles and the veins are to be retracted and the small glands removed, and the internal carotid will be fully exposed. In passing the ligature around the vessel the needle should be carried from without inward, and the pneumogastric nerve and the internal jugular vein should be carefully avoided in the center of the wound and behind the vessel, and the pharynx upon the inner side.

The External Carotid (Pl. XXV) is formed by the bifurcation of the primitive carotid, the division of which takes place upon a level with the superior border of the thyroid cartilage. The artery passes upward in the neck in a curved direction, with its convexity forward, until it reaches a point midway between the external auditory meatus and the condyle of the inferior maxilla. In the upper part of its course it is imbedded in the substance of the parotid gland. The **surface guide** is the sterno-cleido-mastoid.

The incision should begin at a point midway between the angle of the inferior maxilla and the mastoid process of the temporal bone, and extend downward parallel with the anterior border of the sterno-cleido-mastoid muscle to the upper border of the thyroid cartilage of the larynx. The integument, the two layers of the superficial fascia between which lies the platysma myoides, and the deep fascia which is attached to the anterior border of the sterno-cleido-mastoid muscle are to be divided. The superior thyroid, lingual, and facial veins, and also the lymphatic glands, are to be carefully avoided. The posterior belly of the digastric muscle and the stylo-hyoid muscle are to be retracted upward and inward, and the sterno-cleido-mastoid is to be drawn outward. The hypoglossal nerve is now fully exposed to view as it crosses in front of the external carotid artery, and must be drawn inward. A branch of the artery should be sought and found in order to exclude the internal carotid artery, which at this point lies close to the external carotid and might be mistaken for it. Unlike the external, the internal carotid gives off no branches in the neck. At the bifurcation the internal carotid is the more external of the two vessels, and lies on a plane posterior to it. The needle should now be passed from without inward, and any branch that is given off from the external carotid near the site of the ligature should be tied also, in order to ensure the formation of a thrombus at the point of ligation.

The internal jugular vein sometimes overlaps the artery, and great care must be exercised lest the vein be wounded during the necessary manipulations. Before the ligature is finally tightened the operator should see the effect upon the temporal by compressing the external carotid between the ligature behind and the thumb upon the front of the vessel. The internal carotid

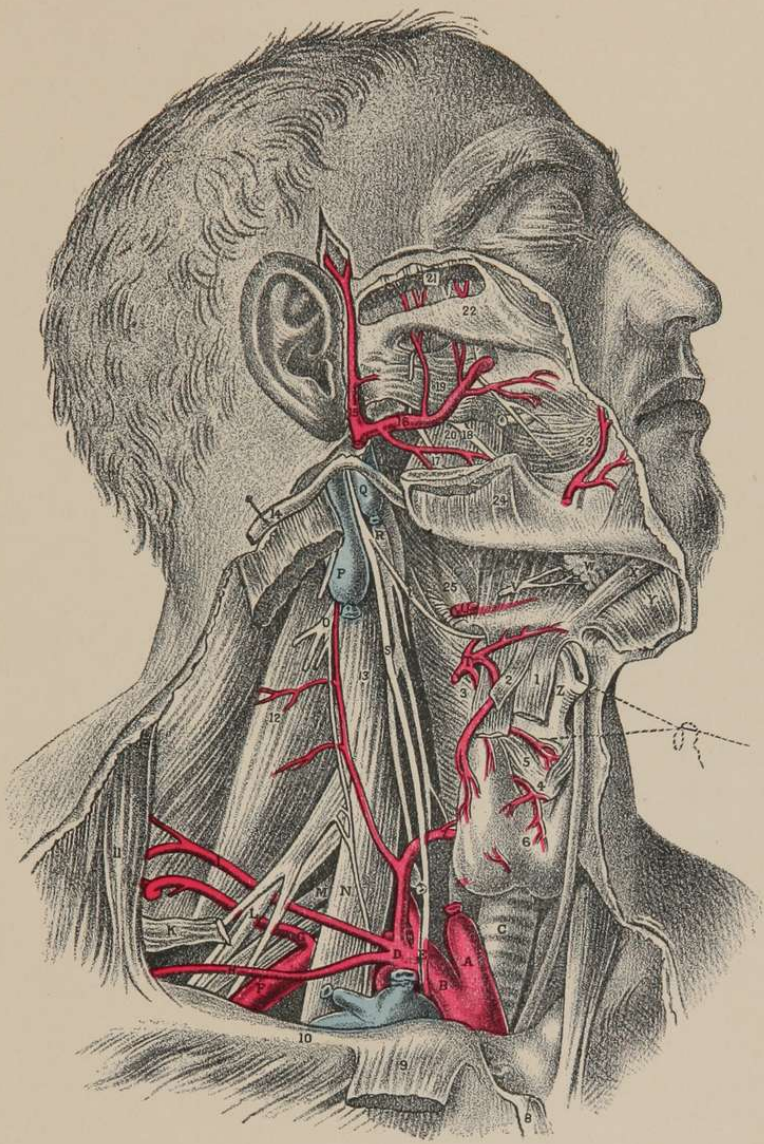
must not be included in the ligature, a mistake that is possible to occur if the external carotid is tied close to the bifurcation.

The Superior Thyroid (Pl. XXV) is the first branch given off from the external carotid artery. This vessel invariably arises from the external carotid by a single trunk, while the lingual and facial often arise from a common trunk which bifurcates to form these two vessels. The artery as it leaves its parent trunk passes upward and forward quite superficially. This vessel is generally injured in attempts to commit suicide, because it stands out prominently upon the anterior aspect of the neck. The artery soon curves downward, and runs deep in the neck to enter the thyroid gland. The **surface guide** is an oblique line drawn parallel with the anterior border of the sterno-cleido-mastoid muscle, while the **muscular guide** is the muscle itself. During the operation the patient's head should be turned to the opposite side and the chin be elevated. An incision should be made parallel to the anterior border of the sterno-cleido-mastoid muscle, its center being at a point corresponding to the superior border of the thyroid cartilage. The skin, the two layers of the superficial fascia between which is the platysma myoides, and the fascia along the anterior border of the sterno-cleido-mastoid muscle are next divided. This will permit the latter muscle to be drawn outward. The superior thyroid artery will now be visible crossing the floor of the superior carotid triangle. As it crosses the triangle it is situated between the primitive carotid artery and the lobe of the thyroid gland, into which it passes. The carotid sheath should be brought fully into view, and the superior thyroid artery will be found along its inner border. The surgeon must exercise care lest the superior thyroid, the lingual, or the facial vein be wounded.

The Lingual Artery (Pls. XXV and XXVI).—This vessel is reached by a curved incision beginning a little below and to the right or left of the symphysis menti, and extending downward and outward to the greater cornu of the hyoid bone (Fig. 443). This incision is then to be carried upward toward the angle of the inferior maxillary bone, terminating at a point on a level with the beginning of the incision, but short of the facial artery. The integument is divided throughout the length of the curvilinear incision; then the two layers of the cervical fascia between which is the platysma myoides. The apex of the submaxillary gland is now visible, which should be seized by a tenaculum and drawn upward by gentle traction, at the same time tearing carefully with the handle of the scalpel the loose connective tissue which binds the gland to the subjacent parts. This dissection will expose *Lesser's triangle.* The base of this is uppermost, and is formed by the hypoglossal nerve, while the two sides lying below are formed by the anterior and posterior bellies of the digastric muscle. The floor of this triangle is formed by the hyoglossus muscle, upon which lies the ranine vein just below the hypoglossal nerve. Beneath the hyo-glossus muscle is found the lingual artery. The movements of the hyoid bone during respiration can be controlled by holding the bone steady with a tenaculum, as suggested by Thiersch. The lingual veins accompany the lingual artery as a rule, but are of small size. The greater cornu of the hyoid bone is also a very serviceable guide.

The Facial Artery (Pl. XXV).—This vessel is secured at the point where the vessel crosses the inferior maxillary bone in a groove just in front of the anterior border of the masseter muscle. To expose the artery, an incision one inch in length should be made from the anterior inferior angle of the masseter muscle in the line of the artery (Fig. 443), dividing the integument, fascia, and platysma myoides. The vessel can be ligated just as it disengages itself from beneath the submaxillary gland. The facial vein is found

PLATE XXVI.



(Maclise.)

A, root of common carotid artery; B, subclavian artery at origin; C, trachea; D, thyroid axis of subclavian artery; E, vagus nerve, crossing origin of subclavian artery; F, subclavian artery at third division of arch; G, post-scapular branch of subclavian; H, transversalis humeri branch of subclavian; I, transversalis colli branch of subclavian; K, posterior belly of omo-hyoid muscle, cut; L, median nerve branch; M, musculo-spiral nerve; N, anterior scalenus muscle; O, cervical plexus, giving off the phrenic nerve, which takes tributary branches from brachial plexus of nerves; P, upper part of internal jugular vein; Q, upper part of internal carotid artery; R, superior cervical ganglion of sympathetic nerve; S, vagus nerve, lying external to sympathetic nerve, and giving off *t*, its laryngeal branch; T, superior thyroid artery; U, lingual artery, separated by hyoglossus muscle from V, hypoglossal nerve; W, sublingual gland; X, genio-hyoid muscle; Y, mylo-hyoid muscle, cut and turned aside; Z, thyroid cartilage; 1, upper part of sterno-hyoid muscle; 2, upper part of omo-hyoid muscle; 3, inferior constrictor of pharynx; 4, cricoid cartilage; 5, crico-thyroid muscle; 6, thyroid body; 7, inferior thyroid artery of thyroid axis; 8, sternal tendon of sterno-mastoid muscle, turned down; 9, clavicular portion of sterno-mastoid muscle, turned down; 10, clavicle; 11, trapezius muscle; 12, scalenus posticus muscle; 13, rectus capitis anticus major muscle; 14, stylo-hyoid muscle, turned aside; 15, temporal artery; 16, internal maxillary artery; 17, inferior dental branch of fifth pair of cerebral nerves; 18, gustatory branch of fifth pair of nerves; 19, external pterygoid muscle; 20, internal pterygoid muscle; 21, temporal muscle, cut to show the deep temporal branches of fifth pair of nerves; 22, zygomatic arch; 23, buccinator muscle, with buccal nerve and parotid duct; 24, masseter muscle, cut on the lower maxilla; 25, middle constrictor of pharynx.

upon the outer side. In making the incision the skin should be drawn upward over the bone, so that when the skin retracts the scar will not be visible upon the face.

Middle Meningeal.—For a description of the method of ligation of this vessel see Intracranial Hemorrhage (p. 502).

The Temporal Artery (Pls. XXV and XXVI) is found by a vertical incision one inch in length made half an inch in front of the tragus and just above the zygomatic arch (Fig. 443). After dividing the skin, the fascia, and the dense cellular tissues, the finger of the surgeon can distinctly feel the pulsation of the vessel. In order to avoid the temporal vein and the auriculo-temporal nerve, the aneurysmal needle should be passed from behind forward, as the temporal artery lies superficial to and in front of the vein and nerve.

The Subclavian Artery (Pls. XXV and XXVI) springs from the innominate artery upon the right side, and from the arch of the aorta upon the left side. The vessel extends from the sterno-clavicular articulation to the lower border of the first rib. It lies behind the scalenus anticus muscle in the second part of its course. In the third portion it lies in the **subclavian triangle,** which is bounded *below* by the clavicle, on the *outer side* by the posterior belly of the omo-hyoid, and on the *inner side* by the posterior border of the sterno-cleido-mastoid.

The artery is ligated in the third portion of its course, just outside of the outer border of the scalenus anticus muscle. Ligation of the subclavian behind, and upon the inner side of, the scalenus anticus has proved uniformly fatal. The **surface guide** is a line drawn parallel to and half an inch above the clavicle, extending from the outer edge of the sterno-cleido-mastoid muscle to the inner edge of the trapezius muscle. The **muscular guide** is the outer border of the scalenus anticus muscle. The tubercle on the first rib into which the scalenus anticus is inserted is the **deep anatomical guide.**

In ligating the subclavian artery in its third portion the shoulders should be lifted by a pillow, the head turned toward the opposite side, and the shoulder corresponding to the side upon which the artery is to be ligated drawn downward. Before beginning the incision the external jugular vein should be compressed and its course distinctly outlined, so that this vessel may be avoided. The skin is now drawn down over the clavicle, and an incision is made directly upon the upper margin of the clavicle and extending down to the bone, and from the outer margin of the sterno-cleido-mastoid muscle to the inner border of the trapezius muscle (Fig. 443). By drawing the integument well down over the clavicle the external jugular vein is retracted underneath the clavicle, and thus escapes injury. When all the tissues are divided to the bone the integument is allowed to assume its normal position, and the line of the incision is found to be about half an inch above the clavicle and directly over the course of the artery. The superficial structures having been divided, the external jugular must be pulled to one side. The loose areolar tissue, with the deep fascia which engages in its meshes the suprascapular and transverse cervical veins, is separated with the index finger and the handle of the scalpel. The tendon of the omo-hyoid muscle is exposed, and this must be pulled upward with a blunt hook, and at the same time the suprascapular artery must be avoided. The surgeon should now feel for the outer border of the scalenus anticus muscle, and carry his index finger down along the edge of the muscle until the tubercle on the first rib is felt. The subclavian vein lies in front of this muscle and upon a lower plane (*i. e.* lower in the erect posture), while the

subclavian artery lies behind the muscle. The artery having been thus exposed and its pulsation clearly felt with the tip of the surgeon's finger, the aneurysm needle should be passed from below upward and from before backward. In passing the needle around the artery in the manner just described, the vein and the pleura must be avoided below, and the cords of the brachial plexus, especially the lowest cord above.

The **Collateral Circulation** is established by three sets of vessels:

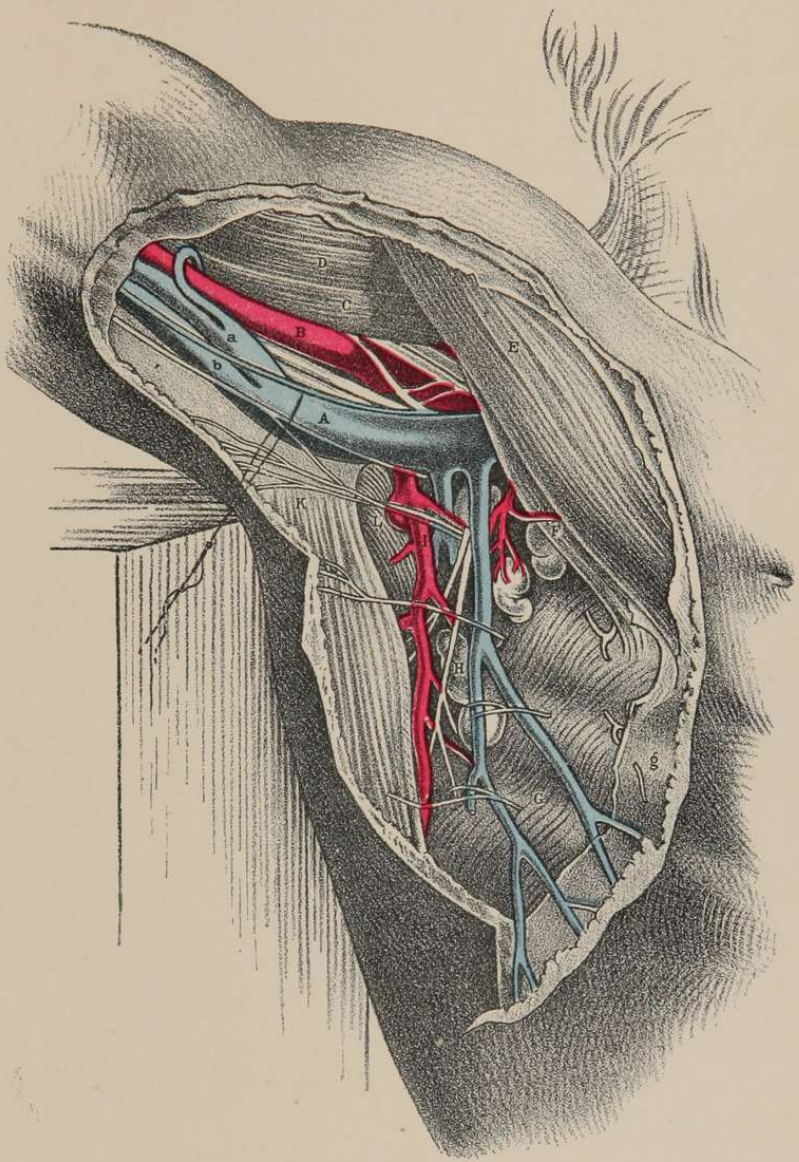
1. The *suprascapular* and the *posterior scapular* from the transversalis colli, with the *dorsalis scapulæ* from the subscapular.
2. The *internal mammary*, the *superior intercostal*, and the *aortic intercostals* with the *long thoracic* and *superior thoracic* from the axillary, and the *dorsalis scapulæ* from the subscapular.
3. *Small branches* given off from the subclavian, anastomosing with unnamed branches from the axillary artery.

The Inferior Thyroid Artery (Pl. XXVI) can be ligated by the same incision that is employed for the purpose of tying the primitive carotid. Having exposed the carotid artery and the internal jugular vein at a point just below where the omo-hyoid tendon crosses in front of the carotid, the sheath and its contents should be gently drawn outward and the tendon upward by blunt retractors. The inferior thyroid artery will now be exposed to view as it crosses behind the carotid, nearly upon the same level as that at which the omo-hyoid tendon crosses in front of the carotid. The artery enters the thyroid gland opposite to the fifth cervical vertebra. This vessel crosses behind nearly on the level of the cricoid cartilage. Care must be exercised by the surgeon not to include in the ligature the middle cervical ganglion or the recurrent laryngeal nerve, nor to injure the œsophagus. If the artery is tied low down, the thoracic duct must be carefully avoided.

The Vertebral Artery (Pl. XXVI) is reached by an incision four inches in length, beginning below the mastoid process and extending downward and forward parallel with the posterior margin of the sterno-cleido-mastoid muscle, terminating about one inch above the clavicle. The external jugular vein must be avoided in making this incision. The transverse process of the sixth cervical vertebra is the **deep anatomical guide** to the vessel. Having exposed the posterior edge of the sterno-cleido-mastoid muscle by drawing it toward the mesial line, the scalenus anticus muscle should become visible. Upon this lie the phrenic nerve and the transverse cervical artery, which should be protected from injury. The border of the scalenus anticus should be made distinct, and in the interval between it and the longus colli muscle the vertebral artery will be found, with its vein lying superficial to the artery. The needle should be passed from without inward and from behind forward, avoiding injury to the pleura and drawing aside the vertebral vein.

The Internal Mammary Artery may be tied in any part of its course, according to the site of injury of the vessel. It lies just beyond the borders of the sternum. In the upper *two intercostal* spaces the vessel lies upon the *pleura;* and if the vessel is injured in this place, the pleura is most likely to be injured also, and hemorrhage takes place into the cavity of the pleura. If the vessel is wounded below the *third intercostal* space, the pleural cavity is not necessarily opened, since the triangularis sterni muscle is between the artery and the pleura. If the vessel is wounded below the third intercostal space, the wound can be tamponed, as the triangularis sterni muscle is behind, and pressure can be made against this muscle. Of course above the third intercostal space strips of antiseptic gauze should not be introduced into the wound. If the injury to the internal mammary artery is above the third

PLATE XXVII.



(Maclise.)

A, axillary vein, drawn from the artery to show the nerves lying between both vessels. On the bicipital border of the vein is seen the internal cutaneous nerve; on the tricipital border is the nerve of Wrisberg, communicating with some of the intercosto-humeral nerves; *a*, the common trunk of the venæ comites, entering the axillary vein; B, axillary artery crossed by one root of the median nerve; *b*, basilic vein, forming with *a* the axillary vein, A; C, coraco-brachialis muscle; D, coracoid head of biceps muscle; E, pectoralis major muscle; F, pectoralis minor muscle; G, serratus magnus muscle, covered by *g*, the axillary fascia, and perforated at regular intervals by nervous branches called intercosto-humeral; H, conglobate gland, crossed by nerve called "external respiratory" of Bell, distributed to the serratus magnus muscle; I, subscapular artery; K, tendon of latissimus dorsi muscle; L, teres major muscle.

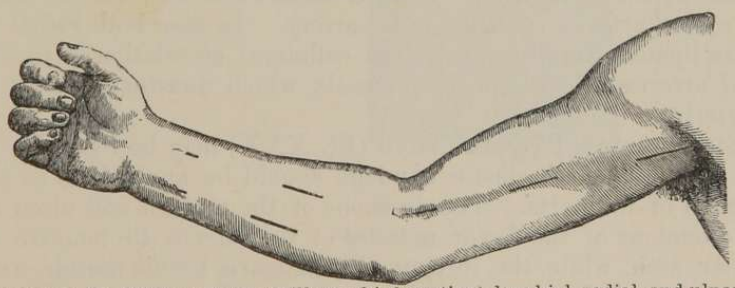
intercostal space, the symptoms of hemorrhage in general are present, and in addition great difficulty of respiration. In a wound of the internal mammary artery both ends of the divided vessel should be tied, or return of the hemorrhage will take place through the deep epigastric. Fig. 443 shows incisions for reaching the internal mammary artery.

THE AXILLARY ARTERY (Pl. XXVII).—The **surface guide** to the axillary artery is a line drawn parallel to the anterior border of the axillary space, at the junction of the anterior with the middle third. The artery extends from the lower border of the first rib to the lower border of the tendon of the teres major and latissimus dorsi muscles, its three portions being respectively above, behind, and below the pectoralis minor muscle. The **deep muscular guide** is the lower border of the pectoralis minor. In operating on the third portion the arm should be drawn outward at right angles to the trunk and abducted (vide Fig. 444), and an incision made three inches in length along the junction of the anterior with the middle third of the axillary space. The integuments and fascia are to be divided along the inner border of the coraco-brachialis muscle. The median nerve is to be drawn to the outer side and the axillary vein to the inner side. The ulnar nerve lies upon the inner side.

Collateral Circulation.—If the ligature is applied *above* the acromial thoracic artery, the collateral circulation is the same as in ligature of the third portion of the subclavian. If the ligature is applied to the axillary *below* the acromial thoracic branch, then the *subscapular* and *long thoracic* anastomose with the *internal mammary*, *superior intercostal*, and *aortic intercostals*.

THE BRACHIAL ARTERY (Pl. XXVIII).—The **surface guide** is a line drawn from the junction of the anterior with the middle third of the axillary space to a point midway between the two condyles of the humerus. The **muscular guide** is the inner border of the biceps muscle. The artery lies upon the triceps, coraco-brachialis, and brachialis anticus muscles. It is overlapped in the upper part for a few inches by the biceps and coraco-brachialis muscles. The **deep anatomical guide** is the median nerve, which lies usually in front of the artery as it comes from the outer to the inner side of the vessel. The incision should be made about the middle of the arm obliquely along the inner margin of the biceps muscle (Fig. 444). Dur-

FIG. 444.



Lines of Incision for ligation of the axillary (third portion), brachial, radial, and ulnar arteries (MacCormac).

ing the operation the arm should be rotated outward and placed at right angles to the trunk, and the forearm supinated; the back of the arm should not be allowed to rest upon anything, lest the triceps muscle push away the biceps and the muscular guide be lost. After the integument and fascia have been divided the median nerve will appear in view. The nerve is to be pulled outward and the basilic vein and ulnar nerve inward with blunt hooks. The

artery will be found directly under the nerve. The operator must avoid making his incision too low down and too far internally, lest he mistake the ulnar nerve for the median and ligate the inferior profunda artery for the brachial.

Collateral Circulation.—The *superior profunda* with the *radial recurrent*, the *inferior profunda* with the *ulnar recurrent*, and the *anastomotica magna* with the *interosseous recurrent*.

The Radial Artery (Pl. XXIX).—The **surface guide** is a line drawn from a point midway between the two condyles of the humerus to a point half an inch internal to the styloid process of the radius. The **muscular guide** is the intermuscular space between the supinator longus and flexor carpi radialis muscles. As the artery passes down the forearm it rests upon the biceps tendon, supinator brevis, pronator radii teres, radial origin of the flexor sublimis digitorum, flexor longus pollicis, and pronator quadratus muscles. At the lower end of the forearm the artery rests upon the radius itself. The nerve is upon the radial side in the middle of the forearm, but at the wrist it has no relation with the artery, having passed to the back of the forearm.

The incision should be made three inches above the wrist-joint, the forearm being extended and supinated. It should be two inches in length, and between the tendons of the supinator longus and flexor carpi radialis (Fig. 444).

Collateral Circulation.—The *interosseous arteries* with the *anterior* and *posterior carpal* arteries from the radial.

The Ulnar Artery (Pl. XXIX).—The **surface guide** is a line drawn from a point midway between the two condyles of the humerus to the radial side of the pisiform bone. The artery in its course down the forearm lies upon the brachialis anticus and flexor profundus digitorum muscles. The flexor carpi ulnaris muscle is situated upon the ulnar side of the vessel. The nerve lies to the ulnar side of the artery.

During the operation the wrist should be extended and the forearm supinated. The incision should be three inches in length, its lower end terminating about an inch above the wrist-joint (Fig. 444). The skin, the superficial fascia, and the deep fascia lying above the ulnar artery are to be divided upon a director or between forceps, and the artery will be exposed. The needle should be passed from within outward, to avoid including the ulnar nerve in the ligation.

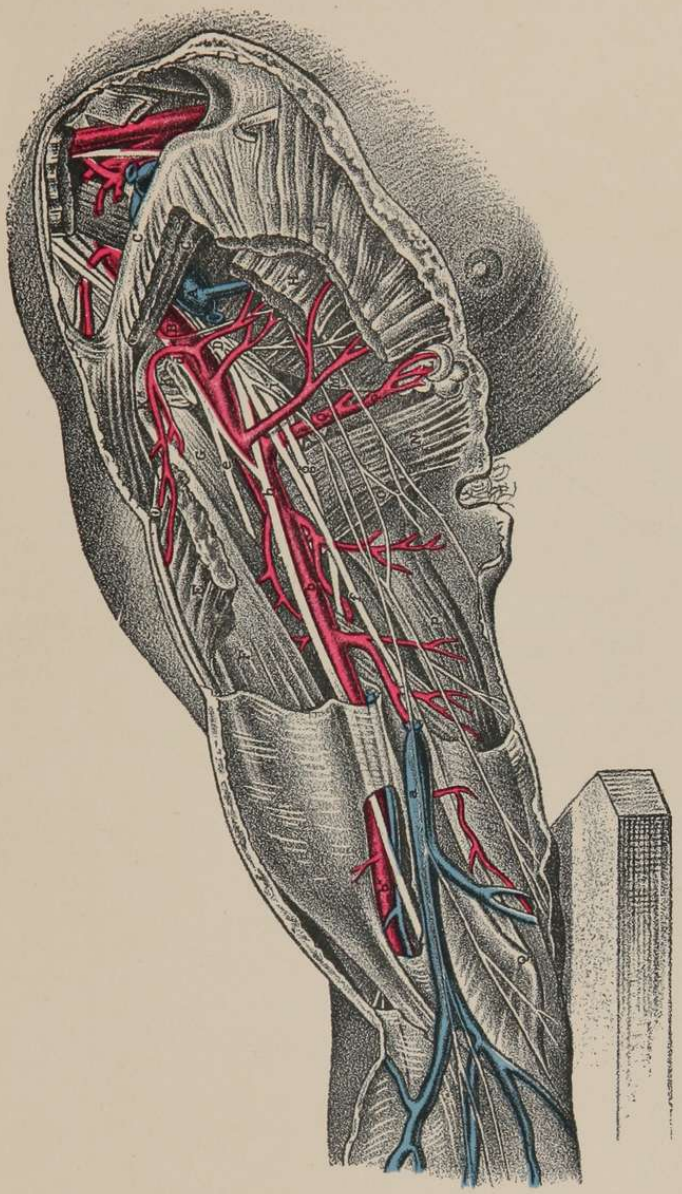
Collateral Circulation.—The *interosseous arteries* with the *anterior* and *posterior carpal* arteries from the ulnar artery. In case both radial and ulnar arteries are ligated simultaneously, the collateral circulation is carried on by the *carpal* arteries of both of these vessels, which anastomose with the *interosseous* arteries.

The Superficial Palmar Arch (Pl. XXX) may be ligated at the point of injury. An Esmarch elastic bandage should be applied, so as to afford a dry dissection of the parts. The divisions of the median and ulnar nerves, as well as the tendons of the flexor muscles of the fingers, lie beneath the superficial palmar arch, while the integument, palmaris brevis muscle, and palmar fascia cover the vessel.

The incision to secure the superficial palmar arch should be made transversely across the palm of the hand along a line drawn from the palmar border of the root of the thumb, when hyperextended, to the ulnar border of the hand (Fig. 445). To prevent the recurrence of hemorrhage *both* ends of the divided arch should be ligated, as well as any branches of the arch that are wounded.

The Deep Palmar Arch (Pl. XXX) is formed by the radial artery and

PLATE XXVIII.



(Maclise.)

A, axillary vein cut and tied; *a*, the basilic vein cut; B, axillary artery; *b*, brachial artery in the upper part of its course, having *h*, the median nerve, lying rather to its outer side; *b**, the artery on the lower part of its course, with the median nerve to its inner side; C, subclavius muscle; C*, clavicle; D, axillary plexus of nerves, of which *d* is a branch on the coracoid border of the axillary artery; *e*, the musculo-cutaneous nerve, piercing the coraco-brachialis muscle; *f*, the ulnar nerve; *g*, musculo-spiral nerve; *h*, the median nerve; *i*, the circumflex nerve; E, humeral part of the great pectoral muscle; F, biceps muscle; G, coraco-brachialis muscle; H, thoracic half of the lesser pectoral muscle; I, thoracic half of the greater pectoral muscle; K, coracoid attachment of the lesser pectoral muscle; K*, coracoid process of the scapula; L, lymphatic glands; M, serratus magnus muscle; N, latissimus dorsi muscle; O, teres major muscle; P, long head of triceps muscle; Q, inner condyle of humerus.

a branch from the ulnar artery. The arch lies upon the interosseous muscles, and likewise upon the bases of the metacarpal bones, and is covered by the flexor tendons of the fingers and flexor brevis pollicis. The deep arch if wounded can be tied by a dissection, having first applied Esmarch's elastic bandage. The wound in the palm of the hand must form the guide to it. Injury of the deep structures of the palm must be carefully avoided.

Fig. 445.

The Figure shows the position of the Superficial Palmar Arch, and the direction and position of the wound which would have to be made in order to reach it (MacCormac).

The Intercostal Arteries are given off from the posterior part of the aorta on each side. Each artery divides into a posterior and an anterior branch, the latter running forward to supply the structures in its intercostal space. The artery runs in a groove along the lower border of the upper rib, where it may be tied, a rib being resected if necessary. If the pleural cavity is filled with blood in consequence of a hemorrhage from this vessel, the cavity should be washed out with an antiseptic solution and drained.

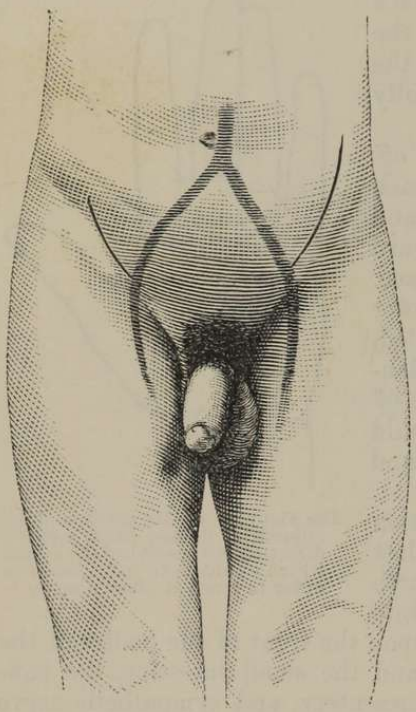
The Abdominal Aorta is a continuation of the thoracic aorta, and extends from the last dorsal vertebra to the left side of the fourth lumbar vertebra, at which point it divides into the common iliac arteries. The artery lies upon the front of the bodies of the vertebræ. The stomach, transverse colon, and the small intestine, the pancreas and the splenic vein, the peritoneum, mesentery, and sympathetic nerve plexus, lie in front of the artery, while behind it are found the left lumbar veins, thoracic duct, receptaculum chyli, and the anterior ligaments connecting the bodies of the vertebræ. To the right of the abdominal aorta lie the inferior vena cava, the thoracic duct, and the vena azygos, while to the left of the aorta no important parts are contiguous except the gangliated chain of the sympathetic nerve.

The abdominal aorta can be ligated by an incision about four inches in length, the center of which is opposite to the umbilicus and a little to its left side. The skin, superficial fascia, aponeurosis of the external and internal oblique muscles, the transversalis muscle, and the peritoneum are all divided. The peritoneum should be held by two sutures to prevent its edges from retracting out of reach. The patient is now turned upon the right side, so that the abdominal viscera will gravitate to that side, and the peritoneum can be torn through upon the left side of the artery. The aneurysm needle should be passed between the vena cava and the artery, care being taken not to include the sympathetic nerve. The abdominal aorta can also be reached by a lateral incision, which begins at the tenth rib and extends downward to near the anterior superior spinous process of the ilium. The skin, superficial fascia, the aponeurosis of the external and internal oblique muscles and the transversalis muscle and fascia having been divided, the peritoneum is carefully stripped up from its attachment to the abdominal parietes, and the vessel reached behind the peritoneum and without opening into the general peritoneal cavity. The needle should then be passed around the artery in the same manner as described in reaching the vessel by the median incision.

The abdominal aorta has been ligated eleven times, with eleven deaths.

The Common Iliac Arteries (Pl. XXXI) are about two inches in length, begin at the left side of the body of the fourth lumbar vertebra, and extend to their bifurcation into the internal and external iliac arteries at the sacro-iliac synchondroses. The right common iliac artery is a trifle longer than the left, because the two common iliac veins join to form the vena cava upon the right side of the fifth lumbar vertebra.

Fig. 446.

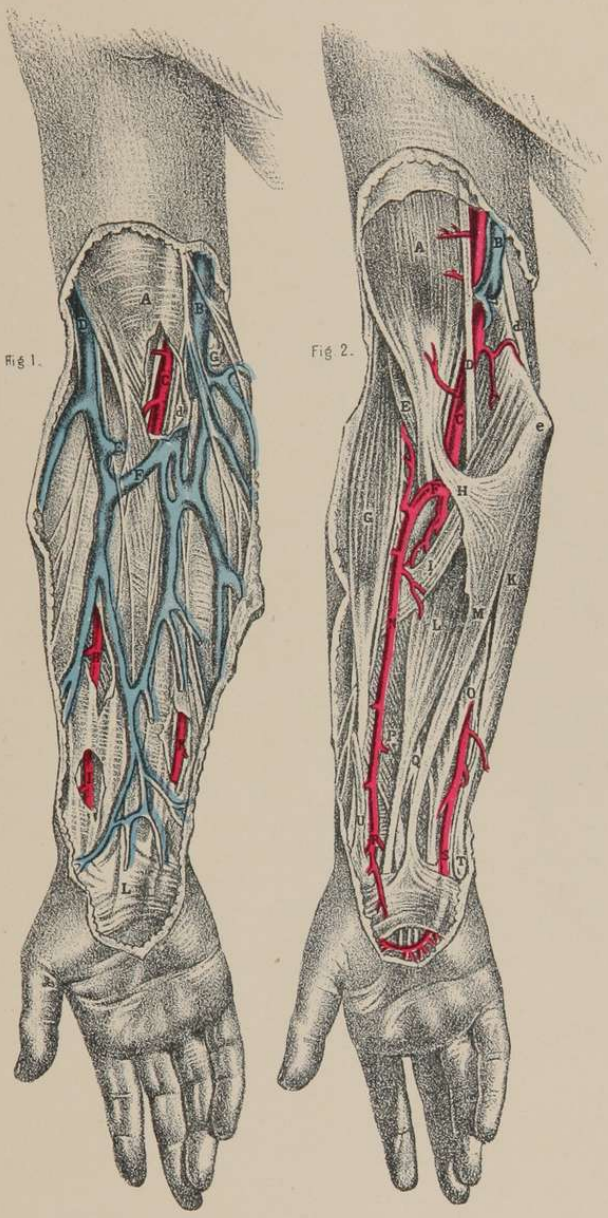


Direction of the Common and External Iliac Arteries, and the positions of the superficial incisions adopted for their ligature. On the right side is that for the external iliac, and on the left side that for the common iliac artery (MacCormac).

The common iliac arteries may be ligated either by an incision which opens the peritoneal cavity, or by a lateral incision which reaches the vessel behind the peritoneum. The **surface guide** of the common iliac arteries is a line drawn from a little below and to the left of the umbilicus to a point midway between the symphysis pubis and the anterior superior spinous process of the ilium. An incision is made six inches in length along the linea semilunaris, beginning from the lower border of the seventh rib and extending to nearly the spine of the pubes (Fig. 446). Having divided all the tissues, including the peritoneum, the intestines are carefully removed and wrapped in hot aseptic gauze, the peritoneum below scratched through, and the needle passed from without inward upon the right side, and from within outward upon the left side. In passing the needle in this way the point is carried away from the vein.

The other method of reaching the common iliac artery is by a lateral incision and by stripping up the peritoneum, so as to secure the vessel without opening the peritoneal cavity. The incision should begin from the eleventh rib, and extend downward to a point two inches above the center of Poupart's ligament; all the tissues are to be divided until the peritoneum is reached. The subserous areolar tissue and the peritoneum are to be carefully stripped upward and forward from the iliac fossa until the fascia covering the psoas muscle comes into view. Just above the sacro-iliac synchondrosis and upon the inner margin of the psoas muscle the common iliac artery is felt pulsating. As the two vessels differ slightly in their relative anatomy, the needle must be passed in a different direction in each case. In ligating the left common iliac artery the needle must be passed from within outward, carefully avoiding the superior hemorrhoidal artery, which must be pushed aside, together with the mesocolon belonging to the sigmoid flexure. The ureter crosses the common iliac below, and is generally raised with the peritoneum. In ligating the right common iliac artery the needle must be passed from without inward, carefully avoiding the iliac veins, which have crossed underneath the artery in order to form the vena cava. The ureter, as in the case of ligating the left common iliac, is usually raised out of reach, but if it is not lifted from the vessel with the peritoneum it must be pulled downward by a blunt hook, so as not to be included in the ligature.

PLATE XXIX.



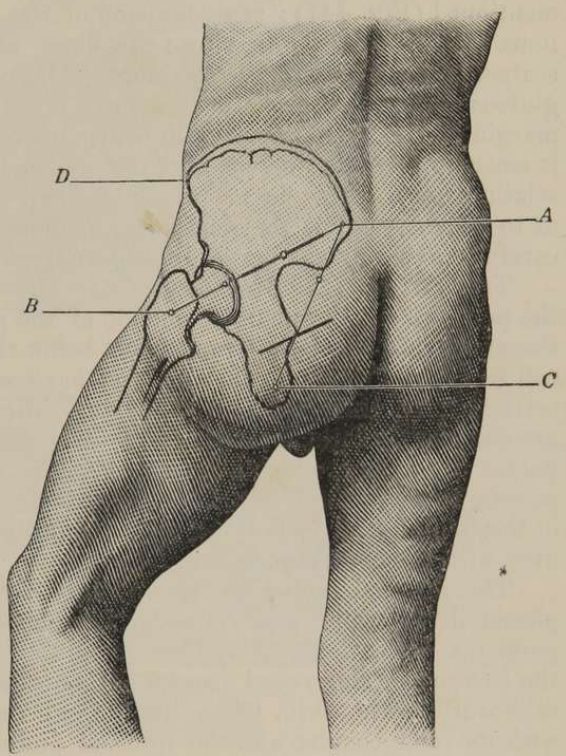
(Maclise.)

Fig. 1.—A, fascia, covering biceps muscle; B, basilic vein, with internal cutaneous nerve; C, brachial artery, with venæ comites; D, cephalic vein, with external cutaneous nerve; *d*, median nerve; E, a communicating vein, joining venæ comites; F, median basilic vein; G, lymphatic gland; H, radial artery at middle; I, radial artery of the pulse; K, ulnar artery, with ulnar nerve; L, palmaris brevis muscle.

Fig. 2.—A, biceps muscle; B, basilic vein, cut; C, brachial artery; D, median nerve; *d*, ulnar nerve; E, brachialis anticus muscle; *e*, internal condyle; F, origin of radial artery; G, supinator radii longus; H, aponeurosis of tendon of biceps muscle; I, pronator radii teres; K, flexor carpi ulnaris; L, flexor carpi radialis; M, palmaris longus; N, radial artery at middle, with radial nerve on outer side; O, flexor digitorum sublimis; P, flexor pollicis longus; Q, median nerve; R, lower end of radial artery; S, lower end of ulnar artery, in company with ulnar nerve; T, pisiform bone; U, extensor metacarpi pollicis.

The Internal Iliac Arteries (Pl. XXXI) arise at the bifurcation of the common iliac near the sacro-iliac synchondroses. The internal iliacs run down into the pelvic cavity to supply the pelvic organs. These vessels can be ligated in either of the two ways already described for reaching the common iliac arteries. After the abdominal cavity is opened or the peritoneum is pushed aside by the lateral incision, the pulsation of the artery can be distinctly felt as the vessel descends into the pelvis upon the inner side of the psoas muscle and along the sacro-iliac synchondroses. The needle used to secure this vessel should be made with the curve at right angles to the shaft, and one must be made for the right and one for the left internal iliac artery. The ligature should be applied about one inch below the bifurcation, and the needle passed from within outward and from behind forward. The ureter lies in front of the artery, and the external iliac vein must be carefully avoided. Dennis of New York has reported three cases of ligation by the intraperitoneal operation. Two recovered; the third—in which both internal iliacs were tied for the first time—died. In ligaturing all the vessels in the abdominal cavity, the bowels should be thoroughly emptied by a cathartic the night previous to the operation, and by an enema a short time before the operation. The bladder should also be emptied, as in all abdominal operations.

Fig. 447.



Position and Direction of the Superficial Incisions which must be made in order to secure the gluteal artery and the sciatic and pudic arteries: *A*, posterior superior iliac spine; *B*, great trochanter; *C*, tuberosity of the ischium; *D*, anterior superior iliac spine; *AB*, ilio-trochanteric line, divided into thirds. This line corresponds in direction with the fibers of the gluteus maximus muscle. The incision to reach the gluteal artery is indicated by the darker portion of the line. Its center is at the junction of the upper and middle thirds of the ilio-trochanteric line, and exactly corresponds with the point of emergence of the gluteal artery from the great sciatic notch. *AC*, ilio-ischiatic line. The incision to reach the sciatic artery and internal pudic is indicated by the lower dark line. It also is to be made in the direction of the fibers of the gluteus maximus muscle. The center of the wound corresponds to the junction of the lower with the middle third of the ischio-ischiatic line (MacCormac).

The Gluteal Artery is a branch of the internal iliac artery, and emerges from the pelvis at the upper part of the great sacro-sciatic foramen above the pyriformis muscle. The gluteal artery can be ligated at the point where the vessel comes out of the pelvis. The patient should be placed upon his abdomen with the thigh extended and the hip-joint rotated inward. The **surface guide** is a line drawn from the posterior superior spinous process of the ilium to the middle of the trochanter major. At the junction of the upper with the middle third of this line the artery emerges from the pelvis (Fig. 447). The **muscular guide** is the upper border of the pyriformis muscle. The gluteus maximus muscle covers the artery. An incision six inches in length should be made along the course of the artery, as indicated by

the linear guide. After dividing the skin and fascia, the gluteus maximus muscle will appear, the fibers of which, running parallel to the incision, can be separated and held apart by retractors. The deep fascia beneath the muscle is to be divided, and the artery will now be felt in the bottom of the wound and at the upper part of the foramen above the tendon of the pyriformis. The venæ comites must be separated and the needle passed around the artery.

The Sciatic Artery is a branch of the internal iliac artery, and leaves the pelvis through the great sacro-sciatic foramen at its lower part and below the tendon of the pyriformis muscle. The artery descends between the tuberosity of the ischium and the trochanter major. This vessel has close to it the internal pudic artery. The patient is placed upon the abdomen with the thigh extended and the hip-joint rotated inward. The **surface guide** is a line drawn from the posterior superior spinous process of the ilium to the tuberosity of the ischium. The **muscular guide** is the lower border of the tendon of the pyriformis muscle. An incision is made along the linear guide already mentioned (Fig. 447): after division of the skin and fascia, the gluteus maximus muscle comes into view; its fibers are separated by the handle of a scalpel and held apart by retractors. Having divided the fascia beneath the gluteus maximus, the sciatic artery can be felt pulsating just below the inferior margin of the pyriformis. The sciatic nerve accompanies the sciatic artery as it emerges from the pelvis, and the internal pudic artery lies internal to the sciatic artery. The course which the two arteries take will dispel any doubt as to which vessel is the sciatic. The ligature is passed around the artery, carefully avoiding the nerve, the internal pudic artery, and the venæ comites.

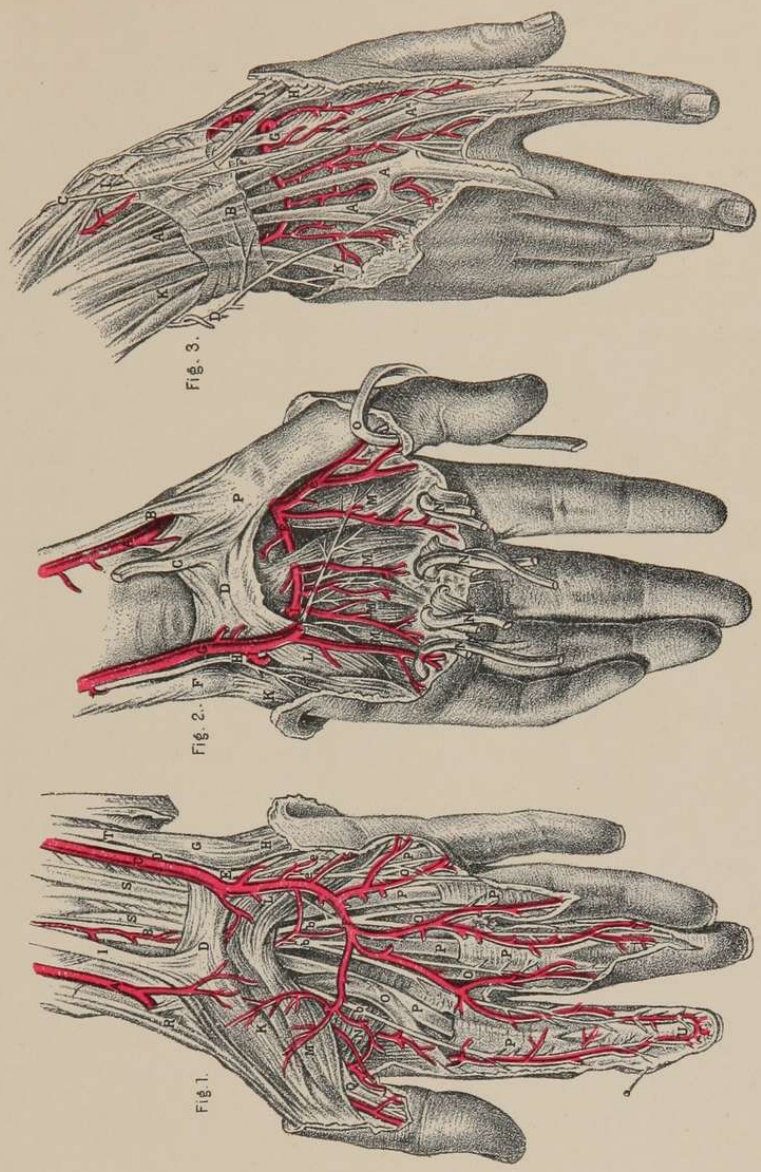
The Internal Pudic Artery.—This vessel may be tied either within the pelvis in the perineum or outside of the pelvis as the artery emerges from the greater sacro-sciatic foramen just below the pyriformis muscle. The vessel can be tied by the same incision that has been already described to secure the sciatic artery, since the artery lies just internal to it at the lower part of the greater sacro-sciatic foramen (Fig. 447). The internal pudic nerve accompanies the artery, which has venæ comites. The artery enters the pelvis by passing through the lesser sacro-sciatic foramen, and skirts along the outer side of the ischio-rectal fossa lying upon the obturator internus muscle and covered over with the obturator fascia.

The internal pudic can also be ligated in the perineum. The patient is placed in the same position as for lithotomy, and an incision is made from a point just beneath the symphysis pubis to the inner side of the tuberosity of the ischium. The vessel can be felt pulsating an inch and a half above the tuberosity. The skin, fascia, and tissues are divided, and the artery found with its venæ comites and the internal pudic nerve. The crus penis is liable to be wounded in the upper part of the incision.

The External Iliac Artery (Pl. XXXI) is formed by the bifurcation of the common iliac, and extends from the sacro-iliac synchondrosis to Poupart's ligament. The external iliac artery runs along the inner margin of the psoas muscle, to which it is bound down by a reflection of the fascia. The genito-crural nerve lies upon the outer side of the artery, and near Poupart's ligament the spermatic vessels cross it. The left external iliac vein lies upon the inner side of the artery, but it is under the artery at its beginning upon the right side. Just above Poupart's ligament the circumflex iliac vein crosses the artery, and the vas deferens winds around the epigastric artery and descends into the pelvic cavity upon the *inner side* of the external iliac artery.

The external iliac artery can be ligated by first performing a laparotomy by an incision in the linea semilunaris, and then tearing through the posterior

PLATE XXX.



(Maclise.)

Fig. 1.—A, radial artery; B, median nerve; *b, b, b*, its branches; C, ulnar artery, forming F, superficial palmar arch; D, anterior annular ligament; E, ulnar nerve; *e, e*, its branches to little and ring fingers; G, pisiform bone; H, abductor muscle of little finger; I, tendon of flexor carpi radialis; K, abductor pollicis; L, flexor brevis muscle of little finger; M, flexor brevis pollicis; N, adductor pollicis; O, O, O, O, lumbrical muscles; P, P, P, P, tendons of flexor digitorum sublimis; Q, tendon of flexor longus pollicis; R, tendon of extensor metacarpi pollicis; S, tendons of extensor digitorum sublimis; P, P, P, their digital prolongations; T, tendon of flexor carpi ulnaris; U, union of digital arteries at tip of fingers.

Fig. 2.—A, radial artery; B, tendons of extensors of thumb; C, tendon of flexor carpi radialis; D, annular ligament; E, deep palmar arch, formed by radial artery, giving off *e*, artery of thumb; F, pisiform bone; G, ulnar artery, giving off branch I, to join deep palmar arch E, of radial artery; H, ulnar nerve. Its deep palmar branch is seen lying on the interosseous muscles, M, M; K, abductor minimi digiti; L, flexor brevis minimi digiti; M, palmar interossei; N, tendons of flexor digitorum sublimis and profundus, and the lumbricales; O, tendon of flexor pollicis longus; P, carpal end of the metacarpal bone of the thumb.

Fig. 3.—A, A, A, tendons of extensor digitorum communis; A*, tendon overlying that of indicator muscle; B, dorsal part of annular ligament; C, end of radial nerve, distributed over back of hand to two fingers and the thumb; D, dorsal branch of ulnar nerve, supplying back of hand and the three outer fingers; E, radial artery, turning round the carpal end of the metacarpal bone of the thumb; F, tendon of extensor carpi radialis brevior; G, tendon of extensor carpi radialis longior; H, tendon of third extensor of the thumb; I, tendon of second extensor of the thumb; K, tendon of extensor minimi digiti, joining a tendon of extensor communis.

layer of the peritoneum in the same manner that has already been described for tying the common or the internal iliac artery. The artery can also be tied by a lateral incision about four inches in length about one inch above Poupart's ligament. The incision should begin just external to the origin of the deep epigastric artery, which is about the center of Poupart's ligament, and continue outward and upward along the crest of the ilium internal to the circumflex iliac artery (Fig. 446). The incision made in this manner avoids wounding these two branches of the external iliac artery, and thus preserves a most important collateral circulation. The skin, the superficial fascia, the aponeurosis of the external oblique muscle, and the internal oblique and transversalis muscles, are all divided to the full extent of the external incision. The transversalis fascia is now severed upon a grooved director, carefully avoiding the peritoneum. The peritoneum and the subperitoneal areolar tissue are next gently stripped up from the iliac and psoas fasciæ with the finger or the handle of the scalpel, and with its contained viscera is pushed inward toward the umbilicus. The spermatic vessels and the ureter are usually adherent to the peritoneum, and are thus pushed out of the way. The surgeon should exercise great care in stripping up the peritoneum, as any rough manipulation would be likely to favor the development of a purulent œdema or a pelvic cellulitis or pelvic peritonitis. The finger should now be carried to the bottom of the wound, and the inner margin of the psoas muscle felt, along the edge of which the artery runs. The needle should be passed from within outward, so as to avoid the external iliac vein, which lies upon the inner side of the artery. The ureter crosses the artery at its extreme upper end, and must be pushed upward if for any reason it should cross lower down than usual. The genital branch of the genito-crural nerve is seen lying upon the front of the vessel, and must not be included in the ligature. The spermatic cord usually is out of reach, but the possibility of its presence, owing to its non-attachment to the peritoneal membrane, must not be overlooked.

The Collateral Circulation:

1. The *internal mammary* with the *deep epigastric* artery.
2. The *ilio-lumbar* with the *circumflex iliac* artery.
3. The *gluteal* with the *external circumflex.*
4. The *obturator* with the *internal circumflex.*
5. The *internal pudic* with the *external pudic.*
6. The *sciatic* with the *perforating branches of the deep femoral.*
7. The *comes nervi ischiadici* with the *branches of the deep femoral.*

The Deep Epigastric Artery is given off from the external iliac just above Poupart's ligament, and runs upward toward the umbilicus. At its beginning it lies just to the inner side of the internal abdominal ring, and in its course runs between the peritoneum and the fascia transversalis.

The epigastric artery can be ligated by an incision beginning one inch above Poupart's ligament and carried parallel to the ligament for three inches. The center of the incision should be over the artery. The **surface guide** is a line drawn from the middle of Poupart's ligament to the umbilicus. The **muscular guide** is the transversalis muscle with the transversalis fascia. The integument, two layers of superficial fascia, the aponeurosis of the external oblique muscle, and the internal oblique and transversalis muscles and fasciæ are to be divided, and when the transversalis fascia is reached it should be cut upon a director and the artery exposed. The needle should be passed in such a manner as to avoid the veins.

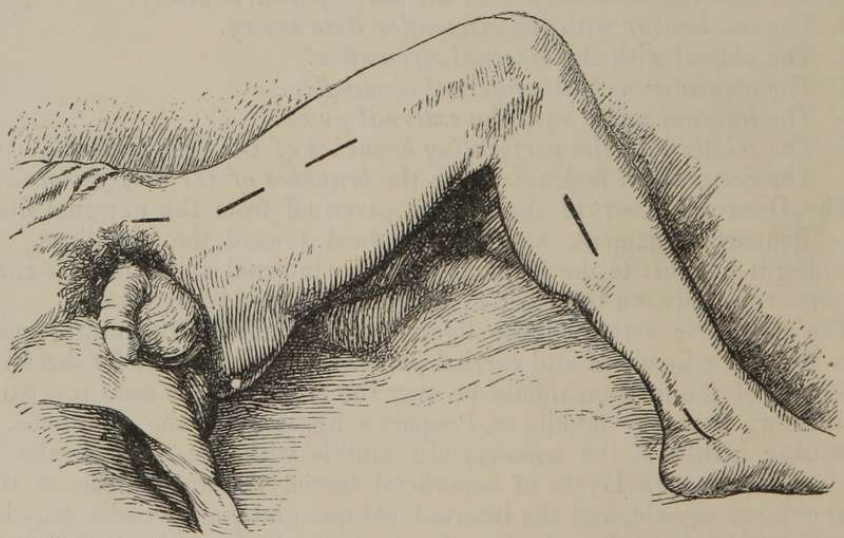
The Circumflex Ilii is another branch of the external iliac artery, and takes a direction upward and outward parallel with Poupart's ligament and the

crest of the ilium. It runs close to the inner lip of the crest. The circumflex iliac artery can be ligated by the same incision that has been mentioned for securing the epigastric artery, or the vessel may be tied by another incision just above and parallel to Poupart's ligament and the crest of the ilium. The different layers must be cut down upon until the transversalis fascia is reached. The artery lies between this fascia and the peritoneum.

The Femoral Artery (Pl. XXXI) is a continuation of the external iliac vessel. It extends from a point midway between the anterior superior spinous process of the ilium and the symphysis pubis to the opening in the adductor magnus muscle, through which the femoral artery passes to become the popliteal. The artery lies in a triangle known as **Scarpa's triangle,** which is bounded as follows: the *base* of the triangle is Poupart's ligament, the *outer side* is the inner margin of the sartorius muscle, and the *inner side* is the inner margin of the adductor longus muscle. The inner border of both muscles must be taken as the boundaries of the triangle, which excludes the sartorius from taking part in the floor of the triangle, but includes the adductor longus. The femoral artery is covered by integument, superficial and deep fasciæ, and the sheath of the vessels. A branch of the internal cutaneous nerve and the crural branch of the genito-crural nerve lie upon the sheath of the vessels. The internal saphenous vein lies superficial to, as well as upon, the inner side of the artery.

The ligation of the femoral artery is usually performed at the apex of Scarpa's triangle, about five inches below Poupart's ligament. The **surface guide** is a line drawn from a point midway between the anterior superior iliac spine and the symphysis pubis to the adductor tubercle upon the inner condyle of the femur. The **muscular guide** is the inner margin of the sartorius muscle. The patient should lie upon his back, with the knee slightly flexed and the hip rotated outward, the femur also being slightly flexed and abducted. The incision should begin three inches below Poupart's

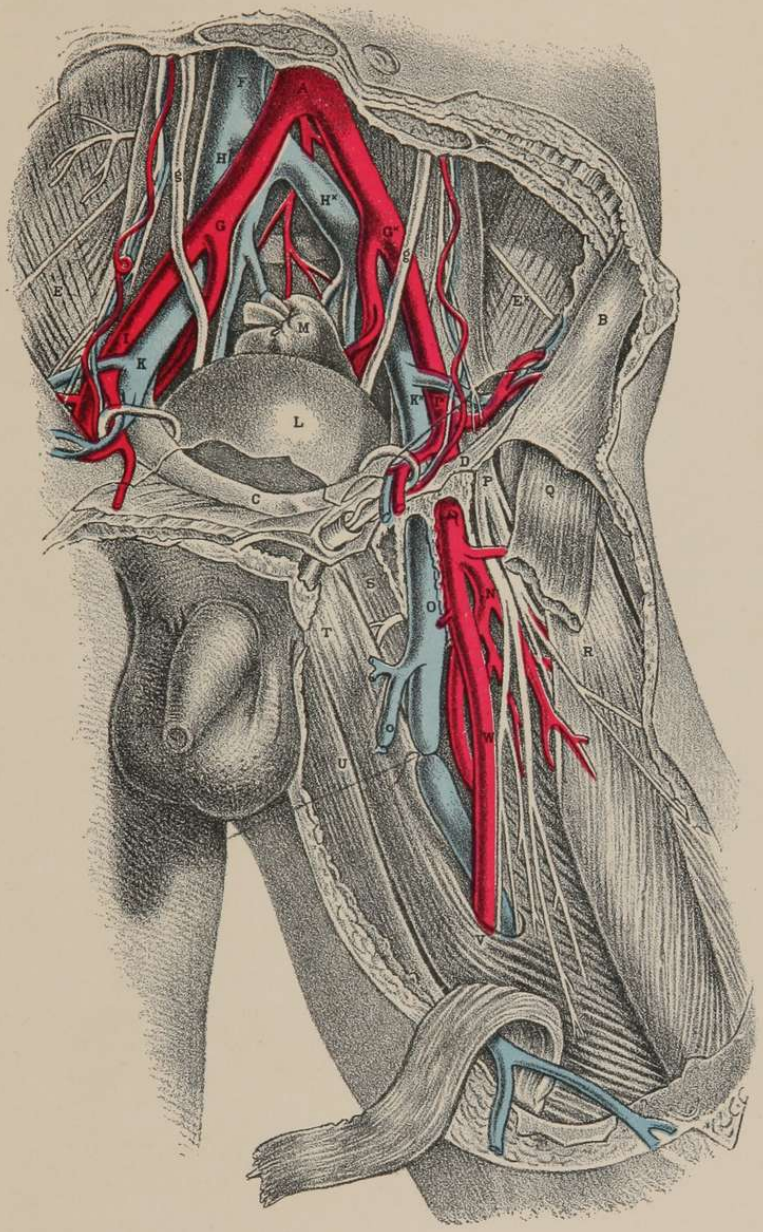
Fig. 448.



The lines indicate the incisions to be made for the ligature of the common femoral, of the femoral in Scarpa's triangle and in Hunter's canal, and of the posterior tibial in the calf and behind the malleolus (MacCormac).

ligament (this should be a measured distance, or the incision will probably be made too low), and be carried downward about three inches along the line of

PLATE XXXI.



(Maclise.)

A, aorta at point of bifurcation; B, anterior superior iliac spine; C, symphysis pubis; D, Poupart's ligament, immediately above which are seen the circumflex iliac and epigastric arteries, with vas deferens and spermatic vessels; E, E*, right and left iliac muscles, covered by peritoneum: the external cutaneous nerve is seen through the membrane; F, the vena cava; G, G*, common iliac arteries, giving off internal iliac branches on the sacro-iliac symphyses; *g*, *g*, right and left ureters; H, H*, right and left common iliac veins; I, I, right and left external iliac arteries: each is crossed by circumflex iliac vein; K, K, right and left external iliac veins; L, urinary bladder, covered by peritoneum; M, the rectum; N, profunda branch of femoral artery; O, femoral vein; *o*, saphena vein; P, anterior crural nerve; Q, sartorius muscle, cut; S, pectineus muscle; T, adductor longus muscle; U, gracilis muscle; V, tendinous sheath given off from long adductor muscle, crossing vessels and becoming adherent to vastus internus muscle (forming Hunter's canal); W, femoral artery.

h

the femoral artery (Fig. 448). The integument, the superficial fascia, and the fascia lata are all divided. The lymphatic glands, if they are in the field of operation, must be pushed aside or removed. The internal saphenous vein lies upon the inner side of the incision, and its position can be readily made out by making pressure upon the vein near its entrance into the femoral. The surgeon should now look for the sartorius muscle, the fibers of which run downward and *inward*. The sartorius must not be mistaken for the adductor longus, the fibers of which run downward and *outward*. Just under cover of the sartorius muscle the sheath of the femoral vessels will be found. The sheath should be opened upon the outer side, so as to avoid wounding the femoral vein in the event of its overlapping a part of the artery. Upon the sheath lies the crural branch of the genito-crural nerve. In passing the needle around the femoral artery it should be carried from within outward. The femoral vein in this situation is posterior as well as internal to the artery. The long saphenous nerve must be avoided as it lies over the artery.

Collateral Circulation.—1. The *profunda femoris* with the *articular branches of the popliteal* and the *tibial recurrent*.

2. The *arteria comes nervi ischiadici* with the *perforating branches of the profunda femoris* and the *articular branches of the popliteal* and *tibial recurrent*.

The Popliteal Artery (Pl. XXXII) is a continuation of the femoral from the opening in the adductor magnus muscle to the lower border of the popliteus muscle. The artery as it runs obliquely downward lies at first upon the posterior border of the condyloid surface of the femur, in its middle portion upon the posterior ligament of the knee-joint, and in its lower portion upon the popliteus muscle. Behind the popliteal artery is the popliteal vein, which is joined by the short saphenous vein from below, while the internal popliteal nerve is superficial and a little external to the vein. The space through which the artery runs is covered over by a dense fibrous fascia which is a continuation of the fascia lata, and this binds down the vessels and nerves and lymphatic glands. The lateral boundaries of this space are formed above by the inner and outer hamstrings, and below by the divergence of the two heads of the gastrocnemius muscle.

The ligation of the popliteal artery may be best accomplished in the upper part of the space. The **surface guide** is a line drawn from a point about one inch internal to the upper angle of the space to the apex of the inferior angle. The **muscular guide** is the external margin of the semi-membranosus muscle. An incision should be made beginning at the upper part of the space and continuing obliquely downward through the space, about four inches in length. This incision should be just external to the outer margin of the semi-membranosus muscle. The integument and superficial fascia having been divided, the fibers of the semi-membranosus appear in view. This muscle should be drawn inward with a blunt retractor. The space will be found to contain loose areolar tissue, which must be carefully teased away with the handle of the scalpel until the sciatic nerve is exposed. Just to the inner side of the nerve lies the popliteal vein, while the artery lies slightly more internal and almost covered by the vein to which it is closely connected. The sciatic nerve and the popliteal vein must now be drawn to the outer side by a blunt hook, when the artery will be fully exposed to view. The aneurysm needle should be passed in a direction from without inward.

The Posterior Tibial Artery (Pls. XXXII and XXXIII) arises at the bifurcation of the popliteal. It begins at the lower margin of the popliteus muscle, and extends down the back of the leg to a point between the internal

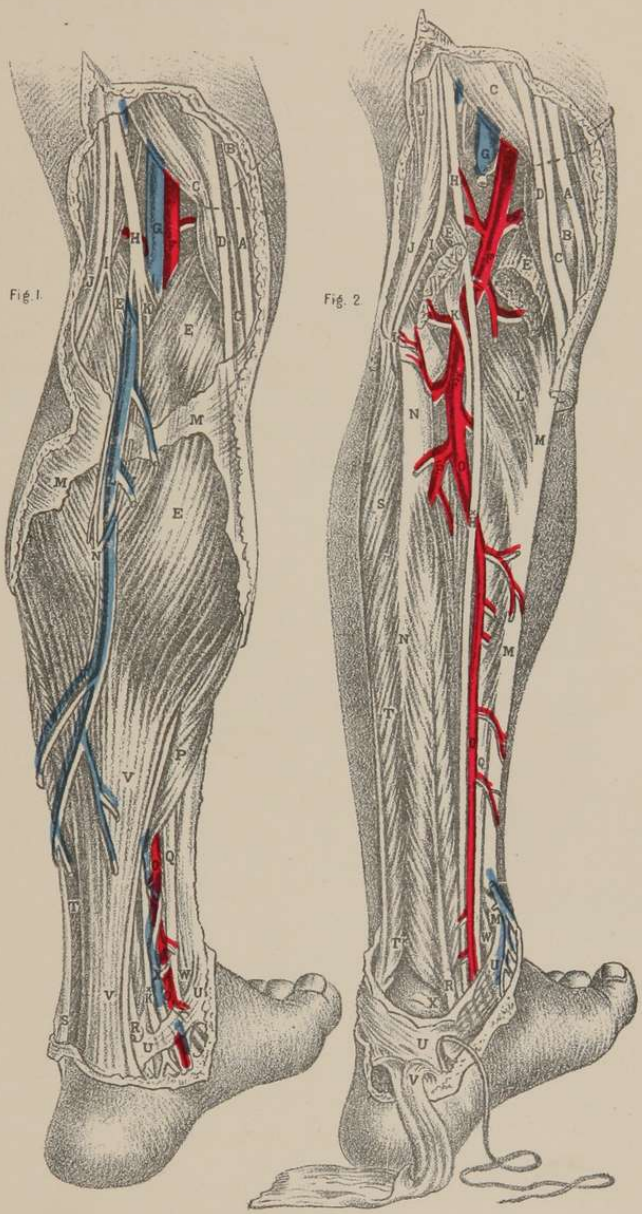
malleolus and the tuberosity of the os calcis, where the artery divides to form the internal and the external plantar. The artery in its course down the leg lies upon the deep layer of muscles of the calf and is covered in by the superficial layer. The **surface guide** is a line drawn from the middle of the popliteal space to a point half an inch behind the tip of the internal malleolus. The **muscular guide** is the outer border of the flexor longus digitorum in the lower part of its course, and the soleus muscle, beneath which it lies, in the upper part of its course. It can be ligated through an incision in the middle of the calf while the patient is lying upon the abdomen. This should be made slightly to the inside of the median line of the leg, and be about six inches in length in order to reach the artery at this depth and fully to expose it. The muscles of the calf are then divided down to the deep fascia beneath which the artery lies. This fascia being divided upon a director, the artery is exposed, the nerve lying to its outer side. The artery is, however, more commonly ligated by an incision four inches in length parallel to the inner border of the tibia and three-quarters of an inch behind it (Fig. 448). In dividing the skin and the fascia the internal saphenous vein must be carefully avoided. The thin tibial attachment of the soleus is next carefully divided throughout the entire length of the incision. The ankle-joint is now extended, thus relaxing the soleus, which is lifted by a retractor, and the deep fascia comes into view. The artery can be felt pulsating under it, near the external border of the tibia, and is exposed by dividing the fascia upon a grooved director. The artery needle should be passed from without inward to avoid the nerve.

The posterior tibial artery can be also ligated just behind the internal malleolus. A crescentic incision is made with the convexity downward, the center of which should be at a point midway between the tip of the internal malleolus and the inner tuberosity of the os calcis (Fig. 448). The skin, the superficial and the deep fasciæ, and the internal annular ligament having been divided, the artery is exposed. The relations of the parts from above downward are as follows: the tendon of the tibialis posticus, the tendon of the flexor longus digitorum, the artery with a vena comes on each side of it, the posterior tibial nerve, and the tendon of the flexor longus pollicis.

The Peroneal Artery begins about an inch below the popliteus muscle, and passes obliquely down the leg parallel with and just posterior to the shaft of the fibula. The incision should be about four inches in length upon the outer part of the calf, while the leg is rotated so that its inner surface rests upon the operating table and its outer surface is turned upward. The skin, the fasciæ, the fibular origin of the soleus muscle, and the deep fascia separating this muscle and the flexor longus pollicis, are all to be divided. The soleus and flexor longus pollicis muscles can be relaxed by extending the ankle-joint, and the cut fibers of the soleus can be retracted inward. The peroneal artery will be found upon the inner side of the flexor longus pollicis: it has occasionally been observed in the substance of that muscle. It lies close to the fibula, and unless this fact is observed the posterior tibial might be tied in its place.

The Anterior Tibial Artery (Pl. XXXIII) is formed by the bifurcation of the popliteal, and begins at the lower border of the popliteus muscle. It passes between the tibia and the fibula just above the interosseous membrane, and then runs down upon this membrane to the ankle-joint, from which point the vessel is known as the dorsalis pedis. The anterior tibial artery in the upper third of the leg lies between the tibialis anticus muscle and the extensor communis digitorum; in the middle third of the leg, between the tibialis anticus and the extensor proprius pollicis; in the lower third of the

PLATE XXXII.



(Maclise.)

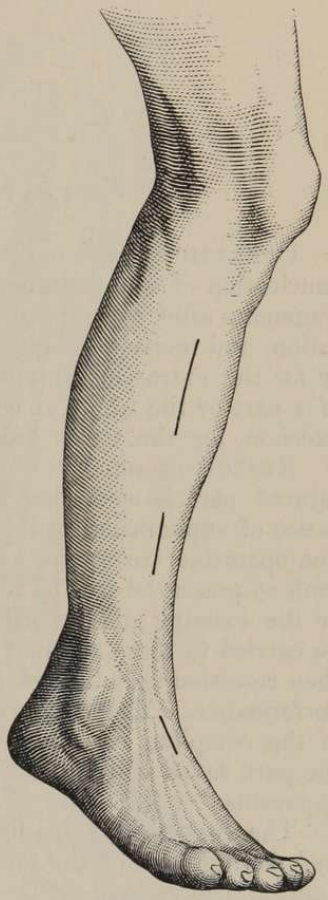
Fig. 1.—A, tendon of gracilis muscle; B, B, fascia lata; C, C, tendon of semimembranosus; D, tendon of semitendinosus; E, E, the two heads of gastrocnemius; F, popliteal artery; G, popliteal vein, joined by short saphena vein; H, middle branch of sciatic nerve; K, posterior tibial nerve, continued from middle branch of the sciatic, and extending to K*; L, posterior (short) saphena vein; M, M, fascia, covering gastrocnemius; N, short (posterior) saphena nerve, formed by union of branches from peroneal and posterior tibial nerves; O, posterior tibial artery, appearing from beneath soleus muscle in lower part of leg; P, soleus muscle, joining tendo Achillis; Q, tendon of flexor communis digitorum; R, tendon of flexor longus pollicis; S, tendon of peroneus longus; T, peroneus brevis muscle; U, U, internal annular ligament, binding down vessels, nerves, and tendons in hollow behind inner ankle; V, V, tendo Achillis; W, tendon of tibialis posticus muscle; X, the venæ comites of posterior tibial artery.

Fig. 2.—A, C, D, E, F, G, H, I, refer to same parts as in Fig. 1; B, inner condyle of the femur; K, plantaris muscle, lying upon popliteal artery; L, popliteus muscle; M, M, M, the tibia; N, N, the fibula; O, O, posterior tibial artery; P, peroneal artery; Q, R, S, T, U, V, W, refer to same parts as in Fig. 1; X, the astragalus.

leg, between the extensor communis digitorum and the extensor proprius pollicis. It has the anterior tibial nerve in the upper third of its course upon the outer side, in the middle third anterior to it, and in the lower third again upon the outer side.

The ligation of the anterior tibial may be accomplished in the lower part of the upper third of the leg. The **surface guide** is a line drawn half an inch from the inner side of the head of the fibula to a point midway between the two malleoli. The **muscular guide** is the outer margin of the tibialis anticus muscle. The incision should be made four inches in length along the line indicated by the surface guide (Fig. 449). The skin and superficial fascia are divided, and then the deep fascia upon a grooved director. The foot should now be strongly extended and everted, in order to make tense the marginal border of the muscular guide. This muscle must be separated by retractors from the extensor communis digitorum. The artery will be found lying upon the interosseous membrane, with the anterior tibial nerve in front of it or to its outer side. The two muscles are to be widely separated, the nerve drawn outward, the veins isolated from the artery, and the aneurysm needle passed from without inward.

FIG. 449.



Position and direction of the incisions which may be made to ligate the anterior tibial and dorsalis pedis arteries (MacCormac).

The anterior tibial artery can be ligated also above the ankle-joint. The **surface guide** is a line drawn in front of the ankle-joint midway between the two malleoli. The **muscular guide** is the outer edge of the extensor proprius pollicis. An incision is made along the linear and muscular guides, dividing the skin and superficial fasciæ. The tendon of the tibialis anticus is made taut by eversion of the foot, and the extensors by flexion of the toes and extension of the foot. The tendons of the two extensors are now separated by retractors, and the artery is felt pulsating in the intertendinous space, with the anterior tibial nerve upon the outer side. The needle is to be passed from without inward, avoiding the venæ comites and the nerve.

The DORSALIS PEDIS ARTERY (Pl. XXXIII) is a continuation of the anterior tibial artery, and its course would be indicated by a line drawn from a point midway between the two malleoli to the interosseous space between the great and second toes (Fig. 449). The **linear guide** to the artery is the prolongation of a line indicating the guide to the anterior tibial, and the **muscular guide** is the outer margin of the extensor proprius pollicis.

In ligating the dorsalis pedis artery the ankle-joint should be extended and the toes strongly flexed, which will bring out in relief the tendons which are to serve as a guide to the artery. The skin and superficial fascia are divided by an incision about three inches in length, and the above-mentioned tendons are separated by retractors after dividing the dense fascia attached to the extensor proprius pollicis. The artery will be felt pulsating at the bottom of

the wound, with the nerve lying upon the outer side and the venæ comites upon the two sides of the artery. The inner tendon of the extensor brevis digitorum crosses the dorsalis pedis artery, and this tendon must be retracted outward in order fully to expose the dorsalis pedis artery.

CHAPTER V.

OPERATIONS ON BONES AND JOINTS.

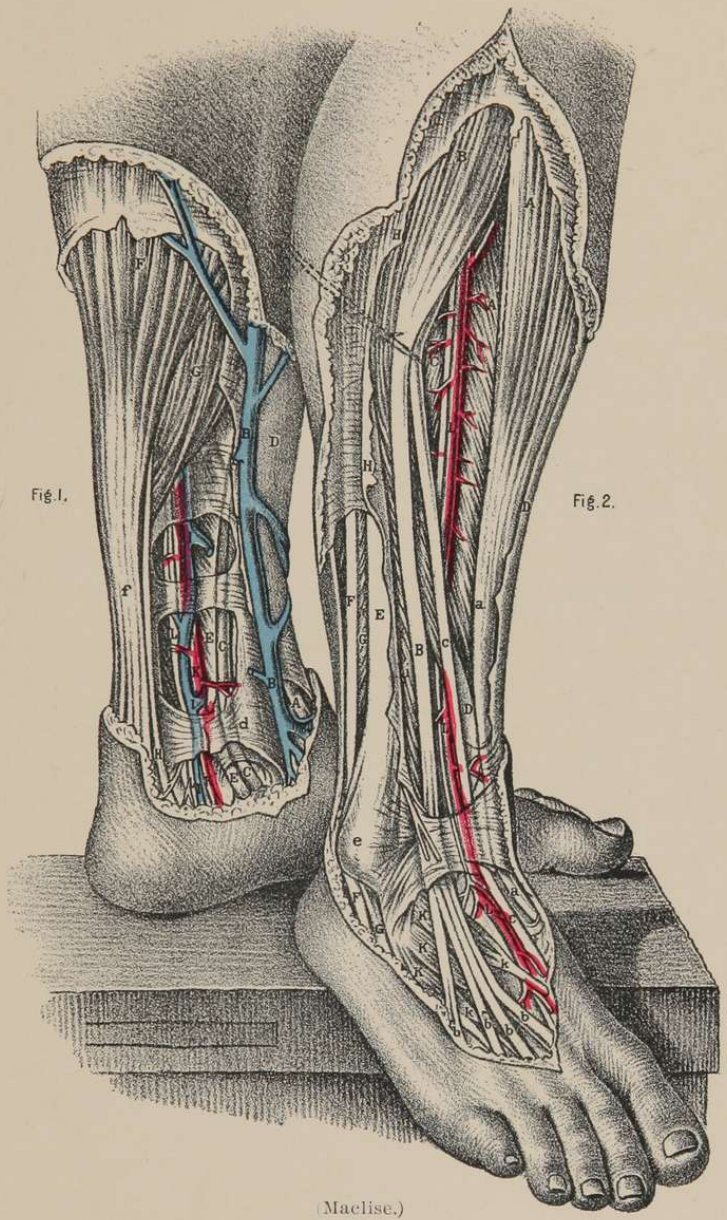
Operations on bones and joints are numerous and of many kinds—the enucleation of non-malignant tumors, the removal of sequestra, the wiring of fragments after fracture, division for the relief of deformity, trephining, aspiration, and incision to give exit to fluids, pus, blood, and excessive secretion, or for the extraction of foreign bodies, etc.; and especially the taking away of a part or the whole of a bone or a joint for injury or disease—resection or excision, for the terms are commonly used interchangeably.

Resection or Excision.—Whenever the condition of the diseased or injured part is such that life will be seriously imperilled by the long continuance of suppuration and protracted confinement that must be associated with non-operative treatment, or when the functional value of the articulation or limb so preserved will be but slight, or the resulting deformity will be great, or the existing disease in all probability will extend to contiguous parts or be carried to those at some distance, or when amputation is the alternative,—then resection is indicated, provided the condition of the patient permits of its performance. The danger of its execution is not excessive; the likelihood of the complete removal of the disease is in many cases at least fair; and the part saved will be serviceable, or can be rendered so by the aid of some apparatus.

The *Instruments* required for its performance are knives and scissors for such laying open of the soft parts as may be necessary to uncover the bone or joint and to remove infected tissues; retractors to keep the field of operation exposed; saws and cutting forceps for division of bone; gouge forceps, sharp spoons, chisels, and hammer for the removal of limited portions of bone; elevators and periosteotomes for removing the periosteum; drills and pins and sutures of wire or other suitable material for the after-fixation of the parts if this be necessary; and the ordinary instruments and dressings for closing wounds. Barker's sharp spoon, which permits the flushing of the field of operation through its hollow handle, will often be found of much service. The Esmarch bandage is generally useful, but in some of the operations it cannot be employed, and in others is of doubtful value because of the great amount of after-oozing. As generally for a considerable length of time immobilization of the limb will have to be secured, splints of special form may be required.

Whenever practicable—and this is almost always the case—the operation should be performed antiseptically and the strictest antiseptic after-treatment employed, the mortality thus being reduced to a minimum, early union secured, the general strength of the patient economized, and the inconvenience and risk of frequent dressing saved to both operator and patient. Whenever it can be done the periosteum should be lifted off the bone, not in shreds, but in as complete a sheet as possible, and preserved, that regeneration more or less complete

PLATE XXXIII.



(Maclise.)

Fig. 1.—A, tendon of the tibialis anticus muscle; B, long saphena vein; C, C, tendon of the tibialis posticus muscle; D, the tibia; *d*, the inner malleolus; E, E, tendon of the flexor longus digitorum muscle; F, gastrocnemius muscle; *b*, tendo Achillis; G, soleus muscle; H, tendon of the plantaris muscle; I, I, the venæ comites; K, K, posterior tibial artery; L, L, posterior tibial nerve.

Fig. 2.—A, tibialis anticus muscle; *a*, its tendon; B, extensor longus digitorum muscle; *b*, *b*, *b*, *b*, its four tendons; C, extensor longus pollicis muscle; D, D, the tibia; E, the fibula; *e*, the outer malleolus; F, F, tendon of the peroneus longus muscle; G, G, peroneus brevis muscle; *i*, the peroneus tertius; H, H, the fascia; K, extensor brevis digitorum muscle; *k*, *k*, its tendons; L, L, anterior tibial artery, and nerve descending to the dorsum of the foot.

according to circumstances may take place. Such **subperiosteal resection** may commonly be done in cases of disease, but in cases of injury, especially if recent, it will frequently, if not generally, be found impossible to effect it.

In all cases the least possible injury should be done to the soft structures consistent with due exposure of the part to be operated upon, the muscles being divided longitudinally rather than cut across, and important vessels and nerves avoided or pushed aside. Hemorrhage should be temporarily controlled by forceps, as, speaking generally, it is inadvisable to spend time in the application of ligatures, as at the close of the operation many of them will be found unnecessary.

When the bone is removed, not because it is diseased, but in order to get at deeper-seated parts, as in certain operations upon the jaws and in the skull, it may be separated only in part, to be later replaced and attached—the so-called **osteoplastic resection.**

When the excision is of a part of the shaft of a bone, it is one in **continuity**; when of an articular extremity, in **contiguity.** Speaking generally, operations in continuity are much less satisfactory than those in contiguity; and this is particularly true if they be done upon the femur and the humerus. Non-union has not seldom been observed, and an ununited fracture of the thigh is a great inconvenience—much more so, of course, than one of the arm, though this is troublesome enough. Besides this, in the thigh the resulting shortening may much disable the patient.

In the forearm and leg, when one bone only is operated upon and any considerable piece is taken away, the ends of the fragments cannot be brought together, and the re-formation necessary to fill in the gap is apt to be imperfect: often it is so in an extreme degree. **Bone-grafting** as now done promises something toward the filling up of such defects, but how much may be accomplished by it the future must determine. Compensatory overgrowth of the other bone may, and often does, render the limb a serviceable one, but there has frequently been observed, especially in the forearm, a gradually produced deformity at once unsightly and crippling. It is much better in these cases to cut out so much of the other healthy bone as will enable the operator to bring the fragments of both bones into proper apposition. Very generally, when the case is one of injury, informal removal of detached fragments, with, if necessary, the cutting off of sharp ends of the others, gives a much better ultimate result than resection in continuity.

When in an excision in contiguity the entire articulation is removed, it is *complete;* when the end of only one bone or a portion thereof, *partial.* At times an entire bone is taken away. When the excision is done in a regular way and after some established method, it is a *formal* or *typical* one; when partial and adapted to the peculiar condition of the particular case, *informal* or *atypical.* If performed for injury and within a few hours after its receipt, it is **primary**; when in the period of local and general disturbance accompanying and following reaction and before the occurrence of suppuration, **intermediary**; when, without regard to the nature of the cause, after suppuration has become established, **secondary.** Under ordinary circumstances intermediary operations should not be done.

When in a limited portion of the shaft a tumor is present, if non-malignant it should be shelled out and the healthy bone preserved; if malignant, the *entire bone* should be resected or the limb amputated or the case left unoperated upon, according to circumstances.

In joint resections the question of partial or total excision will be settled by the nature and extent of the cause and the probable functional value of the

limb after one operation or the other. If there has been received an injury affecting a part of the articulation, that part only should be removed, provided the ultimate usefulness of the joint will be as great as if complete resection had been done. The rule to sacrifice nothing unnecessarily holds good, and late experience of the results of improved wound-treatment has been favorable to partial excisions and those of informal character.

But if the case is one of disease almost certainly tubercular, will partial removal get rid of the entire disease? If the lesion is confined to one bone, there is no reason for complete excision unless a better result functionally can thus be secured; but it is generally the case, at least in the elbow, knee, wrist, and ankle, that by the time the operation is warranted the tubercular deposit is not thus limited, and complete removal in those joints will usually be best. Infected synovial and perisynovial tissues must always be thoroughly removed; and it is in doing this that much of the difficulty of the operation often lies, and the failure to accomplish it is the frequent cause of relapse.

The **prognosis** has of late years become very good, certainly so far as recovery from the operation is concerned. Until the introduction of antisepsis the mortality was heavy from exhaustion, septic infection, amyloid disease of the kidney or intestines, tubercular meningitis, or tuberculosis of the lungs, often greatly aggravated by the resection and its direct results. At the present time the patient is not likely to die if in any fit condition for operation and if properly protected against the dangers of suppuration.

A thoroughly aseptic excision is almost certain to be followed by prompt healing, even if there is coexisting tubercular disease in another joint or bone or in the lung, and improvement, greater or less, of longer or shorter duration, in the condition of such other part may be expected to follow. If the tubercular deposit is not thoroughly removed, the recovery will be incomplete; sinuses will remain, necessitating reopening and scraping; or the apparently healed wound will reopen, or the disease will so extend in the bone and soft parts as to compel amputation; or a general dissemination of the bacilli, at times set free by the operation itself, may occur and speedily cause death. The large majority even of those successfully operated upon die before many years, commonly of pulmonary tuberculosis.

ARTHRECTOMY OR ERASION.

The ideal operation in cases of tubercular joint disease is one in which *all* unhealthy tissue is taken away and all healthy tissue left undisturbed. This cannot be the case when excision is done, since more or less unaffected tissue must be removed: often the error will be in both directions, and some infected tissue will be left.

Erasion is a better term than arthrectomy. The latter term should be restricted to complete extirpation of the synovial membrane and diseased periarticular structures, leaving the bone untouched—an operation which is necessarily of limited application. Erasion is intended exactly to satisfy the requirements, to cut away and with sharp spoon to scrape away the tubercular material present in membrane, ligament, and bone, and nothing more.

If it were possible to ascertain before or at the time of operation just where the tubercular deposits were and their full extent, erasion would afford complete relief, or at least relief as complete as can be effected in a case of local tuberculosis, since there must always be a chance of operative dissemination or of coexisting tubercular disease in near or remote parts. It is not possible, however, to do this, although much can be learned by inspection, by

pressure through the soft parts or directly upon the exposed bone (limited tenderness, which is often pathognomonic, being thus discovered), or by puncture, diminished resistance indicating localized softening, due, it may be safely concluded, to disease.

But while it is true that erasion may not accomplish the desired object, the considerable experience of many surgeons in various parts of the world in the last few years has shown that both in children and in adults thorough cleaning out by knife, scissors, and spoon will, in a large proportion of cases, be followed by highly successful results, even to the preservation of the function of the articulation operated upon. The operation may be done much earlier than an excision is likely to be performed, it is less severe, and if unsuccessful the major operation, typical resection, is still in reserve, can be readily executed, is attended with no more risk than if primary, and if delayed by the erasion until after full growth of the limb has been secured, the ultimate shortening is much less.

In doing an erasion the joint must be fully opened, and that method of incision is the best which most completely and with least injury to the parts permits of thorough exploration, since success can be looked for only after removal of all, or nearly all, of the diseased tissue, although without doubt very small portions of tubercular material can be spontaneously got rid of by degeneration and cicatrization or by encapsulation.

Most of the arthrectomies have been done upon the knee-joint. The term arthrotomy is at times, but improperly, employed as synonymous with erasion or arthrectomy. If used at all, it should be in its proper sense, to indicate simple incision of a joint, without regard to the purpose or extent of the opening.

OSTEOTOMY.

Division of a long bone for the relief of deformity is, as a rule, easy of performance, is attended with but little danger, and is satisfactory in result. The section is ordinarily a linear one, but it may be cuneiform, a wedge being removed (Fig. 450), or trochleiform, the section being a curved one.

Generally it is done subcutaneously, the incision down to the bone being only large enough to admit of the ready passage of the saw or chisel employed, or even this may be omitted and the chisel driven in ; but at times the portion of bone to be operated upon is fully exposed, and with aseptic precaution this open method is attended with little or no more risk than the other. Either saw or chisel may be employed, the latter being generally preferred, as being more under control, easier to use, and making no dust. Two or three chisels of different sizes may be used in dividing the bone, or a single one, according to the preference and habit of the operator. Of saws, the choice lies between the chain saw and the narrow stiff one, and ordinarily the latter will be selected. A sand-bag to rest the limb on will much facilitate the operation. Complete instrumental division of the bone need not be made, as a thin portion of the surface opposite the point of entrance can readily be broken, and the risk of injury to the soft parts by the chisel or saw avoided.

The **dangers** are two—septic inflammation and wounding of important nerves or blood-vessels, especially the latter. The former will be prevented by antisepsis or asepsis during the operation and after-treatment; the latter by care at the time of the section, though the accident has happened in the practice of even the most prudent and skilful operators. When it does occur, the existing conditions will determine whether it is better to let the damaged part alone or to cut down and suture the nerve or tie the vessel. The bone

having been divided, rectification of the malposition should be effected at once, an aseptic dressing with an abundance of cotton placed around the area of ope-

FIG. 450.

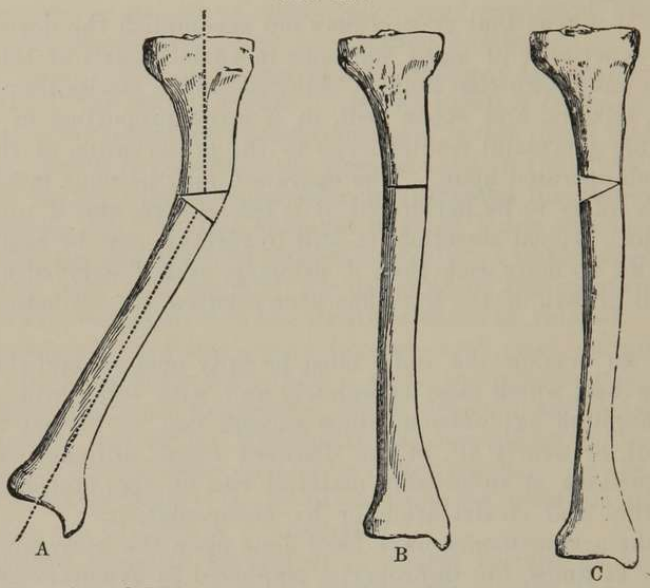
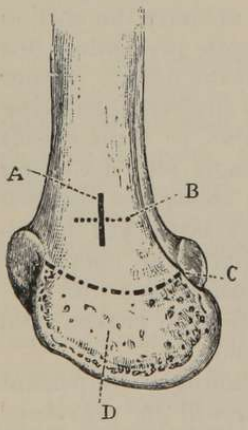


Diagram representing a Curved Tibia: *A*, with a wedge removed for the purpose of straightening the bone; *B*, the same with the bone straightened; *C*, the same with the bone simply divided and straightened, thus necessarily leaving a gap in the bone (Treves, after Little).

ration, and the limb immobilized by a plaster-of-Paris dressing or a splint for a number of weeks—four to eight or more according to the age of the patient and the kind and locality of the operation. Unless the wound becomes infected there are not, at any time, constitutional symptoms of serious import.

OSTEOTOMY FOR GENU VALGUM.—One of the most useful of these osteotomies is Macewen's **supracondyloid osteotomy** for genu valgum. The patient lies recumbent, with the leg flexed upon the thigh and the abducted thigh flexed upon the pelvis, and laid upon its outer side, on a sand-pillow. The surgeon stands upon the outer side of the patient. Macewen's description of his operation is as follows: "A sharp-pointed scalpel is introduced on the inside of the thigh, at a point where the two following lines meet, one drawn transversely, a finger's-breadth above the superior tip of the external condyle, and a longitudinal one drawn half an inch in front of the adductor magnus tendon. The scalpel here penetrates at once to the bone, and a longitudinal incision (Fig. 451, *A*) is made, sufficient to admit the largest osteotome and the finger, should the surgeon deem it necessary. Before withdrawing the scalpel the largest osteotome is slipped by its side until it reaches the bone. The scalpel is withdrawn, and the osteotome, which was introduced longitudinally, is now turned transversely in the direction required for the osseous incision (Fig. 451, *B*). In turning the osteotome too much pressure must not be exerted, lest the periosteum be scraped off. It is then convenient to pass the edge of the osteotome over the

FIG. 451.



Macewen's Operation for Genu Valgum: *A*, skin incision; *B*, osteotome incision; *C*, epiphyseal line; *D*, inner condyle (Treves).

bone until it reaches the posterior internal border, when the entire cutting edge of the osteotome is applied, and the instrument is made to penetrate from behind forward and toward the outer side.

"After completing the incision in that direction, the osteotome is made to traverse the inner side of the bone, cutting it as it proceeds, until it has divided the uppermost part of the internal border, when it is directed from before backward toward the outer posterior angle of the femur.

"In cutting on these lines there is no fear of injuring the femoral artery. The bone may be divided without paying heed to this order of procedure, but it is better that the operator should have a definite plan in his mind, so that he may be certain as to what has been divided and what remains to be done. The writer is persuaded that accidents have happened by not paying heed to this. In using the osteotome the left hand, in which it is grasped, ought to give, after each impulse supplied by the mallet, a slight movement to the blade —not transversely to its axis, but longitudinally—so as to prevent any disposition to fixity which it might assume.

"After the inner portion of the bone is divided a finer instrument may be slipped over the first, which is then withdrawn; and even a third, if necessary, may take the place of the second when the outer portion of the bone comes to be divided. Whether one or more osteotomes be used depends much on the resistance met with. If the tissue is yielding, one may suffice; if hard or brittle, two or three will effect the division more easily and with less risk of breaking or splitting the bone longitudinally. In the adult the dense circumferential layer of bone resists the entrance of the osteotome at the outset, but several strokes cause the instrument to penetrate this superficial dense portion, when it will pass easily through the cancellated tissue.

"After a little experience the surgeon recognizes, by touch and sound, when the osteotome meets the hard layer on the outer aspect of the bone. If it be considered desirable to notch or penetrate this outer dense part of the bone, in doing so the osteotome ought to be grasped firmly by the left hand, the inner border of the hand resting on the limb, so as to check instantly any impetus which may be considered too great. It is better to snap or bend this layer rather than cut it.

"When the instrument is to be altered in position, it ought not to be pulled out in the ordinary way, as it is then liable to be removed from the wound in the soft parts, as well as from the bone. Instead, let the left hand, with its inner border resting on the limb, grasp the instrument, while the thumb is pressed under the ridge afforded by the rounded head, and gently lower the osteotome outward by an extension movement of the thumb. In this way the movement may be regulated with precision. It is desirable to complete all the work intended by the osteotome before removing it from the wound.

"When the operator thinks that the bone has been sufficiently divided, the osteotome is laid aside and a sponge saturated in 1 : 40 carbolized watery solution is placed over the wound. While the surgeon holds the sponge he at the same time employs that hand as a fulcrum, while with the other he grasps the limb lower down, using it as a lever, and jerks if the bone be hard, or bends slowly if the bone be soft, in an inward direction, when the bone will snap or bend as the case may be.

"No drainage-tube is required, and sutures need not be employed. The wound is dressed antiseptically, the extremity is put up in a splint which corrects the deformity, and the case is treated like an ordinary compound fracture."

Osteotomy for Ankylosis of the Hip-Joint.—In certain cases of diseases of the hip-joint ankylosis results, with faulty position (flexion) of the

limb. Osteotomy may be required to correct the deformity and bring the limb into a straight position.

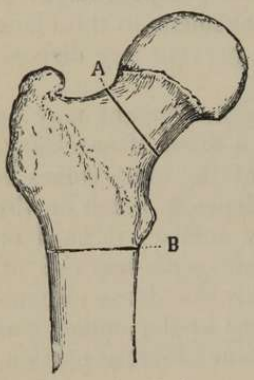
The section of the bone may be made through the neck or through the shaft just below the lesser trochanter.

Osteotomy through the Neck of the Femur.—1. *With a saw (Adams's Operation).*—Mr. Adams describes this procedure as follows:

"The left thumb is placed firmly so as to compress the soft tissues solidly against the bone at a point situated at the center of the top of the great trochanter and the breadth of one finger above it.

"At this point the narrow-bladed knife is pushed in till it reaches the neck of the femur, at a right angle across the front of which it is then carried (Fig. 452, *A*). The knife is then gently moved to cut a space for the easy insertion of the saw, which, traversing the course of the knife, reaches the front of the neck of the femur, and gradually cuts it completely through. The surgeon cuts until he feels that the saw is free of the bone, and moving it in the soft tissues only behind the bone." The limb is to be at once straightened, and in order to do this it will often be necessary to cut with a tenotome, under strict aseptic precautions, the contracted tendons. The wound is dressed antiseptically, and the limb is maintained in extension by the extension apparatus of Buck or by the long external splint of Desault.

FIG. 452.



Osteotomy for Faulty Ankylosis of Hip: *A*, intracapsular (Adams's operation; *B*, extra-capsular, Gant's operation (Treves).

"2. *With the Osteotome.*—A longitudinal incision is to be made, penetrating to the bone and about ¾ inch in length, in the axis of the femoral neck and just above the summit of the great trochanter. The osteotome is pushed in alongside of the knife, which is now withdrawn, and the osteotome is turned so that its edge is at right angles to the axis of the femoral neck. The neck is now divided by striking with a mallet. The dressing is the same as above indicated."

Osteotomy through the Shaft, just below the Lesser Trochanter (*Gant's Operation*).—The osteotome should be employed in Gant's operation, though the saw can be used. A longitudinal incision is made over the outer aspect of the femur at the level of the lesser trochanter (Fig. 453, *B*), the osteotome is introduced and turned on its axis, as described in the previous operation, and the bone is divided just below the level of the lesser trochanter. The straightening and dressing are to be done in the same way as after Adams's operation.

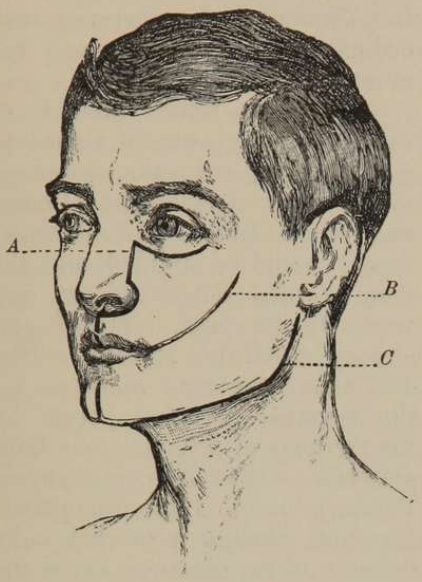
SPECIAL EXCISIONS.

UPPER JAW.—The upper jaw may be removed because of existing disease, non-malignant or malignant, sarcomatous or carcinomatous, or to facilitate the removal of retro-maxillary tumors. Though the operation is a bloody one, it is remarkably free from danger, reunion of the soft parts is rapid, and the resulting deformity is slight and capable of much relief by the application of a dental plate. When done for sarcoma, a cure may often be effected or recurrence is long postponed; and if for carcinoma, life may be made more comfortable, though perhaps not prolonged, or, it may be, even somewhat shortened.

The bone is best exposed by an incision over the infraorbital ridge from the malar bone to near the internal canthus, then along the side of the nose around the ala to the median line, and down through the central part of the

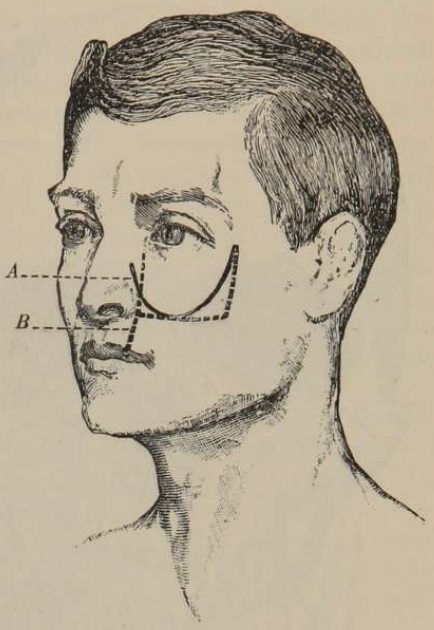
upper lip (Fig. 453, *A*). This cut (Fig. 453, *B*) also shows the incision of Velpeau, which is carried through the cheek from the angle of the mouth to the

Fig. 453.



Excision of the Upper Jaw: *A*, by a median incision; *B*, by Velpeau's method; *C*, excision of the lower jaw (Treves).

Fig. 454.



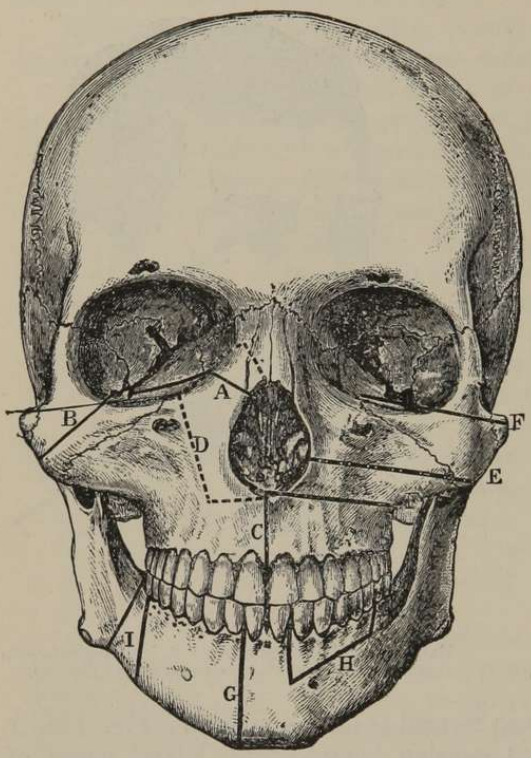
Excision of the Upper Jaw: *A*, by Langenbeck's method; *B*, by Gensoul's method (Treves).

center of the malar bone. The flap so formed is drawn inward. Fig. 454, *A*, shows Langenbeck's operation. This incision begins on the lateral aspect of the nose at the junction of the nasal bone with the cartilage, and is terminated by sweeping upward and outward to the middle of the malar bone. It forms a U-shaped flap, with the convexity downward, reaching as far as the junction of the cheek and upper lip. Fig. 454, *B*, shows the incision of Gensoul of Lyons, who was the first successfully to remove the upper jaw. The flap thus outlined by any of the above methods is dissected off the bone and the free hemorrhage arrested by hemostatic forceps, pressure, and hot water. With a fine saw or the cutting forceps, preferably the former, the malar bone itself is cut through (Fig. 455, *B*), and later the ascending process close to its junction with the frontal (Fig. 455, *A*). After median division of the mucous membrane of the roof of the mouth back to the soft palate with the knife, and laterally between the hard and the soft palate, the horizontal plates of the two maxillæ are separated from above downward with the saw or cutting forceps (Fig. 455, *C*). The bone can then be removed with the lion forceps, the pterygo-maxillary union readily yielding, or if, as not seldom happens in cases of malignant disease, the posterior wall is left behind, it can be easily seized and brought away. When not diseased, and when its removal is not required in order that sufficient room may be secured for necessary further work, the orbital or alveolo-horizontal plate may be left, the bone being sawn across just below the one or above the other; but it is generally necessary to take away at least the latter.

Bleeding vessels, if necessary, having been tied and general hemorrhage stopped (in which the cautery is often very useful), the soft parts are to be apposed as accurately as possible along the line of incision and secured by the requisite number of fine stitches, the cheek-cavity filled with cotton or gauze

plugs, if required either to prevent oozing or to support the flap, and antiseptic gauze and cotton applied externally and secured by a light bandage. Primary union usually takes place. When only the lower part of the bone is to be removed, the operation may ordinarily be done through the mouth.

Fig. 455.



Saw incisions in the maxillæ: *A*, *B*, *C*, excision of the upper jaw; *D*, Poeckel's operation (nasal polypus); *EC*, Guérin's operation (partial excision); *F*, *F*, Langenbeck's operation (nasal polypus); *G*, excision of lower jaw; *H*, removal of portion of alveolus; *I*, Esmarch's operation, ankylosis of lower jaw (Treves).

If done to render possible or easy the taking away of a pharyngeal growth, only the upper or inner bony attachments (malar and frontal, frontal and intermaxillary) should be divided, and the bone turned downward or outward, to be later replaced and almost certainly reunite. Fig. 455 shows the long incisions for the removal of nasal polypi by the methods of Poeckel and Langenbeck. (See Naso-pharyngeal Polyp, p. 593.) Such osteoplastic resection, though somewhat more difficult of performance, saves the deformity and later application of a plate, which are necessarily connected with the ordinary complete removal of the upper jaw. The soft parts need not be removed from the bone, but only incised at the point. Where they remain attached externally, they are utilized as a "hinge."

Lower Jaw.—Resection of this bone may be in continuity, or of one half or of the whole, for injury or for disease. If in continuity and on one side, it can often be readily effected through the mouth, the soft parts being carefully cleared away and the bone divided with the straight or chain saw, or in an informal way with the cutting and gouge forceps. Extensive operations in continuity or involving a half or all of the bone should be done through an external incision of sufficient length, and just below the lower border of the bone, with or without central division of the lower lip and soft parts of the chin according to circumstances (Figs. 453, *C*, 455, *G*). If the middle portion is taken away, as all the attachments to the genial tubercles are severed, dropping back of the tongue must be guarded against by passing a ligature through it until sufficiently strong adhesions of the soft parts have formed to prevent the occurrence of such an accident.

In resecting the half or the whole of the lower jaw, after separation of the soft parts, external and internal, well back toward the angle, the bone is divided in the middle line (Fig. 455, *G*), and firmly held off while the further separation of the soft parts is continued up to and including the coronoid process, after which disarticulation can be readily effected, either by dragging or by a few cuts with knife or scissors kept close upon the condyle. When performed for disease the periosteum should be preserved as far as possible, unless the disease

is malignant; and whenever the object of the resection can be secured by sawing through the body or at the bases of the processes, division at such level should be made.

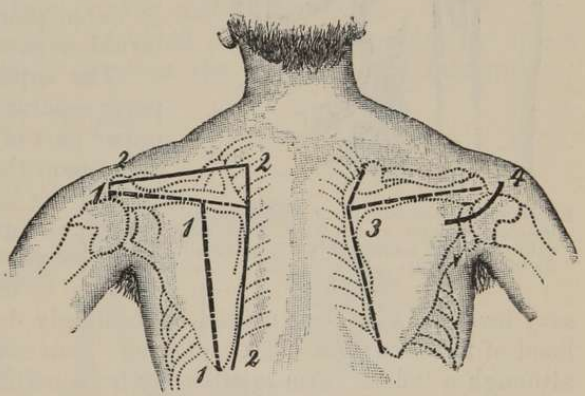
CLAVICLE.—A part or the whole of the clavicle may be removed for disease, generally sarcoma. Exposure is made by a longitudinal incision, the soft parts dissected off carefully, but as rapidly as possible, the bone divided internally to the affected area or separated at the sternal junction, lifted up and cleared posteriorly as far as may be necessary toward or to the scapular attachment, and there sawn through or disarticulated. The hemorrhage, often very great when operating for malignant disease, is to be temporarily checked as the operation proceeds by the application of hemostatic forceps. By keeping close to the bone and the diseased mass there is little danger of wounding the important deep vessels and nerves. Provision for drainage having been made, the edges of the external incision are to be brought together and sutured, an antiseptic dressing applied, and the arm securely fastened to the side. If septic infection is prevented, death, if it follows, will be from shock or hemorrhage or later from recurrence of the malignant affection.

When done for cause other than malignant and the periosteum has been saved, regeneration, at times quite perfect, may be reasonably expected.

SCAPULA.—Removal of the shoulder-blade, partial or complete, may be rendered necessary or advisable on account of necrosis following injury or of the presence of a tumor benign or malignant, the latter cause indicating complete resection, although occasionally a partial operation has not been followed by recurrence. When done for necrosis the operation is comparatively simple and easy; when for osteo-sarcoma, it is not seldom difficult and dangerous.

In complete resection a single vertical incision may be made on a line a little posterior to the middle of the spine, and the soft parts reflected forward and backward (Fig. 456, vertical line of 1); or, better, an incision along the whole posterior border, inclined forward at the upper end and forward and upward for a short distance at the lower end, following the anterior border, with usually an associated one over the course of the spine. Fig. 456 shows the incisions of Syme, Langenbeck, and Collier for extirpation of the scapula, as well as the incision for resection of the glenoid cavity of the scapula. The overlying soft parts having been turned aside, and the spinal muscles saved or left attached to the bone according as the resection is not or is for malignant disease, the superior angle and adjacent upper border is freed from its attachments, then the posterior border and inferior angle, the knife being constantly kept as close as possible to the bone. Lifting up the scapula, its anterior surface is cleared, and then the anterior border toward the glenoid fossa, the dorsal and subscapular arteries being tied when reached. The acromion process being freed, the attachments of the scapular muscles divided close to the humerus, and the coracoid process separated from its liga-

FIG. 456.



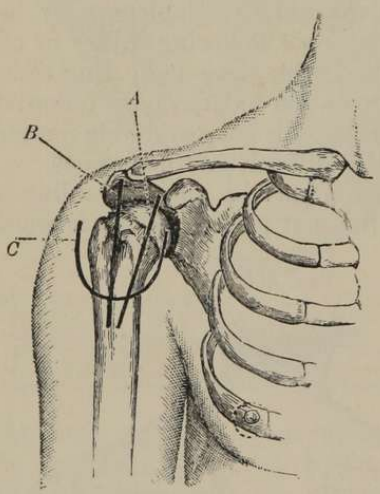
Extirpation of the Scapula: 1, after Syme; 2, after Langenbeck; 3, after Collier; 4, incision for resection of the glenoid cavity of the scapula (Tillmanns).

ments and muscles, only the region of the glenoid fossa remains to be cleared, after which the bone is lifted out, hemorrhage arrested, drainage provided for, the flaps adjusted and united, and an ordinary compressing and retaining dressing applied. By such method of operating control of hemorrhage is well secured.

Shoulder.—Resection of the shoulder—or rather, in the great majority of cases, of the head of the humerus—has generally been for severe injury, especially gunshot, rarely for the compound fractures of civil life, occasionally for the relief of deformity, as that following unreduced luxation or badly-united fracture of the neck of the humerus, and at times, though but seldom, for chronic joint disease, from which this articulation is in an extraordinary degree exempt. Under the present method of wound-dressing purely conservative treatment, with the informal removal of completely detached fragments when necessary, may commonly be expected to give good results, better, indeed, than those after typical excision.

It may be done by a single straight incision from above downward (Fig. 457, *B*), or by a flap raised from the anterior surface (Fig. 457, *C*), the former method being much the better, as it inflicts little damage upon the muscles, and leaves, in consequence, a more useful arm, though occasionally, because of the nature and extent of the original injury, the deltoid has been so wounded that little additional violence will be done it in forming a flap. Generally the cut is made directly down to the bone in a line from the middle of the acromion to the center of the deltoid insertion, separating rather than cutting the muscular fibers, though it may be carried from the inner (Fig. 457, *A*) or outer point of the acromion along the internal or external border of the deltoid.

Fig. 457.



Excision of the Shoulder: *A*, incisions of Baudens, Hueter, and Collier; *B*, vertical incision of Langenbeck; *C*, Morel's incision (Treves).

The capsule is then opened and the soft parts separated from the tuberosities and the upper part of the shaft, the knife being kept close upon the bone, especial care being taken to turn the long head of the biceps uninjured out of its groove. The head of the bone having been luxated through the incision, division is made with the saw at the necessary level, no lower down than is absolutely demanded, in order that the likelihood of the occurrence of a "dangle" joint may be reduced to a minimum, for although a "flail" arm is often far from being a useless one, either without or with the aid of an apparatus, yet if recovery can be secured with close approximation of the upper end of the humerus to the scapula, it is much better.

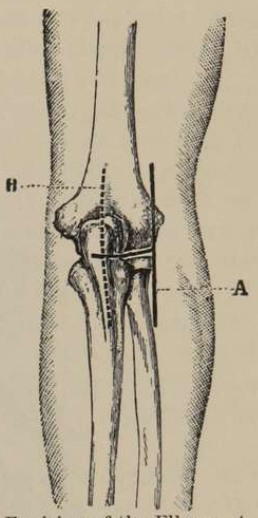
The operation may be done subperiosteally, the periosteum being divided longitudinally and then transversely at the level of the section of the bone, and turned aside, and the tuberosities chipped off, carrying with them the uninjured muscular insertions. In old luxations, as the vessels are pushed backward and inward, the incision can safely be made along the border of the coracobrachialis muscle.

If necessary, though such is seldom the case, the glenoid fossa may be removed by saw or forceps, the attachment of the long head of the biceps being, if possible, preserved by separating a scale of bone or stripping off

the periosteum. The ordinary antiseptic dressing having been applied, the parts are held in place by a bandage, or, better, by an immobilizing plaster splint or casing, carried well up over the top of the shoulder and retained by a bandage passed under the opposite axilla.

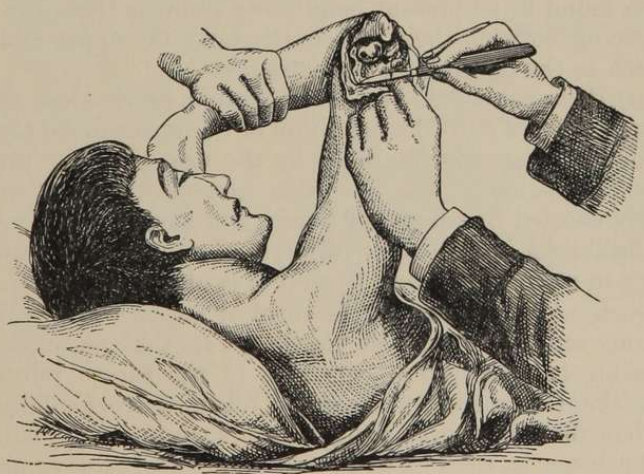
Elbow.—Resection of the elbow is called for in certain cases of compound fracture, gunshot or other, of tubercular disease, of old unreduced luxation, or of bony ankylosis. It may be done in various ways, all or nearly all, however, modifications more or less diverse of the method by a single longitudinal incision, central or lateral, with or without a transverse incision (Fig. 458); or of that by two lateral incisions, with a connecting cross-cut—H-shaped—the former being generally preferred. Cutting down upon the posterior surface of the joint in the median line from a point a couple of inches above the articulation to one at or slightly below the line of junction of the olecranon with the shaft, or along the outer border of the triceps to the level of the epicondyle, and then downward and inward across the olecranon, the capsule is opened and the soft parts dissected off on each side (subperiosteally, if possible) until the condyles have been well uncovered, special care being taken to save uninjured the ulnar nerve. After flexion of the forearm the lower end of the humerus is cleared (Fig. 459), pushed out through the wound, and sawn off (Fig. 460); and then the upper ends of the ulna and of the radius are treated in like manner. Instead of dissecting the soft parts from the epicondyles and the upper edge of the olecranon, these bony surfaces may be chiselled off and turned aside with their muscular attachments undisturbed. If the amount of bone removed is so great that a movable joint is not likely to be secured, the sawn surfaces may be wired or pinned together, or a sort of mortise and tenon may be made between the ulna and the humerus.

Fig. 458.



Excision of the Elbow: *A*, Roux's incision; *B*, median vertical incision (Treves).

Fig. 459.

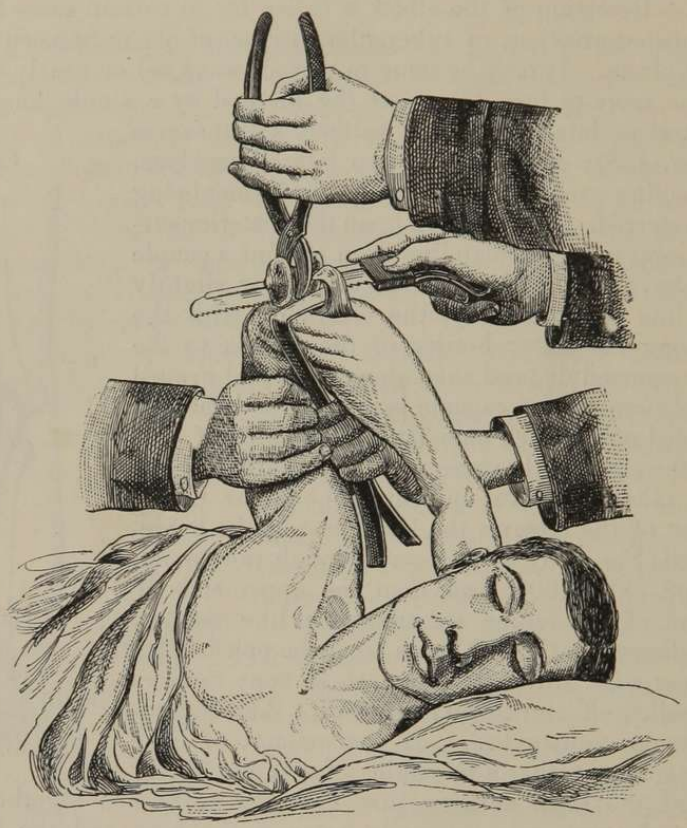


Excision of the Elbow: the clearing of the humerus (Treves).

If there has not been much of the bones excised, restoration of the func-

tions of the elbow to a greater or less extent may be expected, so complete at times as to permit of the hand being laid upon the shoulder. In a few cases

FIG. 460.



Excision of the Elbow: sawing of the humerus (Treves, after Farabeuf).

in which years after the resection an examination of the elbow has been made, there have been found to be present bony down-growths from the sides of the humerus, embracing between them and buttressing the upper end of the ulna and radius, much as the malleoli do the astragalus.

When the portion excised has been considerable, unless close approximation is made and maintained a flail-like condition of the arm will be produced, capable, however, of being greatly improved by the use of proper prothetic apparatus. At the completion of the operation immobilization should be made, readily and fully effected by plaster of Paris, and maintained for six, eight, or more weeks if ankylosis is sought for (always, of course, at a right angle, or a little less, never in extension); but if motion is aimed at, passive movements should be commenced by the end of the third or fourth week. When done in the hope of bony ankylosis, care should be taken that as much of the periosteum as possible is preserved in the area of the future joint.

At times in these cases simple osteotomy, linear or trochleiform, will relieve the difficulty, but there is always danger that such operation will be followed by fusion of the bones in spite of early and methodical passive motion.

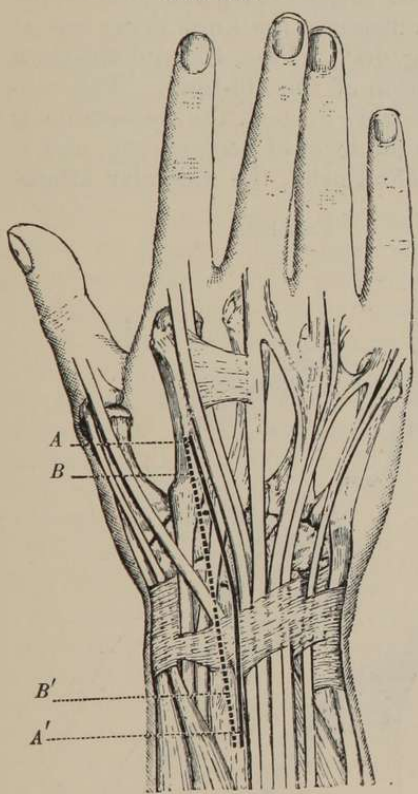
Old unreduced luxations may be treated by complete or partial excision, access to the joint being readily had through an incision across the back of the joint with division of the olecranon at its base, this process being reflected with

the soft parts and later replaced and wired. Oftentimes, after subcutaneous section of the olecranon, reduction of the luxation can be effected, passive motion securing a lax fibrous attachment of the separated process which later allows of the ordinary movements of the joint. As is true of compound fractures of all joints, treatment by resection after this injury at the elbow is now much less frequently required than formerly.

WRIST.—Resection of the wrist is occasionally done because of extensive injury, mainly of the lower end of the bones of the forearm. Ordinarily, however, it is necessitated by tubercular disease, which always chiefly affects the carpus. The best method of operating must vary according as the excision is for injury or for disease. In the former case lateral incisions carried but a little distance, or perhaps not at all, below the joint level will give ready access to the bone and permit of easy removal, with slight danger to the soft parts.

It is widely different with the operation for disease. The carpal bones cannot thus be readily reached nor thoroughly extirpated without serious risk to vessels and nerves. One of three methods will commonly be selected: a single long dorsal median incision, or two incisions placed laterally over the back of the wrist, or a transverse straight or curved division of the structures covering the posterior surface of the carpus, the last affording readiest access to the diseased bones, but objectionable because of the necessary section of the tendons—an objection, however, of much less weight now than formerly, since after their suture early and functionally perfect repair can be secured.

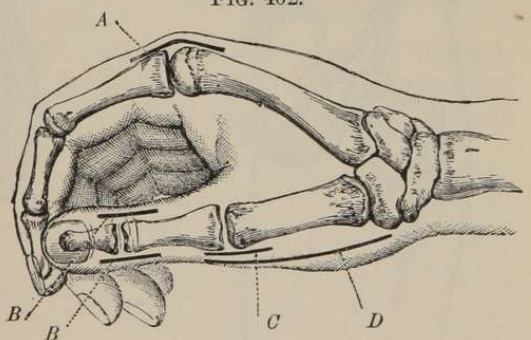
FIG. 461.



Excision of the Wrist: *A A′*, Collier's incision for radial side; *B B′*, Boeckel's incision (Treves).

The method by a single incision will generally be preferred, being easier of execution and less disturbing to the tendons than the others. A very convenient form of the incision consists in carrying it from the middle of the radial border of the metacarpal bone of the index finger upward between the tendon of the long extensor of the thumb and that of the extensor indicis

FIG. 462.



A, excision of metacarpo-phalangeal joint; *B B*, excision of interphalangeal joint of the thumb; *C*, excision of metacarpo-phalangeal joint of the thumb; *D*, excision of first metacarpal bone (Treves).

to the dorsum of the radius between the extensor indicis and the short radial extensor of the wrist, the soft parts covering the carpus being carefully lifted and turned aside, subperiosteally as far as possible (Fig. 461).

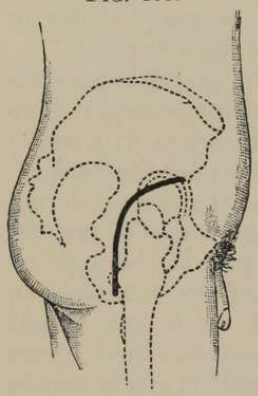
In excising an *interphalangeal joint* a lateral incision is made on the side of the joint (Fig. 462, *B*). The lateral ligament is divided, and the bones protruded and sawn. Two lateral incisions instead of one may be used (Fig. 462, *B*, *B*).

In excising a *metacarpo-phalangeal joint* a single lateral incision is employed, and the operation is done as in the above case (Fig. 462, *A* and *C*).

Fig. 462, *D*, also shows the incision for resection of the *first metacarpal bone.*

Resection in continuity or *complete removal of a bone of the upper extremity* for injury, more often for disease, will be effected in the ordinary way, as already mentioned in treating of such operations in general, care being taken to fasten the ends firmly together when this can be done, and to preserve the periosteum as far as practicable, in order that regeneration may take place, thus lessening, or in the most successful cases preventing, after-deformity.

Fig. 463.



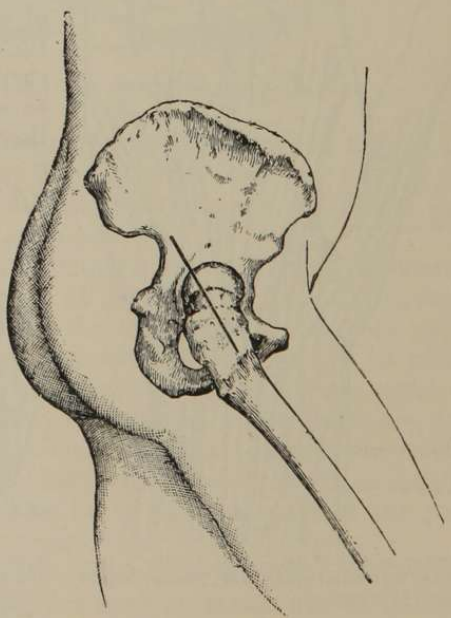
Excision of the Hip-joint (Tillmanns).

Hip.—Resection of the head of the femur in civil life is almost always required because of tubercular caries. It is ordinarily done through an incision beginning about midway between the anterior superior iliac spine and the trochanter, and continued downward around the trochanter or across its outer surface along the outer border of the thigh for a short distance, the knife being carried directly to the bone (Fig. 463). Figs. 464 and 465 show other incisions for excision of the hip-joint. The capsule having been thoroughly opened, the periosteum is divided transversely at the level of bone-section, and as completely as possible separated from the femoral neck, the muscular attach-

Fig. 464.

Excision of the Hip: Luecke's incision (Treves).

Fig. 465.

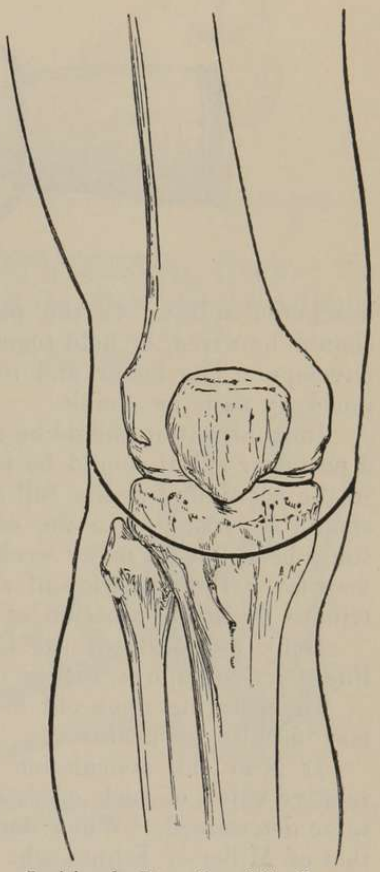


Excision of the Hip: Langenbeck's external incision (Treves).

ment to the trochanters being severed, or, better, the bone-surfaces which secure them being chiselled off, or the whole of the greater trochanter may be split

off and turned aside. It very often happens that the condition of the parts is such that little or nothing can be gained by an attempt at preserving the periosteum, and much time will be saved and as good an ultimate result secured by omitting it. The head of the femur is then forced out of the acetabulum and the diseased bone sawed off, any limited portion of affected tissue being removed by gouge and spoon rather than by a second sawing at a lower level. To facilitate drainage, the trochanter major is generally taken away, but in most of the cases suitable for operation this is not necessary. If the acetabulum is diseased, it should be thoroughly scraped. Instead of luxating the head and then dividing the neck, the steps may be reversed, the neck being first sawn through; but the operation thus done, as a rule, is not so easy of execution.

FIG. 466.



Incision for Resection of the Knee (MacCormac).

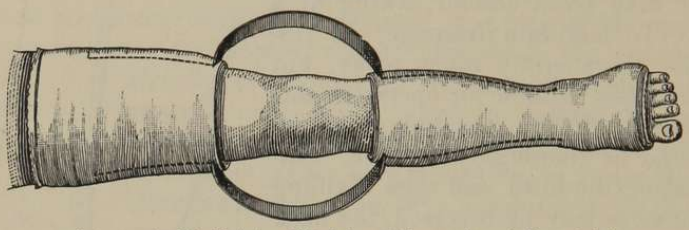
By a few surgeons an anterior incision is preferred (Fig. 464), the knife being entered half an inch below the anterior superior iliac spine and carried downward and a little inward for about three inches, passing between the tensor vaginæ and glutei muscles on the outer side and the sartorius and rectus on the inner. If the operation is done aseptically and the parts protected against after-infection, primary union may be secured.

KNEE.—Resection of the knee is done because of injury, deformity, ankylosis, or especially disease. It is performed in several ways, according to individual preference and the facility and thoroughness of exposure of the joint structures. These methods are a curved incision across the front of the joint, with convexity downward, passing through the ligamentum patellæ (Fig. 466), or with convexity upward above the patella, a straight transverse incision passing through the patella, which is sawn, with or without associated short longitudinal incisions on the sides; or a single longitudinal incision, median or lateral, a method inapplicable to cases of disease.

As ordinarily done, the curved or transverse incision is made from condyle to condyle, opening the joint; the flap containing the patella is turned upward; the limb is flexed, the crucial and lateral ligaments divided, great care being used to avoid wounding the popliteal artery, the end of the femur is thoroughly uncovered, and a slice of necessary thickness sawn off, the epiphyseal line being, if possible, preserved in children. This is very essential, in order that the ultimate shortening may be reduced to a minimum, as the chief growth of the femur—and the point of greatest growth in the entire body—is at its lower end. The saw should be carried in a slightly oblique direction from behind forward and in a plane parallel to that of the epiphyseal line. The articulating surface of the tibia is then to be in like manner removed, all diseased soft parts being cut or scraped away. The patella, if diseased, as is usually the case, should be removed; if not diseased,

it may be removed or left as preferred. The bone surfaces are then apposed, drainage-tubes placed in position from side to side or obliquely from before backward, and brought out through counter-openings on the posterior surface, the edges of the incision sutured, the parts antiseptically dressed, and the limb immobilized by plaster of Paris or a suitable

FIG. 467.



Interrupted Splint (modified from Esmarch and Kowalzig).

bracketed splint. If the patella has been sawn through, its fragments should be wired, or held together by stout catgut sutures through the fascial envelope. The femur and tibia may be sutured with catgut or wire or fastened by nails or dowels.

Immobilization should be maintained for two, or better three, months, and a posterior splint should be worn for many months longer, that firm union in the position of nearly full extension may be secured. The drainage-tubes should be removed in the course of a few days, as, although they have at times been left for many weeks without harm, it is likely that their presence may favor the formation of sinuses which may become tubercular and contribute to the production of an unfavorable result.

Bony ankylosis of the knee, as a rule, may be treated by osteotomy, linear or cuneiform, rather than by resection.

In operating upon old luxations partial excision of the end of the femur may usually be made.

It is at this articulation that erasion is most frequently done, and the relative value of such operation as compared with typical resection has yet to be determined. When done for tubercular disease, an excellent method is that of Miller of Edinburgh. An incision is made below the patella, deeply curved downward toward the tuberosity of the tibia, and another straight across the center of the patella, joining the ends of the first. The upper flap is then reflected upward, the tendon of the rectus and adjacent muscular fibers divided, and the entire anterior portion of the capsule, together with the patella and an elliptical portion of skin, stripped downward and removed *en masse* by cutting through the ligamentum patellæ and the tibial attachments. The remainder of the joint is then cleaned up and the bones resected.

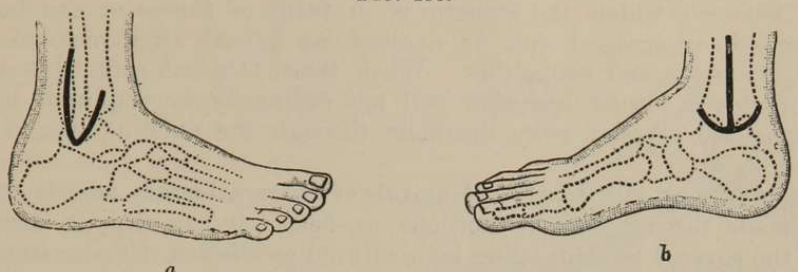
When the joint lesion is great, the destruction extensive, and the general health much enfeebled, especially in poor patients not in hospital, amputation often offers a much better chance of preserving life, and should be performed.

ANKLE.—For the resection of the ankle-joint many operations have been devised of late years—more than for the removal of any other articulation. The methods are lateral, postero-lateral, and posterior, without and with associated division of tendons and removal of the astragalus.

An excellent method is that in which an incision over the inner border of the fibula, commencing an inch and a half or two inches above the tip of the

external malleolus, is carried to and a little in front of the malleolus, and another is made directly backward close under the malleolus to the external

FIG. 468.

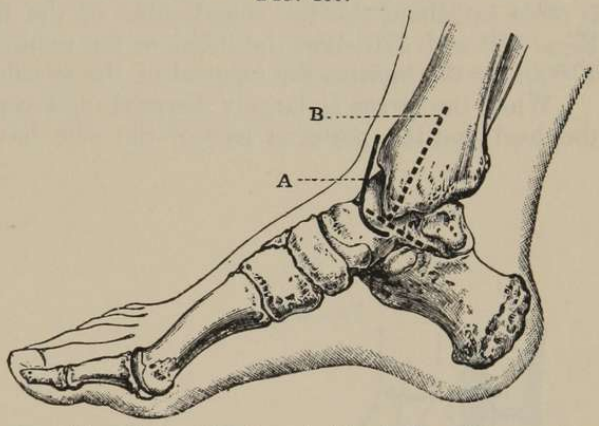


a *b*

Resection of Ankle-joint, after Langenbeck; incision over the lower end of fibula (*a*) and tibia (*b*) (Tillmans).

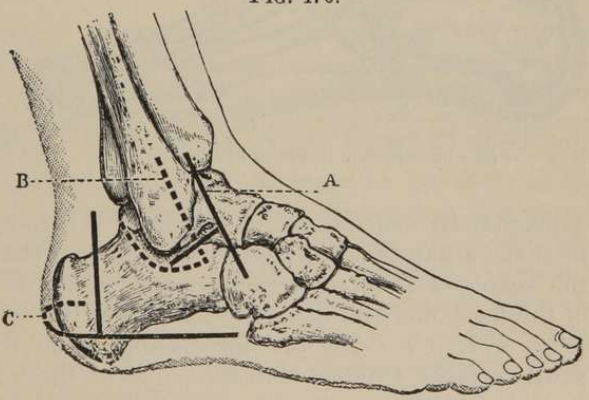
border of the tendo Achillis, dividing the peroneal tendons (Fig. 470, *B*). The flap thus outlined is dissected off the lower part of the fibula, and the malleolus separated with chisel, saw, or cutting forceps—removed if diseased, if healthy turned back to be later reunited. The astragalus is then freed from its attachments and taken away, and the foot dislocated inward, when ready access is had to the lower end of the tibia, which is cut away to such extent as is necessary. The diseased tissues about the joint are easily reached and removed, and by extending the original incision along the outer border of the foot other bones of the tarsus, if affected, can be got at and taken away. The severed peroneal tendons are then sutured, drainage-tubes put in, counter-openings, if thought advisable, being made and through drainage thus secured, gauze and cotton dressing applied, and the leg and foot placed in a splint or immobilized with plaster. Figs. 468, 469, and 470 show the various incisions for excision of the ankle.

FIG. 469.



A, excision of astragalus (inner incision); *B*, excision of ankle (inner incision) (Treves).

FIG. 470.



A, excision of astragalus (outer incision); *B*, excision of ankle (outer incision); *C*, excision of os calcis (Treves).

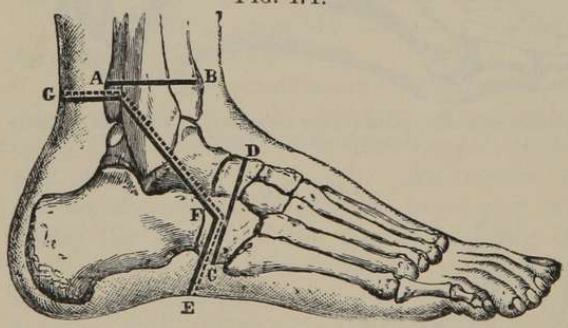
The removal of the astragalus very much facilitates the extirpation of the diseased tissues, hard and soft, and lessens but little if at all the later functional value of the

limb. If it is desired to save uninjured the peroneal tendons, two lateral incisions may be made, one as already described, the other (Fig. 469, *A*) over the inner malleolus and forward internal to the tendon of the tibialis anticus, between which the structures in front of the joint can be lifted up, chiselled, or scraped out, or excised, as before, after removal of the external malleolus and astragalus. When there is a compound luxation of the astragalus a formal resection will not ordinarily be required, it being usually possible to take away the bone through the existing wound or by enlarging it.

Resections of the Foot.—Removals of the tarsal bones, largely atypical, may be made through lateral incisions, or, better, by an incision across the dorsum, the severed tendons being later sutured or allowed to make attachment as they can in the course of the healing of the wound, the former procedure being preferable. It has lately been advised to split the foot back between the third and fourth metatarsals to the middle tarsal joint, and thus gain access to the affected parts. The essential prerequisite to success is thorough removal of the diseased tissues, and the end-result of complete excisions even of the entire tarsus or of its anterior segment and the metatarsus in part or in whole is often excellent, the functional value of the foot being but little impaired. Figs. 469 and 470 show the incisions for removal of the astragalus, and Fig. 470 shows the incision for removal of the os calcis.

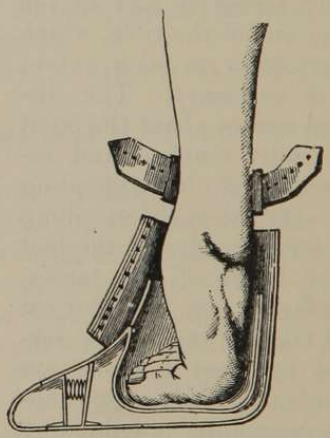
When the tarsus is largely diseased, and especially when the soft parts of the heel and the posterior part of the sole have been destroyed or seriously

Fig. 471.



Osteoplastic Resection of the Foot: *A B* and *C D*, saw-cuts; *E F G*, skin incisions (Treves).

Fig. 472.

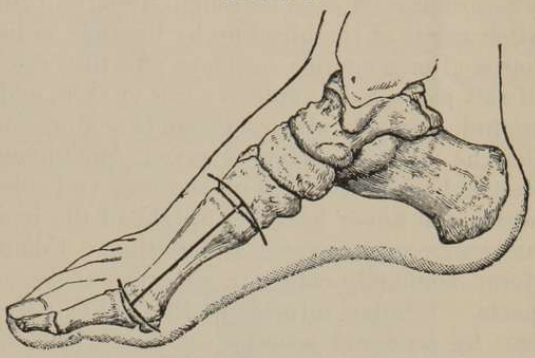


Aspect of Limb and Instrument to be worn after osteoplastic resection of the foot (Treves).

damaged, an osteoplastic operation ("Wladimiroff-Mikulicz operation") may be done, a flap of the posterior tissues from the level of the malleoli to that of the scaphoid tubercle being removed (Fig. 471, *E F G*), the articulating end of the leg-bones and the posterior part of the scaphoid and cuboid sawn through (Fig. 471, *A B C D*), the intervening bone excised, the foot extended, the sawn surfaces apposed, and the edges of the wound sutured, the weight of the body being afterward supported on the ends of the metatarsal bones, and the under surfaces of the toes now bent at a right angle (Fig. 472). Except when there is extensive ulceration or loss of substance at the heel, such osteoplastic resection has no advantage over a large atypical tarsal excision, and is likely to leave a less useful foot.

Resection in Continuity of Bones of the Lower Extremity.—Such an operation should not be done upon the femur, because of the strong probability of non-union. Upon the tibia or fibula it is more likely to be followed by a successful result, regeneration of the bone or compensatory hypertrophy of the untouched shaft frequently taking place. Care must be exercised during the period of repair to prevent deviation of the foot. Upon a metatarsal or phalangeal bone of the foot, as upon a corresponding one of the hand, it may be readily and successfully done, the necessary incision being made over the inner or outer side rather than the middle, to avoid injuring the extensor tendon (Fig. 473).

Fig. 473.



Excision of First Metatarsal Bone (Treves).

When in the hand a first or second phalanx cannot be subperiosteally removed, the distal part of the finger should be allowed to drop back, the resulting fibrous union often becoming short and firm and securing a useful finger, failing which amputation can be done.

CHAPTER VI.

AMPUTATIONS.

Indications.—It is impossible to do more than indicate in very general terms the more important conditions calling for amputation. Injuries of similar degree affecting the upper or the lower extremity call for different treatment, because of the much greater freedom of the collateral circulation in the former, rendering gangrene less probable. Where conservative treatment or excision would be proper in the upper extremity, amputation would be called for in the lower limb. A broken constitution with damaged assimilative and eliminative organs, as in the aged, in alcoholics, in chronic Bright's disease, or when tuberculosis of the lungs exists, often compels the sacrifice of the limb. Avulsion of a whole or part of an extremity of course requires an attempt to place the remaining portions in a condition to heal by amputating at a higher point, or, if the whole limb is gone, by fashioning flaps out of what remains of the soft parts, and approximating and dressing them.

Compound Fractures and Dislocations are the most common accidents demanding amputation. Extensive comminution and loss of bone may demand this in the lower extremity, because even if saved the limb will be useless as a means of locomotion: when in the lower limb rupture of the main vessels is

added to this condition, amputation is indicated, but in the upper limb an attempt should be made to save it by securing the vessel in the wound. In the lower extremity secondary hemorrhage from the main artery after compound fracture usually calls for amputation; but further trial of conservative treatment, after arrest of the bleeding by ligature, is in exceptionally favorable cases justifiable after a similar accident affecting the upper extremity. Great laceration of soft parts, with extensive loss of skin, added to free comminution of bone and wounded vessels, always demands amputation; extensive flaying, which will render the member useless if saved, sometimes calls for its removal; for instance, destruction of the skin of the heel and sole of the foot will result in a cicatrix which can never bear the weight of the body, and extensive burns of an entire extremity may require amputation. Compound fracture involving the knee-joint commonly calls for amputation, because of the great damage to the soft parts. Similar injuries to the ankle may admit of conservatism if the parts can be rendered aseptic; or if the soft tissues are not much damaged, excision should be practised. This latter rule is also applicable to the shoulder and elbow, but bad compound fractures of the wrist require amputation.

Compound dislocations of the ankle, elbow, shoulder, and hip, provided only moderate injury has been inflicted upon the soft parts—where conservatism is not indicated—should be treated by excision, as a rule. Owing to the frequent damage to the popliteal vessels, and the destruction of most of the vessels capable of carrying on the collateral circulation, amputation is the safest course in compound dislocations of the knee.

Lacerated and Contused Wounds inflicted by the claws or the teeth of wild animals, and the extensive shattering of bone produced by gunshot wounds, often demand amputation. While wounds and lacerations of arteries rarely call for amputation except for a traumatic or diffused popliteal aneurysm or similar conditions of the deep arteries of the leg, or for traumatic aneurysm of the axillary, it is often required for secondary hemorrhage the result of previous wound of a vessel or following ligation of an artery in its continuity.

Gangrene the result of frost-bite, of burns, of traumatism, or of a wound of an artery or of its gradual occlusion in the young, demands amputation well above the limits of the disease, and even in the senile form, under favorable circumstances, amputation of the leg or thigh is sometimes proper. The student, however, should consult the section on this disease for the special indications for and against operation.

Many destructive diseases of the *bones* and *joints*, where extensive implication of the soft tissues exists, demand amputation.

Malignant Tumors of the extremities are best treated by amputation when they affect the bones, and even when these tumors are free from bony attachments their relations to other important structures may be such that they cannot otherwise be safely removed. In this case the whole of the bone involved should be removed; that is, the amputation should be at or above the joint on the proximal side of the disease. Very rarely, benign growths reaching such a size as to render life burdensome require removal of the limb; or by their ulceration, followed by profuse discharges, they may menace the patient's life unless removed.

Tetanus, with the modern views as to its pathology, cannot be considered an indication for amputation.

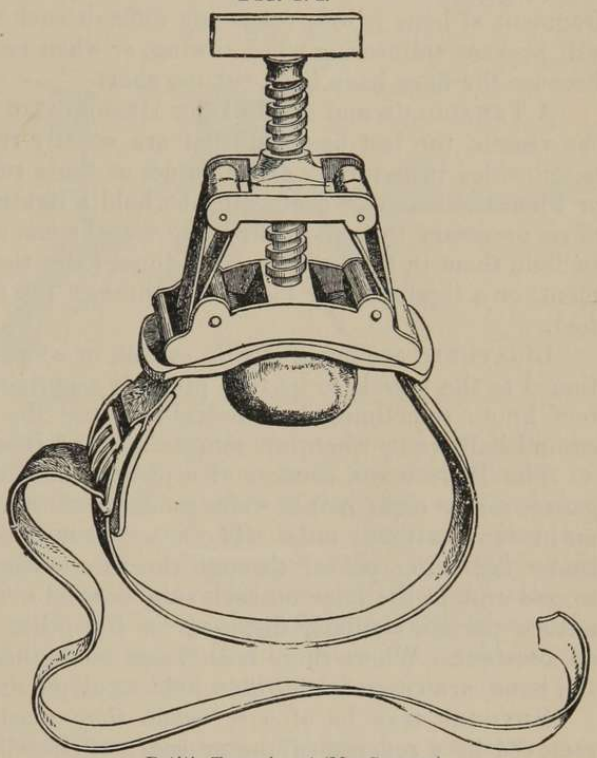
For *Deformities*, such as severe neglected club-foot, limbs rendered useless by cicatrices, mal-union of fractures, etc., amputation is sometimes done in robust young individuals, but these are usually operations of complaisance, not of necessity.

INSTRUMENTS.

The instruments required for amputations are those to arrest hemorrhage during the operation, knives, saws, retractors, cutting bone forceps, strong forceps to hold a bone fragment, tenacula, artery and hemostatic forceps to secure the vessels, needles to sew up the flaps, scissors, and dissecting forceps; in addition, capillary or tube drains must be provided, proper dressings, and a splint to fix the joint above the segment amputated.

TOURNIQUET.—Petit's is that commonly employed, consisting of two metal plates capable of being separated by a powerful screw, and a stout strap with pad and buckle (Fig. 474).

FIG. 474.



Petit's Tourniquet (MacCormac).

Application. — Make a few circular turns around the limb with a three-inch roller; place the remainder of the roller obliquely to the course of the vessel where its pulsations are distinct, pass and tightly buckle the tourniquet strap around the limb—previously elevated to prevent an accumulation of venous blood—with the plates closely approximated on the compress, and rapidly turn the screw. Other forms of instruments have been devised which press only on the vessel and at a point directly opposite—*i. e.* horseshoe tourniquets, Hoey's clamp, and Skey's tourniquet, large sizes of the two latter being used to control the abdominal aorta.

ESMARCH'S APPARATUS.—This consists of a broad rubber *bandage* and a flattened rubber *band* with a hook at one end and a few links of chain at the other. *Application.*—The bandage is put on firmly from below upward, without reverses, as high as is desired, when the band is carried well on the stretch around the limb above, but close to the last turn of the bandage, and is secured with the hook and chain or by tying the crossed ends: the rubber bandage is then removed. Do not draw the band too tight nor leave it on too long, lest paralysis from pressure on the nerves result; again, never allow the member to be decidedly flexed or extended after its application, because tearing of the muscles may result. The annoying oozing following the use of the Esmarch bandage can be lessened by removing it as promptly as possible, thus lessening the vaso-motor paresis; by maintaining elevation of the part combined with the use of hot water; and by digital compression of the main artery for a few moments.

AMPUTATING KNIVES.—Modern knives, having their points sharp and double-edged, are fitted for both the circular and the transfixion method of operating. A breadth of from three- to five-eighths of an inch, and a length of

from six to nine inches of cutting edge, are proper dimensions for the blade. Double-edged, sharp-pointed knives called catlins are employed by some operators in transfixion operations or to clear the interosseous space, but the point of any amputating knife will do for this latter purpose. One metacarpal knife with a three-and-a-half-inch blade, a slender bistoury with heavy back, and a stout scalpel are all the knives absolutely requisite.

Saws.—While many patterns of saws have been proposed, the best is the ordinary flat-bladed one, but it is well to have a smaller instrument (metacarpal saw) with movable back.

Cutting Bone Forceps are necessary to remove rough or splintered edges left by the saw or for dividing the metacarpal or phalangeal bones.

Fergusson's lion-jaw forceps are useful where in compound fractures only a fragment of bone is left, rendering difficult such steadying of it by the hand as will prevent splintering when sawing, or when retrenchment of bone is requisite because the flaps have been cut too short.

A Tenaculum and Artery-, or Hemostatic Forceps are required to secure the vessels, the last being all that are usually requisite, except where a vessel is imbedded in naturally dense tissues or those rendered dense by inflammation, or when the vascular coats will not hold a ligature; in all of which cases it is often necessary to take up with the vessel some of the surrounding tissues and include them in the ligature. In these cases the tenaculum is the best instrument, or a ligature may be carried through the tissues by a curved needle and tied.

Ligatures are made of silk, catgut, or some animal tissue of a size proportioned to the vessels to be tied, properly asepticized and secured by a square or reef knot: sometimes it is desirable to use the surgeon's knot, secured by a second half knot, when including a mass of tissue with the artery.

The Retractor consists of a piece of muslin or of several thicknesses of gauze, six or eight inches wide, rendered thoroughly aseptic, and torn halfway up into two or three tails. The latter form is used for the forearm or leg, the center tail being passed through the interosseous space, the outer ones being wound around the bone on each side, crossed over the soft parts, and, with the untorn portion similarly disposed on the other side, drawn firmly upward by an assistant. Where there is only one bone, the two tails are made to embrace the bone, are crossed, and then held as above directed.

Sutures may be of wire, when they must be twisted and cut off, and removed by a reversal of the process; of chromicized catgut, when they should be introduced in the form of interrupted sutures, tied in a reef knot; or, best, of silkworm gut or silk, employed as the interrupted suture, the stitches being about one-third of an inch apart.

The Needles employed to pass the sutures should be either large, long "saddlers' needles," or ordinary surgical needles with only their extremities slightly curved, or the Hagedorn needle. The best needle-holder for the latter is Abbe's with the spring catch.

Halsted's "gut wool" or "antiseptic wax" for controlling undue bleeding from the bone should be ready. The best formula for the latter is Horsley's, viz.: beeswax seven parts, almond oil one part, and salicylic acid one part.

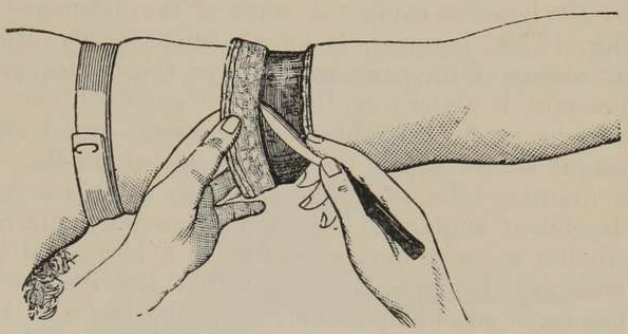
OPERATIVE METHODS.

These are all modifications (1) of the "*circular method*," in which the skin and superficial fascia, being divided in a circular manner, are dissected up for a sufficient distance, the muscles cut circularly down to the bone, and this in

turn sawn at a higher point; and (2) of the "*flap method*," in which a covering is provided for the bones by variously-shaped "flaps" of skin and fascia, or of muscle in addition.

Circular Operation.—After shaving and antiseptic cleansing, hemorrhage having been provided against by Esmarch's band, by the tourniquet, or by digital pressure on the artery, the patient's limb must be made to project over the edge of the operating table or bed, and the floor be protected from the blood by an old blanket, a piece of oil-cloth, or a bucket. One assistant's duty should be to give the anesthetic, another must attend to the tourniquet, a third should hold and manipulate the limb, while a fourth will manage the retractor, assist with instruments, etc. The instruments should be arranged in proper trays or laid on an antiseptic towel conveniently near the surgeon's right hand: unless the operator be ambidextrous, he should stand with his left hand toward the patient's trunk. Drawing the skin of the limb upward with the left hand and stooping slightly, a long knife should be carried by the right hand beneath and around the limb, so that its back presents to the operator's face with its point dropped well downward. The heel being firmly pressed against the skin, the knife must be swept around the limb, the operator gradually rising from his stooping posture, until the entire circuit of the member has been made. A few light touches of the knife as the skin is firmly pulled up will suffice to obtain enough flap for a thin limb; but it is usually requisite rapidly to dissect up and reflect a cuff of skin in length about half the diameter of the member, carefully avoiding scoring the subcutaneous fat, in which ramify the cutaneous vessels, by directing the knife toward the deeper tissues. A longitudinal incision must often be made on one side of the cuff to admit of its reflection over a conical part, as the calf or a muscular forearm.

FIG. 475.



Circular Amputation: dissecting up the skin-flap (Esmarch).

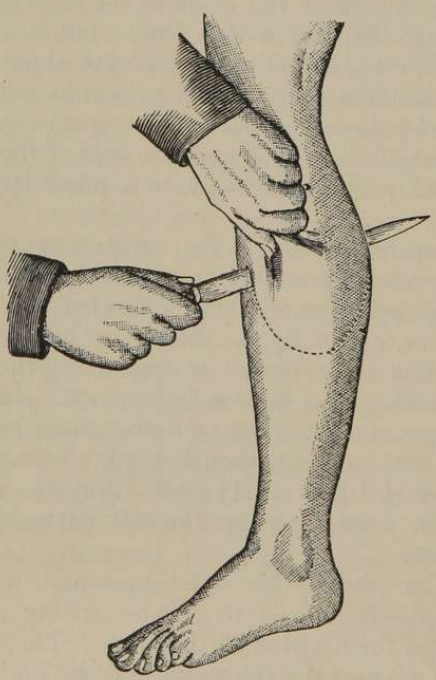
After the cuff has been evenly dissected high enough, the surgeon must apply the long knife to the muscles and cut them as before with a circular sweep of the knife down to the bone. The periosteum must be divided by a circular cut and forced up with the muscles, either by the finger or by the handle of the knife, for an inch or more: this is preferable to separating the muscles from the periosteum up to the point where the bone is to be sawn. In the leg or forearm, where there are two bones, the interosseous tissues must be divided by the point of the knife, entered first in front, then behind, rocking it from side to side, or by a scalpel or narrow catlin similarly used. Adjusting the retractor as before directed, the surgeon must force up the soft parts in order to apply the saw as high as possible.

Holding the saw firmly and steadying its edge by his left thumb-nail, its edge must be drawn from before backward—from heel to point—cutting a groove, when a few even strokes will complete the division of the bone. Theoretically, the saw should be held vertically to prevent the weight of the limb from breaking the bone before its complete division, but if carefully held by the assistant so as neither to strain the unsawn portion nor bind the saw, the divis-

ion can be made in any way most convenient to the operator. In the leg it is better to saw through the fibula before the tibia is completely divided, to avoid straining the superior tibio-fibular joint; and the radius in the forearm, as it is the more movable of the two bones. As soon as the limb is removed, all vessels that can be detected are to be taken up with a tenaculum or forceps and tied; the pressure on the artery is then to be relaxed, and any bleeding points are to be caught first with forceps, and then every bleeding vessel, whether artery or vein, is to be tied. Cut off with the bone forceps any uneven portions of bone, draw out and remove with the scissors all large nerves, retrench projecting tendons, and check capillary oozing with hot aseptic water. If bleeding persists from the bone, and the vessel cannot be plugged with a piece or twisted strand of catgut, a small pellet of antiseptic wax fastened to a silk ligature must be pressed on the spot: this can be brought away by the ligature along the track of the drainage-tube at a subsequent dressing. This, however, is an expedient rarely demanded, as catgut plugging or sewing of the periosteal flaps or the tissues over the bone, so as to exert pressure, is better; or Halsted's "gut wool," or Horsley's "antiseptic wax" may be used. Any bleeding periosteal vessel must be twisted, or tied by a catgut thread passed by a small curved needle. The stump being now dry, a drainage-tube should be placed so as to emerge at what will be the most dependent angle, and the skin sutured by interrupted silkworm gut or silk stitches so as to form a vertical or a horizontal line: an antiseptic dressing must next be applied, such as will be described for flap operations, and a splint bandaged on in amputations below the elbow or knee to keep the whole limb at rest; or it may be made comfortable on a pillow.

Flap Operations.—The flaps may consist of skin alone, or of muscle in addition. When the latter is included, there must be enough skin to cover the muscle, enough muscle to cover the bone, and the bone must be sawn above the angle of junction of the flaps.

FIG. 476.



The Flap Method by Transfixion (Sédillot).

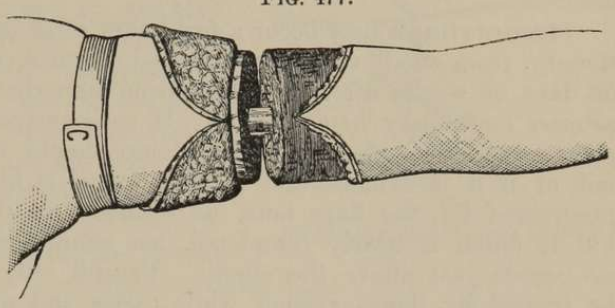
Single-flap Operation.—This is advisable only when from injury or disease the tissues on one side are unfit to use, while on the other they are sound. The flap must be somewhat longer than the transverse diameter of the limb at the point where the bone is to be sawn; should as far as possible be rectangular in outline; must include skin, fascia, and a good layer of muscle, and is best made by cutting from the skin inward, the tissues on the opposite side of the extremity being divided transversely or by an incision slightly convex downward; and the bone cleaned of the soft parts, and sawn off at least one inch above the base of the flap, as directed for the circular operation.

Double-flap Operation (Fig. 476).—In addition to the general rules given above, the following directions will suffice, except in certain instances where special modifications—which will be

described—become requisite. In breadth each should be half the width of the member; in length they may be equal, or one may be longer than the other, but the aggregate length must be somewhat more than the diameter of the limb at the level at which the bone is to be sawn, especially in operations for disease, where the muscles will not at once retract to their full extent, but may do so to an unpleasant degree in the course of a few days. They may consist of skin alone or of muscle also, while they may be lateral, antero-posterior, or antero-lateral. While cut more rapidly by the transfixion method, there is apt to be a redundance of muscle, so that a better stump can be made by cutting from the skin inward, or one flap may thus be made while the other is cut by transfixion. The advantage of musculo-cutaneous flaps is that by buried animal sutures all spaces may be effaced, and thus all, except perhaps capillary, drainage can be dispensed with, which is hardly possible with cutaneous flaps alone.

Mixed Method—*i. e.* flaps of skin and circular of muscles.—The best is that of Syme, where two semilunar flaps are dissected up a short distance above the angles of juncture of the flaps, the remainder of the operation being identical with the circular method (Fig. 477).

Fig. 477.



Mixed Method: skin-flaps and circular through muscles (Esmarch).

Method of Closing and Dressing.—After the first arrest of all bleeding, securing the middle of a bundle of from twenty to forty strands of fine catgut by a suture to the periosteum, first the periosteum, next the muscular surfaces, and then the fascia are to be sutured by interrupted or continuous catgut sutures, bringing three or four drainage-threads between each alternate muscle stitch, or every other such pair, until all spaces have been effaced; finally, the skin must be united by interrupted silk or chromicized gut sutures, between each two of which three or four of the catgut drainage-threads should pass, these being kept parallel and in contact with one another, cut off square, and kept *moist* by a piece of protective which shall cover in the wound and extend one inch beyond the cut ends of the drains. Some surgeons use simply a rubber drain-tube for a day or two, with or without capillary drainage; suture the edges of the flaps, and secure apposition of the surfaces of the flaps by deep sutures passed through and through or by suitable compression by pads and bandages. Over the stump a voluminous mass of gauze, with sufficient antiseptic cotton or wood-wool to absorb the bloody serum, must be applied and bandaged securely in place, the dressing extending many inches above the extremity of the stump; for instance, well above the knee for an amputation at the middle of the leg.

Splints are indicated for amputations below the elbow-, knee-, and wrist-joints. Should no hemorrhage, great rise of temperature, undue pain, or soakage of discharges through the bandages demand it, such a dressing in an aseptic operation may remain undisturbed for from two to three weeks, when if silk thread has been used the stitches must be removed; but if catgut has been employed the stump will usually be found soundly healed. When it is doubtful whether asepticism has been secured, two short rubber drainage-tubes must be introduced, so that one emerges at each angle of the wound, reaching

down to the bone, cut off nearly flush with the surface, and secured by a safety-pin or stitch: these must be removed at the end of two or three days unless required for a longer period.

Amputations in Continuity and in Contiguity.—The first term is used to indicate an amputation where a bone is sawn through, while an amputation in contiguity is synonymous with removal of a limb through a joint.

After-treatment and Complications.—As all dressings should be conducted on antiseptic principles, the student should consult the section devoted to this subject. If the union is not firm, so long as the sutures are not irritating the parts allow them to remain. Where additional support is needed, strips of aseptic or antiseptic gauze fixed with collodion are better than adhesive plaster; but if this latter is used, interpose a few layers of gauze between them and the line of union. Spasm and retraction of the muscles must be combated by firm circular bandaging, adhesive plaster, stirrup-extension by weight and pulley, and splints, as must also the elevation of the heel sometimes following Chopart's operation. Antipyrine internally may also be used.

Hemorrhage may occur a few hours after operation (consecutive or reactionary, from small vessels overlooked, because not bleeding, during shock), or days or weeks after operation from imperfect closure or giving way of arteries (secondary hemorrhage). If consecutive and slight, firm bandaging, elevation, and ice-bags over the stump should be tried. If these measures fail, or if it is evident that a large vessel is bleeding when union has not progressed far, the flaps must be opened and the bleeding points secured; but if union is nearly completed, use acupressure, or, better, tie the vessel or vessels just above the stump. Painful enlargements of the nerves must be treated by their excision, while caries and necrosis of the bones require the same treatment as when arising from other causes, except that reamputation is more often appropriate than primary amputation would be for bone disease.

Mortality.—Circumstances vary so much that only a few facts are beyond reasonable dispute. Age influences the result: thus, operations in children are usually successful, while the reverse holds good for the aged, the death-rate increasing with advancing years. Renal, hepatic, or other visceral disease greatly increases the danger, as do bad hygienic surroundings. Amputations for injury have a higher death-rate than those for disease, as do those for malignant disease as compared with operations for caries, chronic suppurative arthritis, etc.; moreover, amputations of the lower limb are more dangerous than those of the upper; again, the death-rate for the thigh is nearly twice as great as for removals of the leg; the mortality of leg amputations is much greater than that of amputations of the forearm; and, in turn, those of the upper arm are more dangerous than those of the forearm. Antiseptic surgery has enormously diminished the mortality.

Primary Amputation means one done after injury, before the onset of traumatic fever (if shock persists, this may mean after the lapse of even so long a time as seventy-two hours).

Intermediary operations are those performed during the acute inflammatory stage—*i. e.* from two to four weeks, possibly less; while Secondary amputations are those performed after the subsidence of fever and the establishment of suppuration. Amputations for accident should always, when possible, be *primary*, but if this cannot be done, wait for the secondary period rather than run the exceptional risks of an intermediary operation.

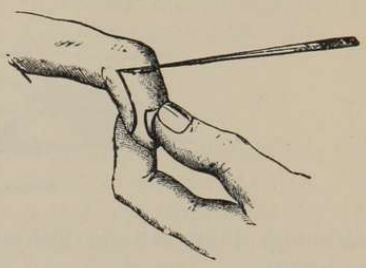
SPECIAL AMPUTATIONS.

AMPUTATIONS OF THE FINGERS.—From the importance of the hand, and because this member possesses its peculiar powers in virtue of the possibility of the tip of each digit being apposed to that of the thumb, it is of paramount importance to preserve even small portions of a phalanx, especially of the thumb.

Amputation through a Phalanx can be done by two square flaps fashioned by making a circular cut down to the bone, supplemented by two vertical ones, or two semilunar flaps may be employed; the bone may be divided either by cutting forceps, or, better, by a small saw, and the digital arteries on each side may be twisted or included in the stitches by which the flaps must be coaptated; the other fingers and the wrist must be kept quiet on a splint for about ten days.

Amputation through an Interphalangeal Joint may be done either by a single palmar flap or by two semilunar flaps, the chief point to be remembered being that the joint in the last row of phalanges is one-twelfth of an inch below the most projecting part of the knuckles; that of the middle row, one-sixth of an inch below; and that of the metacarpo-phalangeal joint, one-third of an inch below. Use a narrow, sharp-pointed bistoury for these operations, and cut the flaps from without inward, after which the lateral ligaments must be divided, when the knife-edge should be entered on the dorsal aspect of the joint, passed between the bones, and made to cut downward and forward, severing the palmar ligaments, and completing the disarticulation (Fig. 478).

FIG. 478.



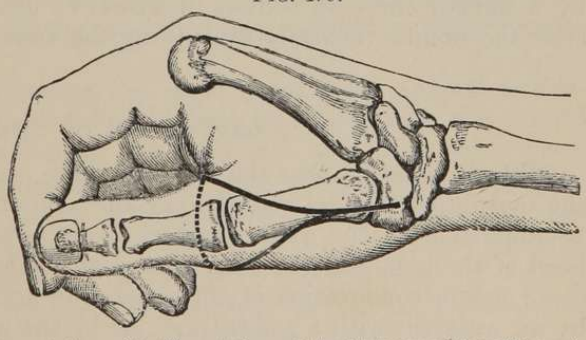
Amputation of a Phalanx (Treves)

Amputation at the Metacarpo-phalangeal Joints.—This may be done by double lateral flaps, or thus: With the patient's hand pronated, make a longitudinal half-inch cut over the head of the metacarpal bone; carry the knife obliquely from the lower end of this incision down on one side to the interdigital web across the base of the finger and upward to the longitudinal cut, dividing the tissues down to the bone; cut the tendons and lateral ligaments, and complete the disarticulation. All the fingers may be thus separately removed, or a transverse dorsal incision may be made, disarticulation effected, and a palmar flap made from within outward.

AMPUTATION OF THE THUMB

through its metacarpal bone (Fig. 479) or with this bone, and **amputation of the little finger** with its metacarpal bone, can be done best by the modified oval method given for the disarticulation of an entire finger.

FIG. 479.



Amputation of the Thumb through the Metacarpal Bone (Treves).

AMPUTATION OF THE METACARPUS.

Amputation of a portion or of all of the **metacarpus,** with or without portions of the **carpus,** must usually be done by fashion-

ing flaps, not according to any given rule, but as the condition of the tissues permits.

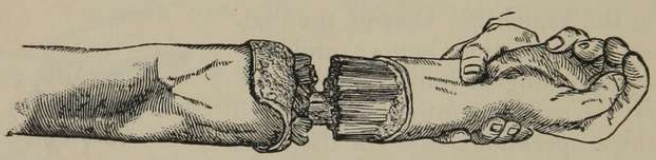
AMPUTATION AT THE WRIST.

This may be effected by the circular method, controlling the circulation through the brachial artery. Make the incision from one inch to one inch and a half below the radio-carpal joint, reflect the flap, open the joint from the radial side, and, having disarticulated, secure the vessels, about three or four in number. A single palmar flap cut from without inward may also be employed.

AMPUTATION OF THE FOREARM.

The circular method does well here, but antero-posterior musculo-cutaneous flaps are preferable (Fig. 480), best made by cutting from without inward,

FIG. 480.



Amputation of the Forearm (Bryant).

although they can be fashioned by transfixion: retrenchment of tendons is requisite.

AMPUTATION AT THE ELBOW.

Elliptical Method.—Semi-flex the arm; enter the point of the knife about one inch below the inner condyle, carry it up over the forearm nearly to the joint in a curve, thence carry the curvilinear incision downward, passing one and a half inches below the external condyle; forcibly flex, and complete the incision by outlining an ellipse extending at its lowest point about three inches below the tip of the olecranon; reflect the skin; divide the anterior muscles half an inch below the joint; disarticulate this from the outer side, cutting the ulnar nerve well above the joint; tie the brachial or radial and ulnar vessels, with a few smaller branches; close the wound transversely.

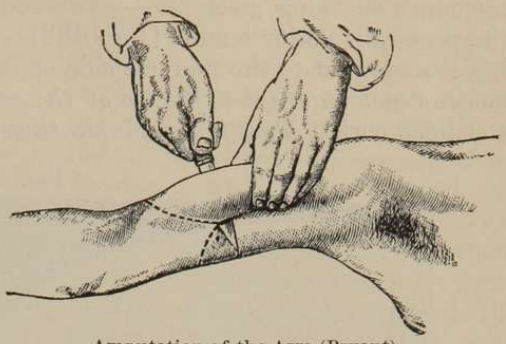
The Flap Method of Guérin.—Hold the forearm semi-prone; introduce the knife in the mid-forearm line one inch below the bend of the elbow; transfix by skirting around the radius with the knife-point; cut an external flap two to three inches long; divide the tissues on the opposite side of the joint by a curved incision, convex downward; disarticulate from the outer side; close the wound vertically after tying the vessels.

AMPUTATION OF THE ARM.

When operating near the shoulder there may not be space enough to apply the tourniquet, but by maintaining the arm at a right angle the compress can be applied over the axillary artery so as to press this against the prominent head of the humerus, the tourniquet plate being placed over the acromion process; again, compression of the subclavian against the first rib can be effected by an assistant with a padded key, or by the use of Keen's method by a com-

press above the clavicle, held in place by an Esmarch bandage passed alternately between the thighs and in the opposite axilla.

Fig. 481.



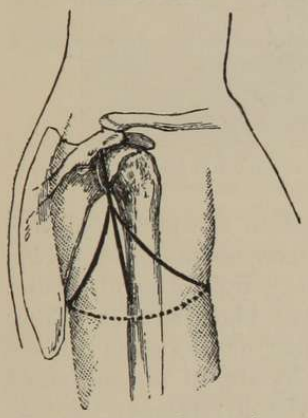
Amputation of the Arm (Bryant).

While the circular method does well in amputation of the arm, the **double antero-posterior flap** is the better operation, this being done either by transfixion or by cutting from without inward (Fig. 481). As the biceps contracts more than the triceps, the anterior flap should be the longer of the two, and the bone must be especially cleaned behind by a few extra touches of the knife: the brachial artery, the superior profunda, and a varying number of smaller vessels require ligature. If the location of the disease or injury prevents the formation of antero-posterior flaps variously disposed, single or double flaps can be made.

AMPUTATION AT THE SHOULDER.

The Oval or Larrey's Method (Fig. 482).—Control the circulation by compressing the subclavian against the first rib, or as above; enter the point of a medium-sized knife below and just anterior to the tip of the acromion process, making a three-inch longitudinal cut; from just below the middle of this make, first in front, then behind, slightly curved lateral incisions with their convexities downward, extending respectively to where the anterior and posterior axillary folds end in the arm tissues; rapidly loosen the edges of the wound; while the bone is rotated outward, forcibly sweep the point of the knife beneath the acromion process across the capsule, dividing it, the long head of the biceps, and the subscapular muscle; then forcibly rotate in, cutting the infra- and supraspinatus and teres minor muscles; finally, pass the knife behind the head and neck of the bone, and while an assistant grasps the flap containing the vessels behind the knife, remove the limb by cutting from within outward, so as to connect the two lateral incisions by a transverse one; tie the brachial and subscapular arteries, the former occupying the first muscular interspace behind the anterior axillary fold; suture the sides of the oval together, so that a linear wound remains.

Fig. 482.

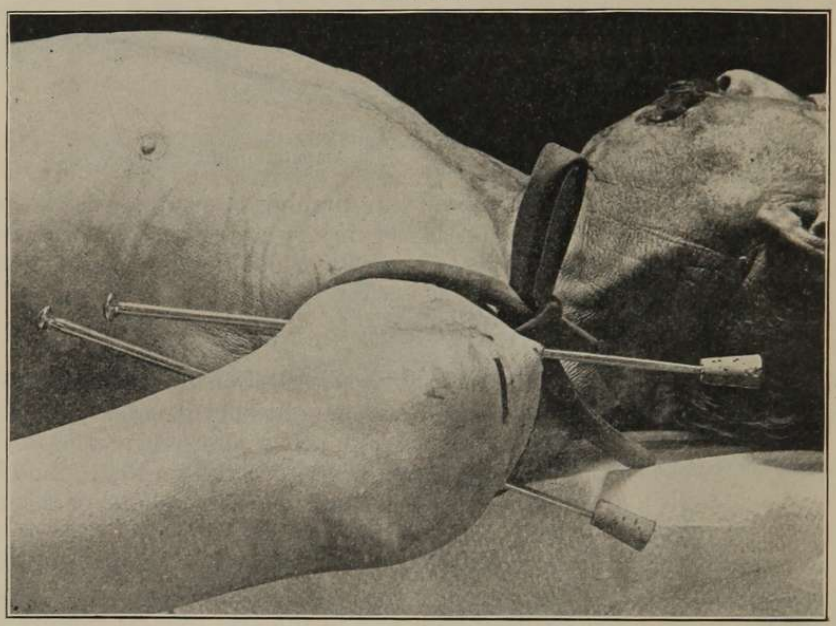


Larry's Amputation at the Shoulder-joint (Treves).

Dupuytren's Method.—Taking the same precautions against hemorrhage, with the patient's arm well extended from the body grasp the deltoid with the left hand; transfix, traversing the joint with the knife entered one inch in front of the acromion process and emerging at the posterior axillary fold, and form a large deltoid flap by cutting downward, backward, and outward; turn this aside; disarticulate by dividing the muscles rendered tense by outward and inward rotation; slip the knife behind the bone and cut a short inner flap from within outward, an assistant grasping the flap behind the blade to control the artery; secure the vessels and suture the wound.

Wyeth's Bloodless Method.—See that the shoulder projects slightly beyond the edge of the table; place the arm at a right angle with the body; introduce one long steel pin—a twelve-inch mattress needle will do—through the pectoralis major tendon (Fig. 483)—*i. e.*, the anterior axillary fold, entering it somewhat to the thoracic side of the middle of the fold; bring the point out *one inch internal to the tip of the acromion process*, and guard it with a sterilized cork. Pass a second pin through the tendon of the latissimus dorsi

FIG. 483.



Amputation at Shoulder-joint by Wyeth's pins and rubber tubing. The acromion is marked by a black line (Keen).

muscle—*i. e.*, the posterior axillary fold, a little internal to the middle of this fold, causing the point to emerge posteriorly *one inch internal to the tip of the acromion process;* guard the point with a sterilized cork; tightly wind around the axilla and shoulder, internal to the pins, a piece of black-rubber tubing one-half inch in diameter; according to the muscular development of the patient two or three turns may be made; disarticulate by any of the subjoined methods; secure the main vessels and any small ones visible; remove the tubing and pins; secure temporarily all bleeding points with forceps and tie them off; complete as directed for each special method.

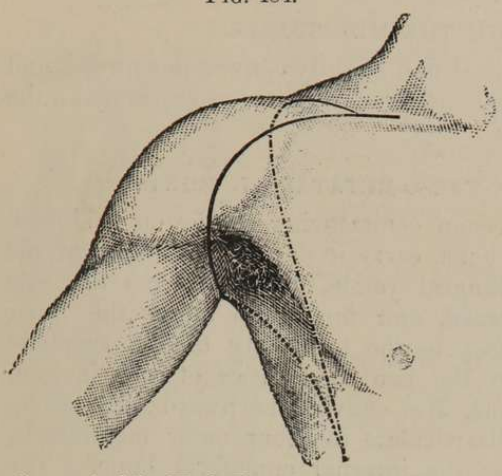
Caution.—It is essential that both pins emerge one inch internal to the tip of the acromion; otherwise, when the humerus is disarticulated, the tubing tends to slip down, thus drawing the flaps together, when the vessels may retract, severe hemorrhage then occurring, necessitating ligation of the subclavian artery or removal of the tube to secure the vessels in the wound, this latter only being possible of execution after severe loss of blood.

AMPUTATIONS ABOVE THE SHOULDER.

The flaps must be fashioned as the condition of parts left by injury or disease will allow; the easiest plan is to disarticulate the arm first, tie the axillary vessels, expose the scapula by a T-incision, detach it by cutting from below upward, and separate it from the clavicle or divide this bone with a chain saw or forceps.

INTERSCAPULO-THORACIC AMPUTATION (REMOVAL OF THE WHOLE UPPER EXTREMITY), PAUL BERGER'S METHOD (Fig. 484).—If the conditions do not forbid, apply an Esmarch bandage to the upper extremity as far as the lower border of the axilla; make an incision extending from the inner extremity of the clavicle outward to the top of the shoulder; uncover and resect the middle half of the clavicle, thus exposing the subclavian vessels, which must next be tied—both artery and vein: it is better as a rule to tie the artery point by two ligatures, each about one inch apart; divide the vessels between the ligatures; cut the axillary plexus with the scissors; commence a second incision at the center of the first, carrying the knife directly across the anterior part of the axilla and inner arm to the inferior angle of the scapula; from the outer extremity of the first incision over the clavicle carry the knife posteriorly across the dorsum of the scapula to its inferior angle, joining the termination of the second incision; reflect the posterior flap thus made; divide all muscular attachments; secure all bleeding points, and suture the flaps.

FIG. 484.



Removal of the Whole Upper Extremity (Treves).

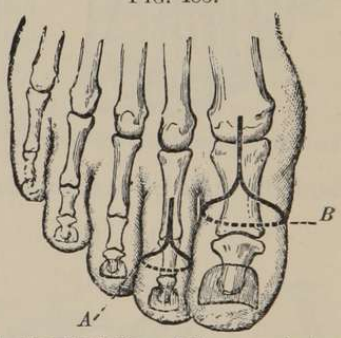
AMPUTATIONS OF THE TOES.

These should not be removed through a phalanx, interphalangeal disarticulation being preferable.

Amputations through the Interphalangeal Joints.—Open the joint transversely from above, disarticulate, and shave off a plantar flap by cutting from within outward.

Amputation at the Metatarso-phalangeal Joint.—This can be done either by lateral flaps or by the modified oval, remembering that the joint is higher than it seems, because the web between the toes is about halfway between this joint and the extremity of the toe. Make a longitudinal incision, commencing on the dorsal surface two-thirds of an inch above the articulation; pass obliquely down one side to the web, across the base of the toe, and up on the opposite side to the starting-point; dissect up the flap, and disarticulate during forcible flexion by dividing tendons, lateral and other ligaments. The oval method (Fig. 485) may also be used for both these last amputations.

FIG. 485.



A, disarticulation of the second phalanx of a toe by the racket or oval incision; *B*, disarticulation of the great toe by the oval incision (Treves).

Amputation of all the Toes may be done by opening the joints by a dorsal incision convexed downward, dividing the tendons, disarticulating, slipping the knife behind the bones, and shaving off a plantar flap.

Amputation of the Great or Little Toe with its Metatarsal Bone can be done by the oval method, the preliminary longitudinal incision curving somewhat upward over the base of the metatarsal bone to give more room. Two

or more toes with their metatarsals may also be removed by the same method, commencing the line of incision half an inch above the tarso-metatarsal joints, and carrying it so as to embrace the toes to be removed.

AMPUTATION THROUGH THE METATARSUS.

Cut from within outward a short dorsal flap slightly convex downward, and a long plantar one; free these; saw the bones across; suture so as to make the line of union on the dorsum of the foot.

AMPUTATION THROUGH THE TARSO-METATARSAL JOINTS.

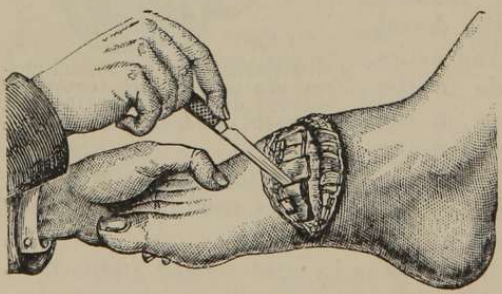
Hey's Operation.—Make an incision commencing on the outer side of the tuberosity of the fifth metatarsal bone, carry it down to the line of the metatarso-phalangeal joints, thence across the sole convex downward, and finally up along the inner side of the foot to the tuberosity of the scaphoid bone; connect the two extremities of this incision by a dorsal one, also convex downward; dissect up both flaps; disarticulate the four outer metatarsals, and saw across the internal cuneiform bone. The more common plan is to disarticulate the first, third, fourth, and fifth metatarsals, and saw across the base of the second metatarsal.

Fig. 486.

Lisfranc's Amputation (Treves).

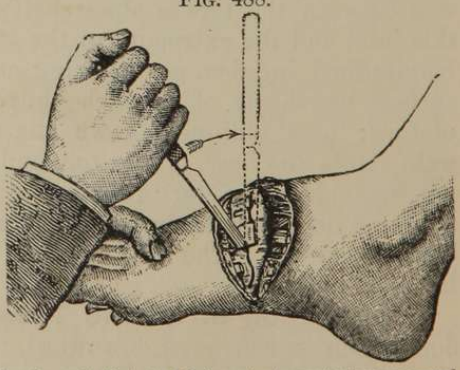
Lisfranc's Operation (Fig. 486).—For the right side grasp the front of the foot with the left thumb on the base of the fifth metatarsal bone, and the forefinger about half an inch in front of the tuberosity of the scaphoid bone; make an incision, convex downward, cutting to the bones between these two points; reflect the flap slightly; disarticulate first the three outer metatarsals, then the first, and finally the second, by cutting upward between its base and the internal cuneiform for about half an inch (the *coup de main*, Figs. 487, 488); repeat this procedure on the outer side, and complete the separation by a transverse cut, dividing the ligaments between the middle cuneiform and the base of the metatarsal bone. The disarticulation of all the bones is

Fig. 487.



The *Coup de Main* in Lisfranc's Amputation: first step (Guérin).

Fig. 488.



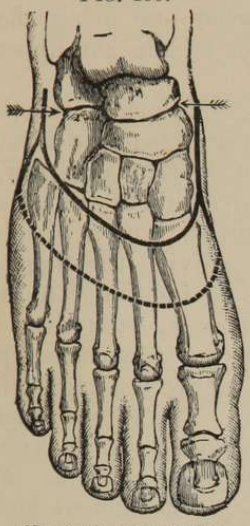
The *Coup de Main* in Lisfranc's Amputation: second step (Guérin).

greatly facilitated by forcibly depressing the front of the foot. Finally, pass the knife behind the bones and shave off a long plantar flap, longer on its inner side.

AMPUTATION AT THE MEDIO-TARSAL JOINT.

Chopart's Operation (Fig. 489).—As now performed, grasp the foot so that the thumb and forefinger (according to the side) are respectively about half an inch behind the tuberosity of the scaphoid and midway between the base of the fifth metatarsal and the outer malleolus; make a dorsal incision, curved downward between these points; divide the extensor tendons; forcibly depress the anterior part of the foot; disarticulate by dividing the ligaments, uniting the scaphoid with the astragalus and the cuboid with the os calcis; slip the knife behind and then under the bones, shaving off a long plantar flap, longer on its inner side.

Fig. 489.

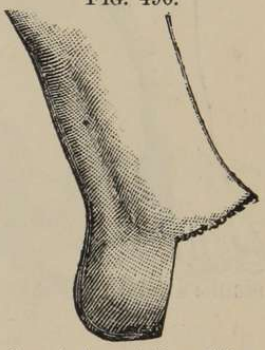


Chopart's Amputation (Treves).

AMPUTATIONS AT THE ANKLE.

Syme's Amputation (Fig. 490).—Hold the foot at right angles to the leg; enter the point of a short straight knife below the center of the external malleolus, and cut straight across the sole to a corresponding point on the other side—not to the tip of the internal malleolus; dissect the tissues of the sole back of the os calcis, keeping close to the bone, until the point of the heel is turned, and then cutting the tendo Achillis; unite the extremities of the first incision by a transverse one across the instep; open the joint; divide the lateral ligaments and complete the disarticulation; finally, clear the tibia and fibula and saw off the malleoli, including a small slice of the articular surface of the tibia; pass a drainage-tube through an opening made at the thinnest portion of the flap posteriorly; tie the anterior and posterior tibial vessels.

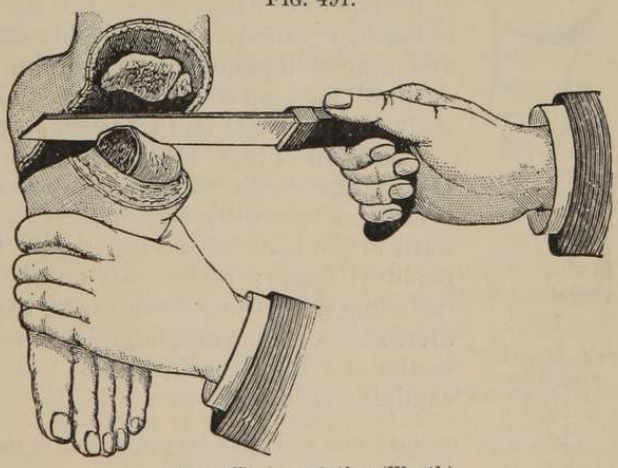
Fig. 490.



Syme's Amputation of the Foot (Treves).

Pirogoff's Amputation (Fig. 491).—Make a plantar incision obliquely forward from the tip of one malleolus to that of the other, extending down to the bone; dissect back half an inch; unite the extremities of the first cut by a second convex anteriorly, exposing the ankle-joint; disarticulate; slip a saw back of the astragalus and divide the os calcis obliquely downward in the line of the first incision; now remove the ends of the tibia and fibula; secure the vessels; suture the wound so that the sawn bones are in contact, and hold them there by two broad straps of adhesive plaster, crossing the end of the stump at right angles over the dressing; secure the limb on a posterior splint.

Fig. 491.

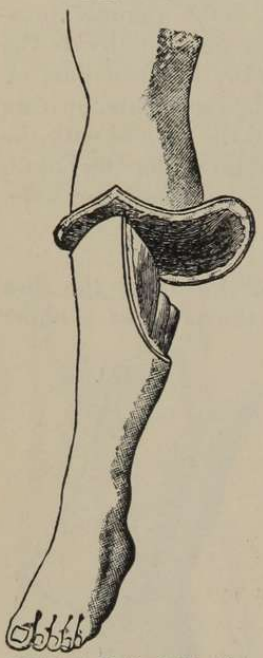


Pirogoff's Amputation (Wyeth).

AMPUTATION OF THE LEG.[1]

The modified circular is the best for the lower third,[2] while the double antero-posterior flap method, the anterior one being the longer, or Sédillot's, is better for the middle and upper portions.

FIG. 492.



Sédillot's Method (Wyeth).

Sédillot's Method (Fig. 492).—Make a short longitudinal skin incision along the *inner* edge of the tibia; draw the tissues to the fibular side, so that a narrow, long knife can be passed to the *outer* side of the tibia and fibula, transfixing the calf muscles; cut a broad, rounded flap by a sawing motion; divide the tissues on the inner side of the limb by an incision convex downward; clear the bones by a circular cut; divide the interosseous membrane; force the soft parts up so as to expose the bones one inch above the angle of the flaps, where they must be sawn. The anterior and posterior tibial and peroneal arteries, with two or three smaller branches, will require ligature; the line of union will be vertical, one angle being dependent and well fitted for drainage. In all leg amputations removing half an inch more of the fibula than of the tibia makes a better stump. The tibia should be first sawn for an inch obliquely from above downward and backward, and then by a fresh cut transversely. This bevels the sharp tibial crest, which otherwise might perforate the flap.

AMPUTATION OF THE KNEE-JOINT.

Flap Method.—Cut a long anterior quadrilateral cutaneous flap with rounded corners by commencing near the back of one tuberosity of the tibia and extending to the other, passing from one to three inches below the tubercle of the tibia, according to the length of the posterior flaps; dissect this up until the ligamentum patellæ is reached; divide this; forcibly flex the knee; cut the lateral and crucial ligaments; slip the knife behind the joint and cut outward, forming a short, square musculo-cutaneous posterior flap. Only the popliteal and a few small vessels will require ligature.

FIG. 493.

The Bilateral Flap Method of Stephen Smith.

Lateral Flap Method (Fig. 493).—**Stephen Smith's Operation.**—With a large scalpel commence an incision one inch below the tuberosity of the tibia; curve it downward and backward to the back of the leg, thence upward to the middle of the popliteal space; repeat this on the other side; raise the flaps, including everything down to the bone, until the joint is reached; divide the patellar and lateral ligaments and complete the disarticulation; the line of union is longitudinally median behind the condyles of the femur.

[1] See page 1194 for point of election for amputation of the leg, under the heading "Artificial Limbs."

[2] See page 1177 for "circular method" (Fig. 475), page 1178 (Fig. 476) for "single-flap" operations, and page 1179 (Fig. 477) for "mixed method."

AMPUTATION ABOVE THE KNEE.

This may be done by either of the methods advised, by sawing off more or less of the condyloid end of the femur, but the antero-posterior flap method is the better.

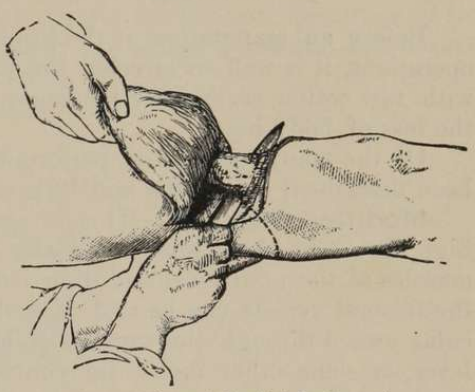
Carden's Operation.—This is done by dissecting up a large rounded anterior cutaneous flap, dividing the tissues behind by a transverse incision, and cutting the muscles in a similar manner down to the femur in front *above* the patella, which is drawn downward by flexing the knee; complete the operation by sawing through the base of the condyles.

Gritti's Operation.—In this a rectangular flap is raised from the front of the leg and knee, a shorter posterior one fashioned, the femur sawn across above the condyles, the cartilaginous surface of the patella removed by a small saw, and the two freshened osseous surfaces maintained in apposition.

AMPUTATION OF THE THIGH.[1]

At the **lower third** cut from without inward a semilunar flap, in length rather more than one-half the diameter of the limb at the point where the bone is to be sawn, and in width half the circumference; dissect this up, including everything down to the bone (Fig. 494); reflect it, and, passing the knife behind the femur, cut downward and backward, forming a posterior flap fully equalling the anterior in length, since the posterior thigh muscles will retract more than the anterior; clear the bone by a few circular cuts of the knife; force the tissues, including the periosteum, up with the knife-handle, and saw the bone an inch and a half above the angles of junction of the flaps. Seven or eight vessels will require ligature, perhaps more.

FIG. 494.



Amputation of the Thigh (Bryant).

Middle and Upper Thirds.—In either situation the same operation is to be recommended, as a rule cutting both flaps from without inward, lest they be too bulky, the posterior muscles being cut longer than the anterior to allow for retraction. The modified circular operation is also well adapted for operations at these points. In high thigh amputations there is oftentimes no room either for the tourniquet or for Esmarch's tube: in such case recourse must be had to either Wyeth's method, digital compression of the femoral against the brim of the pelvis, the abdominal tourniquet, or Macewen's method, controlling the circulation through the abdominal aorta. Macewen's method (Fig. 498) is as follows: As the patient lies upon his back on the table, the assistant, facing the patient's feet, stands upon the left side of the table in a line with the patient's umbilicus. He then places his closed right hand upon the patient's abdomen a little to the left of the middle line, the knuckles of the index finger just touching the upper border of the umbilicus, so that the fist covers about three inches of the distal extremity of the aorta above its bifurcation. The assistant, then standing upon his left foot, his right foot crossing his left and resting upon the toes of the right—an attitude commonly assumed by public speakers—leans upon his right hand and thereby exercises the necessary

[1] For point of election see Artificial Limbs, p. 1194.

amount of pressure. With the index finger of the assistant's left hand the weight necessary for the purpose can easily be estimated by the effect produced upon the flow of blood through the common femoral just below Poupart's ligament. Whenever the flow of blood through the femoral is absolutely arrested, the abdominal aorta is sufficiently controlled, and no further weight ought to be applied. If vomiting occurs, the pressure must be increased to overcome the resistance of the abdominal muscles. A strong rubber Esmarch tube passed around between the buttocks and over the iliac crest on the side of operation, crossing the pubic bone upon a firm compress placed over the vessel, where it is to be held by a special assistant, has been advocated (Jordan). Where injury or disease has destroyed the tissues irregularly or on one side of a limb, single, double, or triple lateral or antero-lateral flaps, as well as antero-posterior ones, can be successfully employed.

Amputation through the Trochanters, as being less dangerous than exarticulation at the hip, may be performed for injury or even for malignant disease, in which latter case, if on section the bone proves to be involved, the remaining fragment can be dissected out of the joint.

AMPUTATION AT THE HIP-JOINT.

Before an amputation at the hip-joint, as in some other similarly serious operations, it is well to envelop the patient's body and the other three limbs with raw cotton secured by bandages, so as to diminish shock by preventing the loss of body heat.

Of the many methods of performing this amputation (over forty-five have been described) only a few will be given.

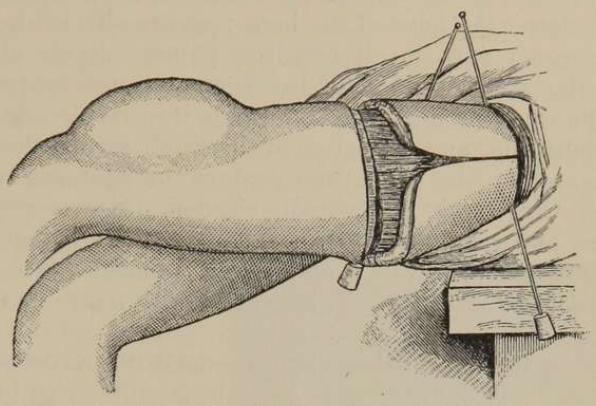
Modified Circular.—This is useful when a tumor involves the muscles high up. Cut short antero-posterior skin-flaps; make a circular cut of the muscles at the joint level and disarticulate: after the flaps have been reflected the femoral vessels can be tied, if desired, before they are divided by the circular sweep through the muscles. The abdominal tourniquet, Davy's rectal lever, or some other means for controlling the circulation must of course be employed if the artery is not to be tied after the anterior skin-flap has been reflected.

Hemorrhage during an amputation at the hip-joint may be prevented by compressing the common iliac artery by means of *Davy's lever*, which consists of a wooden rod two feet long and about one inch in diameter, with carefully rounded ends. After injecting two ounces of olive oil into the rectum, the instrument should be introduced until its extremity lies over the artery, where it occupies the groove between the last lumbar vertebra and the psoas muscle: the free end of the lever must then be carefully elevated and brought against the opposite thigh until the pulsation is arrested, the perineal tissues serving as a fulcrum: special care must be exercised when compressing the *right* common iliac vessels lest the rectum be lacerated—a not unknown accident.

Wyeth's Bloodless Method of Amputating at the Hip-joint.—With the hip well over the edge of the table, if the condition of the limb allows it, apply an Esmarch bandage as high as possible; enter the point of a steel mattress needle, three-sixteenths of an inch in diameter at its base and one foot long, one inch below and slightly to the inner side of the anterior superior iliac spine, carrying the needle through the tissues, so that the point will emerge on a level with and about three inches from the point of entrance; pass a second needle an inch below the level of the crotch internally to the saphenous opening, through the adductors, so that the point will come out about

an inch below the tuber ischii (Fig. 495); cover the needle-points with corks; pass a long piece of half-inch black—*i. e.* pure—rubber tubing, on the stretch,

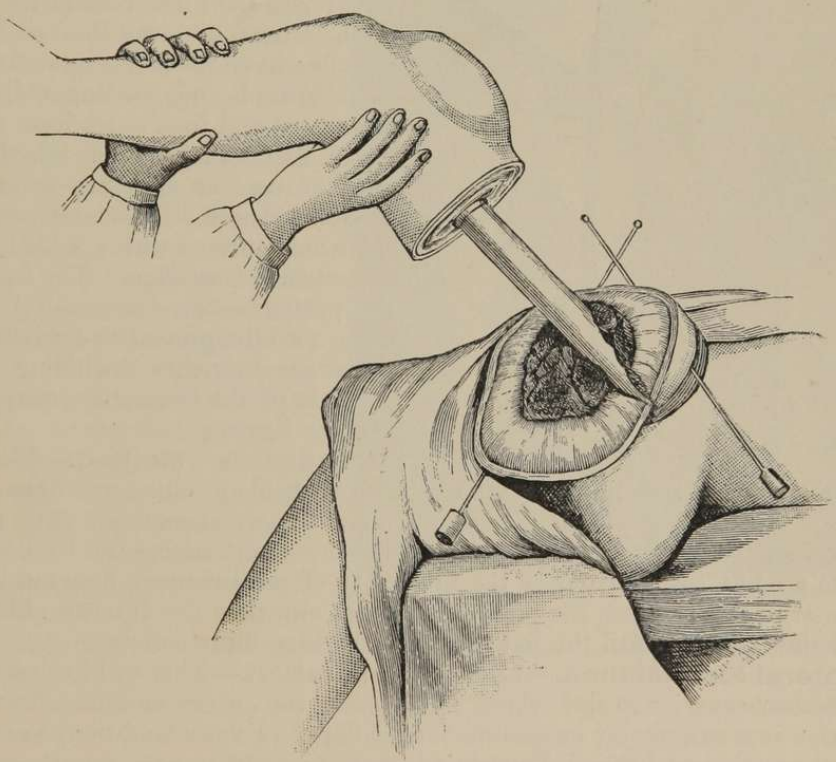
FIG. 495.



Wyeth's Bloodless Amputation at the Hip-joint: The pins and rubber tubing applied; circular and longitudinal incisions for skin-flap.

tightly five or six times around the thigh above the fixation needles, and tie or clamp it; remove the Esmarch bandage; six inches below the tourniquet

FIG. 496.



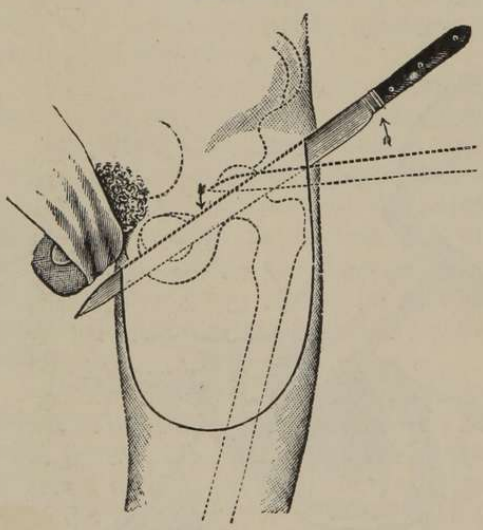
Wyeth's Bloodless Amputation at the Hip-joint: Cuff of skin and subcutaneous fat turned back, muscles divided at level of small trochanter, bone partly stripped, and large vessels exposed for deligation.

make a circular skin incision down to the deep fascia; this is joined by a longitudinal incision commencing at the tubing and passing over the trochanter

major; reflect the cellulo-cutaneous cuff to the level of the trochanter minor; by a circular sweep of the knife divide all the muscles at the same level (Fig. 496); remove the soft tissues from the bone for about four inches downward so as to reach the vessels; do not saw off the bone, but keep the entire limb for use as a lever in dislodging the head of the bone; secure all visible vessels; loosen the rubber tourniquet and tie all bleeding points; divide all the muscular attachments of the upper portion of the femur, always keeping close to the bone; expose the capsular ligament and divide it in its circumference. Forcible elevation, abduction, and adduction of the thigh permit the entrance of air into the socket and at the same time rupture the ligamentum teres, and the disarticulation is thus easily and rapidly effected. Secure any vessels cut by the last incisions, and coaptate the flaps vertically. To obviate the danger of infection from urine and feces, especially in women, place the drain well externally and seal the inner end of the wound with gauze or cotton and iodoform collodion.

Antero-posterior Flap Operations.—Liston's Operation.—With a ten- or twelve-inch blade transfix by entering the point midway between the anterior superior iliac spinous process and the trochanter major; graze the front of the joint, emerging in front of the tuber ischii, carefully avoiding wounding the genitals or opposite thigh, and rapidly cut an oval flap about five inches long (Fig. 497); let an assistant reflect this; open the capsule with the limb strongly rotated outward; cut the ligamentum teres; slip the knife behind the head of the femur, dividing the rest of the capsule; have the femur rotated somewhat inward, and, cutting obliquely downward and backward, form a posterior flap equalling in length the anterior one; as each flap is cut an assistant should seize it and compress the whole surface with a folded towel to control hemorrhage. The femoral, the profunda, the comes nervi ischiadici, with the gluteal and sciatic and numerous branches, including some of those of the obturator artery, will require ligature.

Fig. 497.



Liston's Amputation at the Hip-joint (Wyeth).

Guthrie's Method.—With a four-inch blade cut a semilunar posterior flap, commencing a little above the trochanter major, and passing in a curve downward across the back of the limb to a point just in front of the tuberosity of the ischium; map out a similar anterior flap; divide the posterior muscles and then the anterior obliquely from below upward until the joint is reached; then disarticulate.

Lateral Flap Method.—Larrey's Operation.—This will be described, not because superior to the others, but because the injury or tumor for which operation is required may necessitate lateral flaps. Expose and tie the common femoral vessels just beneath Poupart's ligament; transfix with a knife entered in the incision perpendicularly between the muscles inserted into the trochanter minor and the contiguous under surface of the femur, and cut a short internal flap by directing the knife obliquely downward and inward, which should be reflected by an assistant; freely incise the capsule as the femur is forcibly

abducted; divide the ligmentum teres; slip the knife between the head of the femur and the acetabulum and cut a postero-external rounded flap by an incision directed downward and backward; pressure with a towel and the hand must control bleeding until catch forceps can be applied to the bleeding points.

Hemorrhage in Hip-joint Amputations.—As the chief immediate danger in hip-joint amputation is that of hemorrhage, it is important to understand how to apply the abdominal tourniquet unless Wyeth's method be employed. As this is one of the most efficient means, so it is also attended with some danger if applied with too much force. The bowels must be well emptied by a cathartic and an enema, and got out of the way by gently rolling the patient upon the right side before applying the pad. The pad should then be adjusted, with a soft sponge interposed between it and the skin a little to the left of the umbilicus; but as the aorta may be median, it is better to feel for the pulsation of the vessel rather than to rely upon any arbitrary rule: either Pancoast's (a large Skey's tourniquet) or Lister's (a large Hoey's clamp) may be used, the pad being screwed down only hard enough to control pulsation in the iliac; and not a moment should be lost in putting catch forceps on every oozing point after ligating the main vessels, so that the tourniquet may be promptly loosened. With a thin patient digital compression of the aorta may be effected, while a firm pincushion secured over the vessel by a few turns of an Esmarch bandage makes a good improvised tourniquet, the chief objection to this being that it interferes unduly with respiration. An Esmarch bandage applied up to the lower limits of the tumor or injury and allowed to remain during the operation is invaluable, because it drives into the circulation, and thus saves, all the blood contained in the limb. Macewen has effectively controlled the abdominal aorta by throwing the weight of the body on the aorta through the closed right hand (Fig. 498) placed a little to the left of the middle line, the knuckles of the index finger just touching the upper border of the umbilicus. With the left hand the arrest of the blood-current is ascertained by feeling the femoral at the brim of the pelvis. Only enough weight to arrest the femoral pulse is required. If the patient vomits or coughs, the pressure must be increased, lest the hand be lifted from the aorta by the abdominal muscles.

FIG. 498.

Macewen's Method for Compression of the Abdominal Aorta.

ARTIFICIAL LIMBS.

As it is not possible for all patients who lose limbs to obtain artificial ones, many of the methods of amputating described will still be practised; but while it is true that owing to the inefficiency of prothetic apparatus for the upper extremity all that can possibly be saved should be here conserved, in the lower limb an amputation at the junction of the middle and lower thirds of the thigh, or one at the same point of the leg, renders artificial progression far easier than is possible after knee- or ankle-joint amputations or partial amputations of the foot, and should always be adopted if possible.

The attempt to supply lost portions of limbs dates back to about the beginning of the sixteenth century, and the present "box-" or "peg-leg" is essentially that described by Ambroise Paré.

Artificial Arms.—The simplest form of apparatus for amputations *below the shoulder* consists of a leather socket accurately fitting and ensheathing the stump for several inches, secured to the part and to the body by proper straps; by means of light internal and external steel rods jointed at the elbow, and a concealed cogged wheel and ratchet manipulated by the other hand, movement with fixation at any desired angle can be obtained; at a point corresponding to the wrist is secured a wooden block with central iron socket, into which a knife, fork, show-hand, or iron hook can be screwed. With the latter a man can use the spade, drive, and indeed make a living by light manual labor.

A similar apparatus with the socket fitting what remains of the forearm, and secured by a broad laced band or straps above the elbow, serves an excellent purpose for amputation *below the elbow*. When a cheaper arm for amputation above the elbow is desired, and flexion at the joint can be dispensed with, a raw-hide moulded apparatus, curved according to Biggs's suggestion, and stiffened by two lateral steel bands, fitted of course with the same terminal wooden block and screw socket, both looks well and enables the patient to work with considerable ease.

Many pages could be devoted to the consideration of the more complex artificial limbs, but the attempt will be made here only to describe a few typical apparatuses, while those desiring more explicit information in the English language are referred to special treatises on this subject.

The power by which the artificial member is moved, if the amputation be above the elbow, is often communicated by cords passing from the other arm, but by Graefe's plan, which is employed in a modified way to-day, spontaneous movement is effected by springs or catgut strings secured to a corset embracing the shoulder and thorax, by the action of the shoulder and trunk muscles, unaided by the other hand, even in amputations of the arm proper. Where the thumb remains, but the rest of the hand down to the metacarpus has been removed, the best results are to be obtained by an artificial hand with immovable, partly-flexed fingers secured by a moulded leather socket fitting over the carpus and secured to the forearm.

For amputation *through the forearm* the following apparatus of Van Peterson, although old, is one of the best: A sheath of light wood enclosing the stump is secured to the arm by two padded leather bands connected by vertical straps; the hand, movable at the wrist in flexion and extension, has the fingers kept constantly flexed, with the thumb apposed to the tip of the forefinger by springs; from the encircling band just above the elbow is a strap connected with a cord passing around a concealed pulley near the wrist, so that when the arm is extended to seize an object the fingers are also extended, while when the forearm is flexed to bring the object forward, the fingers close

by virtue of springs, grasping the object. The efficiency of this apparatus is in proportion to the length and strength of the forearm stump.

The loss of the arm *at or above the elbow* is also best remedied by Van Peterson's adaptation of Graefe's ideas. This apparatus consists of an articulated arm, forearm, carpus, and phalanges, the stump being received into a socket which is secured to the shoulder and chest by a "corset of that sort which readily transmits to the artificial arm all the movements which are made by the stump if he brings it forward, backward, upward, or downward." Three catgut cords are fastened to the corset—one back of the sound shoulder, one beneath the armpit on the side of amputation, and one near the shoulder of the same side. These are so disposed that when the stump is drawn forward the traction flexes the forearm; when it is carried back, the forearm is extended and carried away from the body, in which position the fingers—held flexed by springs—are opened. To seize anything, the patient need only carry the hand thus opened to the object, and gently draw the stump toward the body, when the springs will close the fingers upon, say a cup, which can now be carried to the mouth by bringing the stump forward, this motion flexing the forearm and bringing the hand to its destination. The arms of Charrière, Mathieu, and Bechard are far inferior in usefulness to that of Van Peterson.

Artificial Legs.—For *partial amputations of the foot* a metallic sole, somewhat elastic at its fore part, with a raised margin around the heel, should be secured to two light lateral steel splints extending to just below the knee, jointed opposite the ankle, and held in proper relation with one another and the leg by two transverse padded semicircular metallic bands, to which straps are attached in front so as to secure the apparatus to the leg. A hollow wooden or moulded raw-hide foot may be used to fill out the boot in front.

Bechard's modification of Martin's apparatus—for the description of which there is not space—is the best for the average *Chopart stump*. For a *Syme or subastragaloid amputation* the simplest apparatus is a laced leather boot-leg stiffened by lateral steel supports, with a heel composed of thick cork lined with chamois leather.

For amputations *below the knee* the peg or bucket leg employed since the time of Paré may be used, consisting of a stout wooden peg with an expanded lower extremity, attached by the other end to a socket composed of a conical piece of light wood, with two lateral splints embracing the thigh, the inner of which should extend only to the middle of the thigh, while the external reaches to the iliac crest and is fastened around the pelvis by a padded belt; a strap passed around the lower part of the thigh holds the inner short splint to the outer. The front of the flexed knee rests upon a cushion between the two splints.

When selecting a more elaborate apparatus certain *general principles* must be kept in mind—viz. no pressure must be made on the end of the stump; the points of support must be the thigh, the circumference of the leg, the inferior border of the patella, and the tuberosities of the tibia, the tuberosity of the ischium, one or all, according to the point at which the limb has been removed or as the special requirements of the case demand; moreover, where an artificial knee-joint is required the center of motion must be *behind* the long axis of the lower extremity, and it is essential that the foot shall be capable of eversion and inversion as well as of flexion and extension, so that the whole surface of the bottom of the foot can rest upon the ground whatever may be the direction of the artificial limb. Probably the best leg is that of Bly of Rochester, consisting of a proper socket and bearings with the center of movement of the knee-joint posterior to the axis of the limb, a foot with a metatarso-phalangeal joint,

and a tibio-tarsal articulation formed by a glass ball enclosed in a vulcanized rubber sac, with four adjustable rubber muscles, which enable all the normal movements of the foot to take place, while the eccentric position of the knee-joint does away with the necessity of any thigh extensor when the limb has been removed above the knee. The artificial limb of Myops may perhaps serve a better purpose when the amputation has been made just above the tibio-tarsal articulation, being constructed on the same principles as that of Bly, but employing spiral springs instead of compressed rubber for muscles. Marks's rubber foot, constructed of a light piece of wood imbedded in a mass of rubber of the shape of the foot, is immovably connected with the leg, but the rubber, by virtue of its elasticity, is said to accommodate itself to all surfaces, thus compensating for the absence of the movements of the tibio-tarsal joint.

After amputations *at the knee-joint*, both in the peg leg and in the more elaborate substitutes, the end of the stump—as in Hudson's limb—must rest upon the distal extremity of the thigh armor. This in Hudson's apparatus consists of a concavo-convex posterior splint laced on the thigh, with a lower extremity modelled so as to represent the femoral condyles, which is secured by proper bolts and joints to a metal surface on the leg section resembling the articular surfaces of the head of the tibia. Artificial ligaments and muscles favor the natural knee movements.

Sufficient has been already incidentally said about artificial limbs for *thigh amputations*, except that the support ought to be taken from the tuberosity of the ischium, the gluteal region, and the pelvis, and not through the medium of the thigh armor, which will sooner or later create trouble with the stump.

Prothetic apparatuses for *hip-joint amputations* are so rarely required, and are in general so unsatisfactory, that only a few words need be devoted to the general principles involved in their construction, the student being referred for further details to Watson on *Amputations and their Complications*. (Acknowledgment is here made to this source for many of the foregoing facts.)

Pelvic armor, moulded to the gluteal and iliac regions on the side of amputation and on as much of the opposite side of the pelvis as can be utilized, and bearing upon the tuberosity of the ischium, must be firmly secured by circum-pelvic straps supported by suspenders: the artificial hip- and knee-joints can flex only in the sitting position, this movement being permitted by the withdrawal of bolts which are movable at will by means of a strap. The usual means of progression is by undulatory movement of the body, projecting the limb by a swing similar to that employed by the hemiplegic, although a strap passing from the foot, secured over the front of the knee and obliquely encircling the shoulder of the sound side and thorax, may be employed to impart additional movement to the limb by the action of the opposite shoulder muscles: it hardly again needs mention that during progression the artificial knee- and hip-joints must be rigid; a cane or even a crutch is usually needful.

CHAPTER VII.

MINOR SURGERY.

I.—SURGICAL DRESSINGS.

ANY surgical wound-dressing should be *absorbent*, to admit of the ready impregnation with medicinal substances and to absorb discharges. The substances in most common use are lint, absorbent cotton and gauze, tow, oakum, jute, wood-wool, moss, peat, and pine sawdust.

Lint, in the form of "patent lint," is well adapted for wet dressings and for spread cerates; *domestic lint* is prepared from old linen, boiled in a weak alkaline solution, freed from this by washing, dried, and scraped on one side with a knife; this latter procedure may be dispensed with. *Paper lint* is moderately absorbent, and can be used with fair satisfaction for the application of wet dressings over unbroken surfaces. *Absorbent gauze* is ordinary cheese-cloth from which all greasy material has been removed by boiling in a weak alkaline solution (*e. g.* washing soda or soft soap), thoroughly rinsing out in pure water, and drying. It can readily be impregnated with any medicinal agent, and freely absorbs discharges. *Tow*, unless rendered aseptic, should only be used outside other dressings as an absorbent or to pad splints; the same remark is applicable to *oakum*, *jute*, and the substance now to be considered. *Absorbent cotton*, made by a process similar to that for preparing gauze, is an exceedingly useful material, readily rendered antiseptic by impregnating it with antiseptics in solution or in fine powder; it can also be used for wet dressings. *Moss*, long-fibred, such as abounds in the far South, cleansed and baked, is an excellent outside dressing, as is *wood-wool*, *peat*, or *pine sawdust* sewn up in bags of proper size. So far as possible, all these substances, when not made antiseptic by germicidal drugs, should be rendered aseptic by proper heating.

Practically speaking, the **antiseptic gauze** prepared with corrosive sublimate or carbolic acid and the **sublimated wood-wool**, prepared in sheets, are the two dressings chiefly used in this country.

For various mechanical purposes surgical dressings are used in the form of *compresses*, firm masses of different sizes and shapes, oblong, square, cylindrical, graduated, etc., made by folding up lint or muslin. *Graduated compresses* may be either pyramidal or wedge-shaped, and are formed by superimposing one upon another, in proper relation, a series of square or oblong compresses of gradually diminishing size. A square of lint or muslin cut from the angles toward its center forms a *Maltese cross* well adapted for snugly applying a dressing over a projection, as a stump. *Pledgets* are compresses formed of cotton, tow, oakum, etc., in which the fibers are pulled longitudinally until most are parallel, the ends folded and tucked in, and then formed by pressure of the hands into various shapes: they are used externally to other dressings to absorb discharges or to exert compression. *Tents* are small cylinders or cones made by rolling strips of gauze or lint or by twisting masses of oakum into the required shape: they are occasionally used to keep wounds open to permit serum or pus to escape. If wet dressings are employed, especially where warmth is desired, some covering impervious to heat and moisture must be used, such as "rubber dam," oiled silk, paper passed through melted wax or paraffin, or even stout paper thoroughly greased.

II.—BANDAGES.

Roller Bandages (Plates XXXIV to XXXVII) consist of strips of unbleached muslin varying from one inch to four inches in width and from one to twelve yards in length, which are rolled up from one end so as to form cylindrical masses or "single-headed" rollers, or are rolled from both ends, constituting "double-headed" rollers. Bandages are rolled either by the hand or with some kind of bandage-roller. To roll by hand, fold one end for two or three inches several times upon itself, then, forming this portion into a small mass, roll the bandage up upon the thigh until a small cylinder is formed. Next seize this between the thumb and forefinger of the left hand, the unrolled portion firmly held between the extended right forefinger and thumb, keeping up moderate traction so as to tighten the cylinder, which is formed by first supinating the left hand, then, loosening the grip, pronating the same hand to gain a fresh hold, so that by supinating again the cylinder will be rolled around its long axis from right to left: this rotation is kept up by a series of movements of supination and pronation, the remaining fingers of the left hand aiding in the revolution of the cylinder, while the extended right forefinger and thumb revolve partly around the cylinder. A single-headed roller consists of an initial or free end, a terminal one—*i. e.* that in the center of the roll—and a body, the portion between the two extremities. In applying a single-headed roller hold it between the thumb and fingers of one hand, pressing it firmly into the palm by the fingers, and always place the external surface of the free end on the part to be bandaged, to prevent its sudden unrolling: retain it there by pressure of the fingers of the other hand until it can be fixed by one or two circular turns. All bandages must lie smoothly, exercising the same pressure by their edges as elsewhere, otherwise excoriation of the skin or interference with the circulation may result. The turns of a roller applied to a cylindrical part may pass in a circular manner, each turn exactly covering the preceding ones (*circular bandage*).

A conical part may be covered by causing the turns to ascend more or less rapidly in a spiral manner (*spiral bandage*), each turn overlapping the preceding one about one-third. In most limbs the attempt to cover in with a spiral will result in only one edge of the bandage being in contact with the part, the other standing freely off. To obviate this, adopt the following manœuver: hold the spiral turn just made with the fingers of the left hand on the upper surface of the limb, then with the roller held in the supinated right hand, four to eight inches being unwound so as to form a dependent loop, pronate the hand; carry the bandage loosely beneath the limb until the opposite side is reached, when by gentle, gradual traction the reversed turn will snugly apply itself to the part: this is called a "reversed turn" or "making a reverse," and, combined with the spiral turns, "*a spiral reversed bandage.*" The secret of success is to make the loop of bandage turn over without the slightest traction, this being made only when the opposite side of the limb is reached.

When a projecting point is to be covered—the elbow, for instance—a series of *figure-of-8* turns, applied alternately above and below, will best secure this end, each overlapping its neighboring turn by one-third of its width. Such regions as the groin, axilla, shoulder, and breast can be best covered by what are essentially figure-of-8 turns, each succeeding one ascending from below upward, overlapping by one-third, forming a figure like "the leaves of an ear of corn," one member of the figure-of-8 encircling the thigh, for instance, the next the pelvis, the next the thigh and groin, and so on: this bandage is called a *spica.*

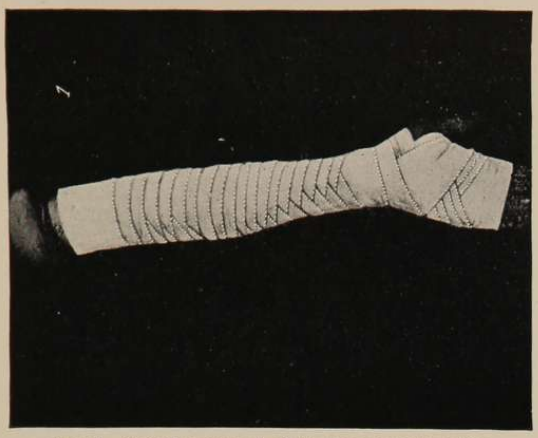


FIG. 1.—Spiral reversed of the upper extremity.

FIG. 2.—The gauntlet.

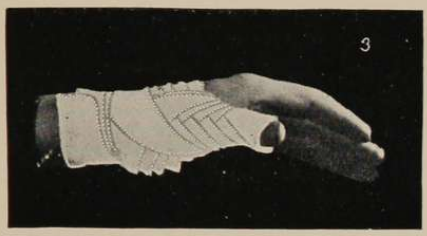


FIG. 3.—Spica of the thumb.

FIG. 5.—Spiral reversed of the lower extremity.

FIG. 4.—The demi-gauntlet.

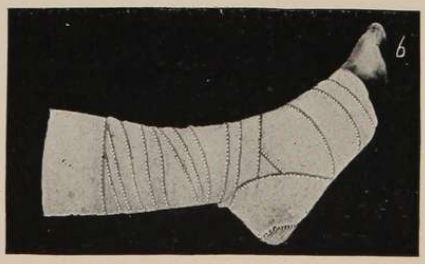


FIG. 6.—Method of covering the heel.

Bandages placed on the extremities should be applied more loosely as they advance from below upward, especially if the limb is flexed, in order not to interfere with the circulation. Until experience teaches the surgeon how firmly turns of bandage can with safety be drawn, they should be applied loosely rather than tightly. When used to retain dressings or splints, a number of moderately firm turns, passing and repassing over one another, will secure better fixation than a single layer drawn dangerously tight. All firmly-applied dressings of the extremities should leave the fingers and toes exposed: the patients should be seen within a few hours, when, if the parts do not feel easy, or a duskiness of the exposed portions is seen, or numbness of the fingers or toes is complained of, the dressings should be loosened. If a pin secures the end of a bandage, it should be introduced point downward. In bandaging the arm to the chest, etc. a pad must be interposed to prevent chafing. Skin must never be in contact with skin.

The special methods of applying certain bandages will now be given in detail, by modifications of which any form of dressing may be devised.

Spiral Reversed Bandage of the Upper Extremity.—With the initial end of a roller eight yards long, take two circular turns around the wrist; pass thence obliquely across the back of the hand to the extremities of the fingers; ascend the hand by three or more spiral turns to the metacarpo-phalangeal joint of the thumb; cover this and the wrist by figure-of-8 turns, and ascend the forearm by spiral turns, adding reverses when requisite until the elbow is reached, when, if the joint is to be flexed, it must be covered in with figure-of-8 turns, after which continue the spiral or spiral reversed turns up the arm (Plate XXXIV, Fig. 1).

Spiral of the Fingers.—By two circular turns around the wrist fix the initial end of a roller one inch wide and one and a half yards long; pass obliquely across the back of the hand to the root of the finger; descend to its tip by very oblique turns, whence the bandage must ascend by a series of spiral reverses; secure by splitting the bandage for a few inches and tying the ends around the root of the finger, or ascend to the wrist by a spiral turn, terminating by a circular turn. All the fingers may be thus bandaged in succession, the hand finally being covered in by a series of figure-of-8 turns, forming the *gauntlet* (Plate XXXIV, Fig. 2).

The Spica of the Thumb is started by a circular turn around the wrist, and a second turn follows to hold the first in position. It then sweeps across the back of the hand and the back of the metacarpo-phalangeal articulation under the middle phalangeal joint to the upper surface of the last phalanx of the thumb: several ascending spiral turns are now made, and the ball of the thumb is then covered by a series of ascending figure-of-8 turns. The spica of the thumb is used to retain splints and dressings or to arrest hemorrhage by pressure (Plate XXXIV, Fig. 3).

The Demi-gauntlet has but a limited field of usefulness, and, as it leaves the fingers free, it must not be tightly applied. It is used to retain dressings on either the dorsum or palm. If we desire particularly to cover the palm, that portion of the hand is turned up, or if the dorsum, that part is made superior. Take two circular turns around the wrist; sweep to the root of either the thumb or little finger; pass it around the base of the extremity and return to the wrist, and so progressively bandage each finger, and finally run a series of ascending figure-of-8 turns, including the hand and wrist, from the roots of the fingers (Plate XXXIV, Fig. 4).

Spiral Reversed Bandage of the Lower Extremity.—With the tip of the patient's heel on the surgeon's knee or properly supported by an assist-

ant, fix the initial extremity of a roller seven yards long and two and a half or three inches wide by circular turns just above the malleoli; descend obliquely over the dorsum, under the sole, and back to the dorsum of the foot, up which the bandage must pass by several spiral turns, covering in the instep; when this is reached, pass the bandage under the point of the heel, thence to the dorsum, then down beneath the sole, then along the outer surface of the heel, next around the heel above its point to reach the instep, whence, passing to the sole, a turn is made around and above the point of the heel on the inner side, again to pass to the instep, when the roller must be carried by spiral and reversed turns up to the knee. There it is finished off by a few circular turns. If it is desired to extend the dressing above the knee, this must be covered by figure-of-8 turns of a second roller, and the thigh ascended by spiral and reversed turns. When the heel does not require covering, the turns beneath and around the point of the heel must be omitted (Plate XXXIV, Fig. 5).

The method of covering the heel is shown in Plate XXXIV, Fig. 6.

The Spica of the Instep starts by a circular turn around the ankle, followed by a second turn to hold the first; the roller now sweeps across the instep to the root of the toes under the sole of the foot, and ascends for a distance by several spiral or spiral reversed turns. From the instep a turn is made across the point of the heel, another somewhat higher and another somewhat lower to catch the free edge, and the bandage is ascended by figure-of-8 turns around the ankle and instep (Plate XXXV, Fig. 1).

The Crossed or Figure-of-8 of One or Both Eyes.—Place the initial extremity of a two-inch roller five yards long on one temple; make two circular turns around the forehead and occiput from right to left for the right eye; reaching the occiput, pass from under the right ear up over the right eye, across the opposite temple, down to the occiput; then, repeating two or more of these oblique turns, finish off with a circular turn around the forehead. If both eyes are to be covered, proceed as before until the third oblique turn over the right eye has reached the left parietal protuberance, when, instead of descending to the nape of the neck, pass around the forehead, down over the root of the nose, the left eye, left cheek, under the same ear to the nape of the neck, thence to the right parietal protuberance, down again over the left eye, and, making two more similar turns, finish off with a few circular turns around the forehead (Plate XXXV, Fig. 2).

Barton's Bandage, or Figure-of-8, of the Jaw.—Place the initial extremity of a roller two inches wide and five yards long on the nape of the neck just beneath the inion; pass over the right parietal bone to the vertex, down over the left temple to the chin, beneath this up the right side of the face and right temple to the vertex, down over the left parietal bone to the starting-point at the nape of the neck, thence around the right side of and along the jaw to the chin, across the front of which the bandage must pass back to the nape of the neck: a repetition of these turns, with pins at their points of intersection, completes the dressing (Plate XXXV, Fig. 3).

The Gibson Bandage starts with three vertical turns around the head and jaw and in front of the ears. Just above the level of the ear, after the three vertical turns have been made, the bandage is reversed and carried three times horizontally around the head and forehead. As the bandage reaches the occiput after completing the third horizontal turn, it drops to the base of the skull, and is run forward below the ear and around the chin back to the opposite side of the head and neck to the starting-point. Three of these neck-and-jaw turns are made. On completing the third turn the bandage is reversed and carried from the occiput to the forehead over the vertex, and fastened with a

FIG. 1.—Spica of the instep.

FIG. 2.—Crossed or figure-of-8 of both eyes.

FIG. 3.—Barton's bandage, or figure-of-8 of the jaw.

FIG. 4.—Gibson's bandage.

FIG. 5.—Oblique or crossed bandage of the angle of the jaw.

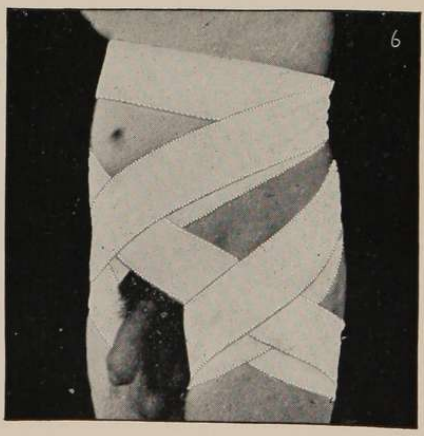


FIG. 6.—Spica of the groin.

pin. Pins are now introduced at points where the turns cross each other. This bandage is used in fracture or dislocation of the jaw (Plate XXXV, Fig. 4).

The OBLIQUE or CROSSED BANDAGE OF THE ANGLE OF THE JAW is started by a circular around the forehead, and a second turn to hold the first, running toward the affected side. After the completion of the second turn the bandage is carried around the head to the base of the skull, passes forward to the opposite side, and is carried under the ear and under the jaw to the front of the ear of the injured side. A series of advancing turns are now made, in front of the ear of the injured side and back of the ear of the sound side, until the parts are sufficiently covered. The bandage is ended by carrying the last turn under the ear of the injured side to below the occiput on the opposite side, and then by a circular around the forehead and occiput (Plate XXXV, Fig. 5).

This bandage is used with a compress in fractures of or near the angle of the lower jaw, and for retaining dressings on the chin, side of the face, and vault of the cranium. It is a useful dressing, but is tight and uncomfortable, and it makes so much pressure on the throat as to be rather unsafe for young children or to apply to a person not entirely recovered from an anesthetic.

THE SPICA OF THE GROIN OR FIGURE-OF-8 OF THE PELVIS AND THIGH.—With a three-inch roller ten yards long make two circular turns around the pelvis, passing from right to left, and from before backward if for the right groin, and the reverse if for the left. Reaching the front of the right groin, pass over the inner side of the thigh, beneath and around it to reach the groin, whence the bandage, crossing the first turn, ascends to the ilium of the opposite side, beneath the back around the pelvis to the right groin as before, each turn ascending the thigh and covering one-third of the previous one until by their repetition the roller is exhausted. With a longer bandage by passing every other turn around the opposite instead of the same thigh a *spica of both groins* may be applied (Plate XXXV, Fig. 6).

SPICA OF THE SHOULDER.—Start a two-and-a-half-inch roller by one or two spiral reversed turns around the upper arm, then pass up from behind over the shoulder, over the front of the chest, beneath the opposite axilla, across the back, over to the front of the arm, around which it must wind to pass from over the back of the shoulder to the front of the chest, the successive turns advancing from below upward (Plate XXXVI, Fig. 1).

FIGURE-OF-8 BANDAGES of both SHOULDERS (Plate XXXVI, Fig. 2), of one or both BREASTS (Plate XXXVI, Fig. 3), of the NECK and AXILLA (Plate XXXVI, Fig. 4), of the ANKLE (Plate XXXVI, Fig. 5), or of the ELBOW (Plate XXXVI, Fig. 6), convey in their names the method of application, the only advice requisite being to fix the initial end by circular turns around the arm, leg or chest.

VELPEAU'S BANDAGE.—Place the palm of the hand of the injured arm on the shoulder of the sound side, with padding between the arm and the chest-wall to prevent chafing; place the initial extremity of a two-and-a-half-inch roller ten yards long under the axilla of the sound side, pass up over the back, over the clavicle, down the front and *outside* of the arm, under the *outside* of the elbow, up over the chest to the sound axilla; repeat the first turn, but on reaching the sound axilla the second time, pass around the chest and over the injured arm to the same axilla, then make a turn over the clavicle and arm, then a circular, the turns *ascending* spica-wise: pin the points of intersection of the turns (Plate XXXVII, Fig. 1).

The DESAULT BANDAGE consists of three rollers, a pad, and a sling. The first roller is to be applied while the arm of the injured side is extended at

right angles to the body. A wedge-shaped pad with the base up is inserted into the axilla, and this first bandage holds the pad. It is applied by ascending spiral turns around the chest, and is fastened by carrying the roller obliquely across the front of the chest, over the sound shoulder, under the axilla, over the shoulder across the back to the pad, obliquely over the lower portion of the chest to opposite the lower portion of the pad, and then ascending spiral turns are made to a level with the top of the pad (Plate XXXVII, Fig. 2).

The arm is now brought to the side over the pad. This pad is the fulcrum, the arm is the lever, and the second roller of Desault is the force to correct the inward displacement of the fracture of the clavicle. The second roller of Desault holds the arm to the side by a series of ascending spiral turns, including the arm and chest, starting just above the elbow and terminating just below the shoulder of the injured side (Plate XXXVII, Fig. 3).

The third roller corrects the downward and forward displacement from a fractured clavicle. It starts in the axilla of the sound side anteriorly, runs to the top of the shoulder of the injured side, down the back of the arm to the elbow, and from this to the point of origin. The roller is now carried backward under the axilla of the sound side, runs across the back to the shoulder of the injured side, down the front of the arm to the elbow, and from this point across the back to the point of origin. These turns give us two triangles, an anterior and a posterior. Remembering that the third roller of Desault starts in the axilla of the sound side anteriorly, its formula is: from axilla to shoulder, from shoulder to elbow, from elbow to axilla, pass to the back; and again from axilla to shoulder, from shoulder to elbow, from elbow to axilla (Plate XXXVII, Fig. 4).

After the application of the third roller the hand is hung in a sling.

Recurrent Bandage of the Head.—Fix the initial extremity of a six-yard roller, two inches wide, by circular turns parallel to the supraorbital ridge. When the middle of the forehead is reached, reverse, hold the reverse with a finger of the left hand, carry the bandage over the sagittal suture to the occiput, reverse here; let an assistant hold the turn, carry back the roller obliquely to the forehead, reverse, hold, carry back to the occiput, repeating these turns, covering in one-third of each preceding one until the left half of the head is covered from above downward to the circular turns; then cover in the right side by similar turns, fixing all by circular turns and careful pinning (Plate XXXVII, Fig. 5). The same bandage can be applied by a double-headed roller, the body placed over the occiput or forehead, circular turns made, and then the recurrent turns by one head of the roller while the other is continued in a circular manner, fixing each recurrent turn as it is made.

Recurrent Bandage of Stumps.—This should be applied with a single-headed roller of proper width precisely as for a recurrent of the head, commencing by circular turns a few inches above the end of the stump, followed by the recurrent turns covering the stump, and finishing off by circular turns (Plate XXXVII, Fig. 6).

T-Bandages.—These consist of a strip of muslin long enough to encircle the part once or twice, to the middle of which a second shorter strip, or sometimes two strips, are secured at a right angle: when one cross-strip is employed, the bandage is called a single T, when two, a double T.

Double T of the Perineum.—Pass the transverse portion around the body just above the iliac crests, with the vertical strips at the mid-point behind; tie or pin; then bring one vertical strip over the dressings between one thigh and the genitals, and the other between the opposite thigh and the genitals, securing both to the transverse portion. A single or a double T-bandage may

FIG. 1.—Spica of the shoulder.

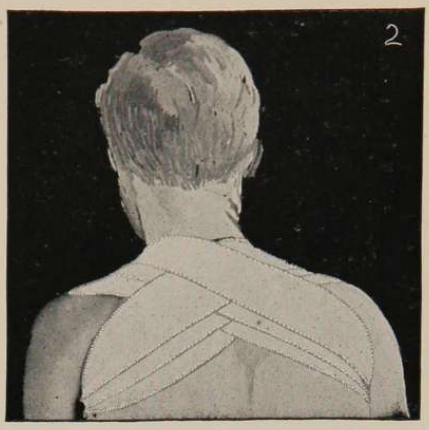


FIG. 2.—Posterior figure-of-8 of both shoulders.

FIG. 3.—Figure-of-8 of one breast.

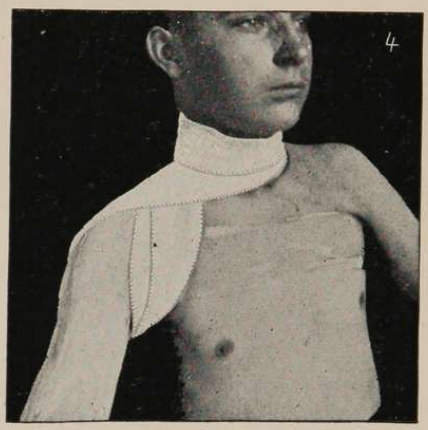


FIG. 4.—Figure-of-8 of neck and axilla.

FIG. 5.—Figure-of-8 of the ankle.

FIG. 6.—Figure-of-8 of the elbow.

be employed to retain dressings on the head, the transverse portion passing around the cranial vault, the other passed over the dressings, *beneath* the transverse strip, back again to it, and there pinned: a wide vertical piece, for instance, may be used to cover in an ear.

FOUR-TAILED BANDAGE.—This is useful to retain dressings on the chin, etc., and is made of a strip of muslin three to four inches wide, long enough to encircle the part and overlap somewhat; turn down the middle of each end toward the center. In applying it to the chin, for instance, place the body of the bandage over the point of the chin, pass the anterior or upper pair of tails over the front of the chin, beneath the ears to the nape of the neck, and secure them; then bring the other tails up beneath the chin to the back part of the vertex; tie or pin.

HANDKERCHIEF BANDAGES.—These consist of large handkerchiefs or pieces of muslin about three-fourths of a yard square, one of which, folded once, forms an *oblong;* its diagonal angles being brought together, a *triangle;* by folding a triangle from its summit to its base, a *cravat* is formed; while a cravat twisted is a *cord.* It would require many pages to describe all temporary or permanent handkerchief bandages, and but three will be explained, premising that in applying all forms the body of a cravat and the base of the triangle correspond *to the initial end of a roller bandage.*

FRONTO-OCCIPITAL TRIANGLE.—Place the base on the forehead; carry the apex over the vertex, letting it drop below the occiput; bring the lateral angles around the head over the apex of the triangle crossing them at the occiput until they reach the temples or the forehead; pin or tie: the summit is then to be turned up and pinned behind to the body of the handkerchief. A hand or a stump can be dressed in a similar manner.

FRONTO-OCCIPITO-LABIAL CRAVAT.—Place the body on the forehead, carry the ends to the occiput, and cross them, bringing them forward to each side of the lip and pin, or first pass one end through a slit in the other.

FIGURES-OF-8, serving a similar purpose to that of Barton's bandage of the jaw, or similar figures of the neck and armpit, the shoulders, the chest, suspensories of the breast or of the testicle, can be devised by using more than one triangle or cravat.

III. FIXED DRESSINGS.—Such substances as glue and zinc oxide, glue and chalk, paraffin, dextrin, and starch have all been employed, but the application of plaster of Paris and silicate of sodium alone will be described, the former being the one almost universally employed.

PLASTER OF PARIS.—This must be of good quality, recently calcined, and may be applied in one of two ways: Bandages, pieces of blanket or strips of other materials, are passed through a watery mixture of plaster of the consistency of cream, loosely rolled, and rapidly applied to the part, or the liquid plaster may be smeared over a bandage previously applied. Unless employed in the form of one or more thicknesses of old blanket, cut into the shape of the required splints and soaked in the liquid plaster, this method is undesirable.

Almost universally, some loose texture, as cheese-cloth, cross-barred muslin, mosquito netting, or, preferably, crinoline, is cut into strips of a width proper for the part (two to three inches), and the meshes filled by rubbing in dry plaster with the hand as it is loosely rolled up. Wrapped in waxed paper and kept in a warm, dry place, these rollers will be serviceable for some time, but are best prepared just before using. Various special apparatuses have been devised for preparing and rolling plaster bandages, but the hand will do equally well.

Mode of Application.—Cover the part with a woollen stocking, a flannel roller bandage, or a knit undervest, according to the part. Immerse a roller

endwise in a basin of warm water, and when all air-bubbles have ceased to escape take out, squeeze with the hand, and apply as any roller bandage, but *more slackly*, smoothing the turns with the other hand as they are made: three or four thicknesses of bandage are usually sufficient. When the first bandage is taken out of the water, put in another. A little dry plaster may be used to strengthen the dressing, sprinkled over the exterior and smoothed down with the wet hands as it sets. A little mucilage, glue, or stale beer will delay setting, while a little table salt or alum will hasten the process, which unassisted takes from ten to thirty minutes. Some one of the plaster shears or Hunter's saw is the best instrument for the removal of plaster dressings, but a stout knife—a pruning-knife is the best—will do, while painting a strip of the dressing with dilute hydrochloric acid will soften it so that an ordinary knife or shears will divide it.

Silicate-of-Soda Dressing.—After protecting the part in the same way as when applying a plaster dressing, bandage the limb *loosely* (because if unwashed the bandages will shrink, thus constricting the parts) with ordinary wet muslin rollers, painting each layer thickly with the silicate: from four to six layers of bandage will suffice. As water softens this material, the dressing is easily removed. The disadvantage of the silicate dressing is that it requires many hours to dry thoroughly, and that it becomes softened by discharges or wet dressings.

IV. Rubefacients.—These are agents which revulse by causing congestion of the skin: a few teaspoonfuls of oil of turpentine sprinkled over a piece of flannel wrung out of hot water, applied to the skin and covered with oiled silk or dry flannel, form *the turpentine stupe:* twenty minutes is the maximum for this application. *Mustard* flour (the black being the stronger), mixed with tepid water into a paste, spread thinly on a piece of muslin or paper, and covered with gauze or thin cambric, is an excellent counter-irritant. Few skins will bear pure black mustard for more than ten minutes. Diluted one-half with wheat or corn flour, twenty minutes should be the maximum of application, because blistering must be avoided, that produced by mustard being specially painful. After removing a mustard plaster, greased lint should be applied. A *mustard foot-bath* consists of one or two tablespoonfuls of pure mustard in a bucket two-thirds full of water at 105° F.: the feet may be kept in this for about twenty minutes, a blanket being thrown around the limbs and including the bucket to retain the heat. Revulsives must be used with caution in cases of shock or coma, lest impaired vitality or sensation to pain result in extensive sloughing of the skin.

V. Vesicants are agents which cause a more permanent congestion of the skin by producing inflammation, terminating in a serous effusion, elevating the cuticle into vesicles or blisters. Rapid vesication can be effected by the strong aqua ammoniæ of the Pharmacopeia, by wetting with it a piece of lint of the desired size and covering with oiled silk; or by a suitably shaped iron (knife-blade, etc.) heated in boiling water. *Spanish fly* in the form of cantharidal cerate or collodion is the vesicant most often used, the cerate being spread thinly on a piece of adhesive plaster, leaving a margin of from one-half to three-fourths of an inch, which will serve to retain the blister in position. The skin must be well cleansed before its application: six to eight hours will usually suffice to produce incipient vesication, when removal of the blister and the application of a poultice for a few hours will cause the "filling up of the blister." If no further effect is desired, the serum should be drained

FIG. 1.—Velpeau's bandage.

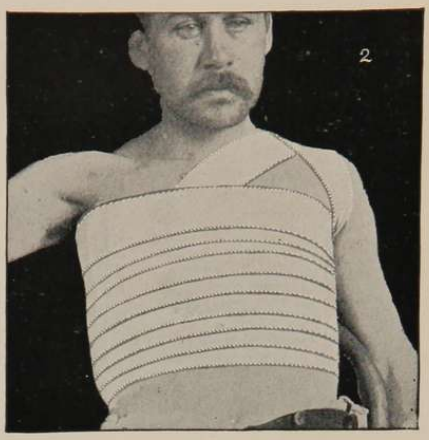


FIG. 2.—Desault's bandage, first roller.

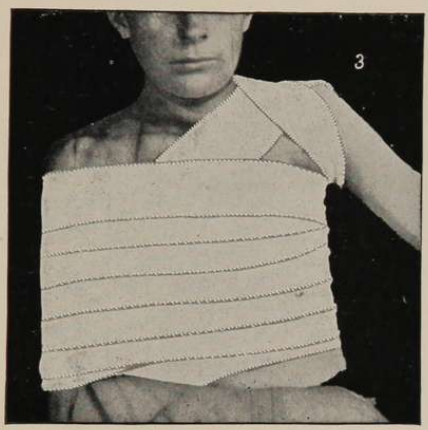


FIG. 3.—Desault's bandage, second roller.

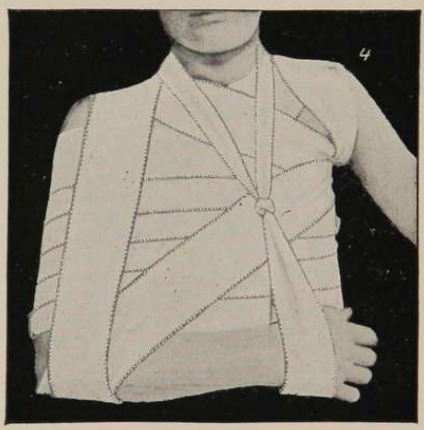


FIG. 4.—Desault's bandage, third roller.

FIG. 5.—Recurrent bandage of the head.

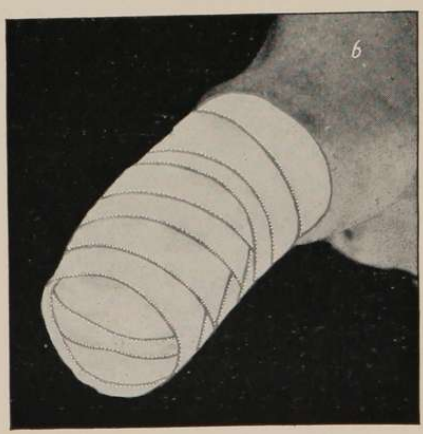


FIG. 6.—Recurrent bandage of stumps.

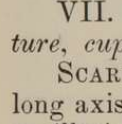
off by a puncture at the most dependent point, and an ointment of oxide of zinc be applied; but if a more persistent irritation is requisite, the cuticle must be removed and the surface kept covered with some irritating ointment, as compound resin cerate. Cantharidal collodion, when of good quality, will vesicate if painted on in several layers, but as found in the shops is an uncertain remedy. Blisters must be cautiously employed in either the aged or the young, and especially in those suffering from any low form of disease.

VI. The Actual Cautery is used in the form of variously-shaped irons (hatchet-edged, round, or olivary) fitted into wooden handles and heated in a charcoal furnace. As a counter-irritant the iron should be heated only to a dull red heat, and be quickly drawn in parallel lines, about one inch apart, over the skin, avoiding all bony prominences: compresses wet with cold water or with some antiseptic lotion may then be applied.

The Paquelin Thermo-cautery is a convenient form. It consists of hollow platinum cauteries and a handle covered with wood; a benzole reservoir; a pair of rubber bulbs, like those for a hand-spray apparatus, connected by a tube with the reservoir; a long rubber tube to connect the cautery handle also with the reservoir; and a spirit-lamp with attached blowpipe. Screwing on the desired point, the tube from the reservoir is slipped over the handle, the point is heated in the lamp, is removed from the flame, and by compressing the bulbs—previously connected with the reservoir—benzole vapor is forced into the point, which will heat up, and can be maintained at any temperature by the rapidity with which the bulb is worked: if the point will not heat with the simple flame, attach the bulbs to the blowpipe on the lamp, and, compressing them, heat the cautery to a bright-red heat, and then connect with the reservoir and proceed as before directed.

VII. Bloodletting.—Local depletion is effected by *scarification, puncture, cupping, and leeching.*

Scarification consists in numerous small, parallel incisions made in the long axis of the limb or part with a sharp-pointed knife, which, depleting the capillaries of such parts as inflamed skin, the tongue, the tonsils, or the conjunctiva, is often beneficial; the length and depth of the incisions must vary with the part. When employed to relieve tension of skin or fascia, by disposing them as in the subjoined diagram, the maximum of yielding will be obtained by the minimum of cutting. The flow of blood can be encouraged by warm fomentations, or, if excessive, packing with antiseptic gauze will check the flow. *Puncture* is a modification, as when, for instance, a narrow bistoury is plunged into an inflamed testicle to relieve tension.



Cupping may be *dry* or *wet.* Dry Cupping consists in employing an exhausted receiver over the integument, whereby congestion of the included skin is effected and sometimes serum is effused. When cupping-glasses with a suction-pump are employed, the glasses must be firmly held in position and the air exhausted; but small tumblers or wineglasses will do. In using them, moisten their interiors with a little alcohol or whiskey, light this, and at once apply, holding firmly over the part: as the contained air cools the glass will "suck," owing to contraction of the air. Always remove cups either by opening the stopcock or by tilting them while pressing down the skin on one side.

Wet Cupping.—Having congested the skin by a dry cup, make parallel incisions with a lancet point, or apply the spring scarificator set to such a depth as only to cut through the true skin; spring the lancets, set, reapply

at right angles, and spring again, and at once apply a cup; the second cutting is not always necessary, and adds to the inevitable scarring. When the cups have ceased to fill, remove them, empty, apply, and exhaust again; when enough blood has been drawn, wash the parts with some mild antiseptic solution and cover with dry aseptic or antiseptic compresses.

Leeching.—Two varieties of leech are employed: the American, capable of withdrawing one dram of blood, and the European or Swedish, abstracting about half an ounce; but warm fomentations after the animals have dropped off will in both instances increase the amount. *Method of Application.*—Select the most vigorous, remove them from the water, in which they should be kept one hour before using, dry in a soft warm cloth, and apply to the part, previously shaved if necessary and thoroughly cleansed with warm water and soap. A few drops of blood placed on the part or smearing it with milk will induce the leeches to take hold. By a cone of paper a single leech can be confined to one part, as the canthus of the eye, while for the cervix uteri a cylindrical speculum must be employed. When a number are used on external parts, they may be confined beneath a tumbler: if only one or two are needed, they can be taken one at a time between the thumb and forefinger and held to the part until they bite. Such parts as the eyelids or the scrotum should never be leeched, nor should the inflamed area itself, but only the circumjacent tissues. Never pull off a leech, but sprinkle salt on it if slow to drop off; injecting a solution of salt will serve a similar purpose in the vagina. Pressure usually checks all oozing, but if it should fail to do so, touching with a pointed stick of nitrate of silver or with a red-hot knitting needle, or passing a fine cambric needle beneath the wound and throwing a figure-of-8 thread around it, will check the bleeding. The artificial leech may be employed, but is uncertain in action and produces raised, rounded scars.

Venesection, or Phlebotomy.—All the advantages, with none of the risks, of arteriotomy, or of bleeding from the jugular vein, can be effected by opening a vein in the arm; and this operation alone will be described. Rendering the parts and instruments thoroughly aseptic (for septic phlebitis is the only thing to be dreaded after phlebotomy), make a few moderately firm turns of a narrow bandage or of a tape around the middle of the arm; fix the median cephalic vein with the left thumb, and with a lancet or a sharp-pointed bistoury open the vein obliquely to its long axis: few practitioners possess a spring lancet, and if used on the median basilic vein it may wound the subjacent brachial artery. If the vein does not become prominent, make the patient firmly grasp a stick or merely close the hand forcibly; alternate opening and closing of the hand will promote the flow after opening the vein. Having obtained the requisite effects as indicated by the pulse, remove the tape, apply a dry aseptic compress, and, securing this by a few figure-of-8 turns of bandage around the elbow, place the arm at rest. The more rapidly the blood is abstracted, the less will be required to lower the force of the circulation, so that the sitting or standing posture is desirable where marked effects are required and but little blood can be spared.

VIII. Artificial Respiration.—Sylvester's, being that most generally applicable, will alone be described: Lay the patient on a level surface; clear the pharynx of all mucus, etc.; keep the tongue drawn forward by forceps or a suture; secure it to the lower jaw or let an assistant hold it out; remove all constricting clothing from the chest and abdomen; support the head and shoulders slightly by a folded-up coat. Kneeling or standing behind the patient, grasp the forearms near the fully-flexed elbows; firmly compress the lower part

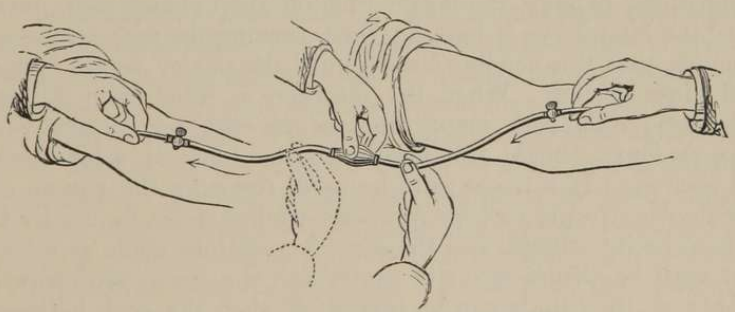
of the thorax for a few seconds by pressing the patient's elbows against the front of the chest; then sweep the arms outward and upward alongside of the head until the hands touch, pulling firmly upward for a few seconds to secure thorough elevation of the thoracic walls (*inspiration*); then bring the arms with flexed elbows down against the sides and lower part of the chest, firmly compressing it as before, thus imitating *expiration*. Repeat these procedures from twelve to fifteen times a minute until voluntary respiration recommences, when the movements must be continued to reinforce the natural effort so long as nature is unequal to assume all the labor. The efforts at resuscitation must not be abandoned for an hour or more, meanwhile employing dry warmth, warm frictions to the surface, and stimulants hypodermatically, by the rectum, or by the mouth when swallowing becomes possible; carefully watch for secondary apnea, and promptly resume artificial respiration if it supervenes.

Fell's method of forced artificial respiration is described on page 1119.

IX. Transfusion of Blood.—Of the many methods introduced, only one of the "direct methods"—Aveling's—will be described, as the simplest and safest, and requiring only an inexpensive apparatus capable of being improvised. This consists of a small rubber tube twenty inches long with a stopcock at each end, and at its middle a small bulb like that of an enema syringe. Two blunt, bevel-ended canulas complete the apparatus.

Operation.—Fill the tube and bulb (Fig. 499) by immersing them in a warm saline solution (6 : 1000), and compressing the bulb so as to expel all the air; then turn off the stopcocks. Place the donor's arm close to and parallel with the patient's; open a vein in the former near the elbow; insert one canula filled with saline solution, directed downward toward the fingers, and connect it with the tubing: while this is being done let an assistant open a vein in the patient's arm and introduce the other canula, also filled with saline solution, with its point directed upward; connect with the tubing and turn on the stopcocks. Next compress the tube *between* the bulb *and the donor* with the finger and thumb of one hand while emptying the bulb with the other: now let an assistant compress the tube between the bulb *and the patient* while the operator releases his pressure on the tube on the donor's side and on the bulb, which

Fig. 499.



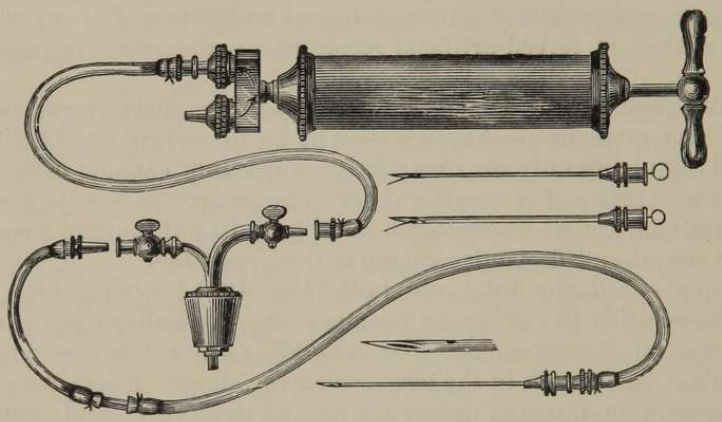
Aveling's Apparatus for Immediate Transfusion.

will at once fill with blood; finally compress the tube between the donor and the bulb; let the assistant remove his pressure from the tube on the patient's side, when by compressing the bulb about two drams of blood will be forced into the circulation. A repetition of these processes—easily carried out if the directions be strictly followed—can be made until as much blood is transfused as is requisite.

A few ounces of Little's saline solution or a dram of sodium chloride to the pint of warm sterilized water thrown into a vein or into the cellular tissue (hypodermoclysis) by gravity, by means of an aspirator needle previously connected with a few feet of aseptic tubing, the other extremity of which has been slipped over the end of a small funnel, will do in an emergency nearly as well as blood to keep up such a bulk of fluid as will enable the heart to carry on the circulation. The strictest asepsis is imperative.

X. Aspiration.—The usual form of aspirator (Potain's, Fig. 500) consists of a hollow needle with a lateral eye (or trocar and canula with plunger to clear it if

Fig. 500.



Aspirator and Injector.

blocked); of a stopcock and joints, to which on one side is attached the needle and on the other a long rubber tube having a short piece of glass tubing interposed near the needle end; of a rubber cork with two stopcocked tubes, one for the tube connecting with the needle, the other for the short tubing connecting with the pump; finally, a wide-mouthed bottle must be provided.

Operation.—Having arranged the instrument as directed, secure the cork in the bottle, turn off the stopcock on the side next the needle, and open that on the pump side; exhaust the bottle, turn off the exhaust cock, introduce the needle until the lateral eye is buried; then, turning the cock on the needle side of the vacuum, pass the needle onward until the pus or serum appears in the segment of glass tubing. When the reservoir is filled, turn the cock on the needle side, remove the cork, empty, replace the cork, form a new vacuum, and proceed as at first: should the needle become blocked, a few strokes of the pump will clear it. If a trocar is to be used, screwing the canula on in place of the needle, the trocar, with its properly-packed joint to render the canula air-tight, is to be introduced, and the same connections made as before, but the instrument must be thrust into the cavity and the trocar withdrawn until the stopcock back of the canula can be turned off, then the cock between the canula tubing and the vacuum is to be turned on. If the canula becomes blocked, introduce the appropriate plunger, turn on the canula stopcock—the trocar having been withdrawn—remove the plunger and turn off the canula cock, all with the vacuum connected. When the packed joint for both trocar and plunger fits into the connecting joint, a groove on each instrument informs the operator when it has been sufficiently pulled out to enable the stopcock to be turned off; when the packed joint belongs to each trocar or plunger, these

instruments can be withdrawn only to a certain point, which will allow the stopcock to be turned. After the canula or the needle has been withdrawn the little puncture must be sealed with collodion or plaster.

XI. Hypodermatic Injections.—These are made with a syringe containing about thirty minims and having an adjustable hollow needle point, the cylinder being of metal, glass, or hard rubber. When not in use a fine wire should be kept in the needle, which must always be cleansed and dried after using, while the cap should be adjusted over the end of the syringe to prevent the packing of the piston from drying: if iodine is employed, gold or platinum points, instead of steel, and a hard rubber syringe should be used.

Operation.—As perfect asepticism is essential, it is better to boil the needle in a little water in a spoon. Then draw up about twenty minims of the water into the syringe and empty this into the spoon, having thrown out any of the water left after having removed the needle; drop into the fluid the powdered drug or compressed pellet (as it is most commonly prepared for hypodermatic use), aid its solution by stirring with the end of the syringe; then charge the instrument, attach the needle, and, holding it point upward, that all air may rise to the top, slowly force up the piston until the air is expelled, as shown by the escape of a drop of fluid from the needle. While strychnine and ergot are usually thrown into the muscles, morphia, atropine, and brandy are to be injected into the subcutaneous cellular tissue.

There are two ways of introducing the needle—one by pinching up a fold of skin free from veins (usually over the outer anterior surface of the forearm or thigh) between the thumb and first two fingers of one hand, while with the other the needle is quickly thrust into the cellular tissue parallel with the fold: the other method, far less painful, is to select an avascular portion of the skin, render it tense by the thumb and finger of one hand, and quickly drive the needle so obliquely through the integument as to reach the cellular tissue, which it must penetrate—introduced in either way—for about three-fourths of an inch; the fluid must next be slowly injected, the needle withdrawn, and the puncture compressed for a few moments by one finger, while with another gentle friction is exercised over the projection formed by the fluid, to diffuse it over a larger area.

XII. Vaccination.—This should be done immediately after birth if exposure to variola has occurred or if an epidemic of that disease is prevalent; but about three months is the preferable age. Infants suffering from any slight ailment or from any form of skin affection should first be cured of such diseases. Humanized virus in the form of lymph taken from a typical vesicle *on a healthy infant* and of *healthy parentage* at the eighth or ninth day of the disease (arm-to-arm vaccination); carefully pulverized fragments of dried human scab of such a child free from all blood or pus, ground up between two clean glass plates and mixed to a creamy consistence with tepid water; and *bovine* or *animal* virus—*i. e.* the lymph from the eight-day-old vesicle of the inoculated *natural* vaccine disease on the udders of young heifers, allowed to dry on quills or ivory points,—are all employed, but the safest plan is to use only bovine virus.

Operation.—With an aseptic lancet the skin over the insertion of the deltoid muscle, or, better, on the leg, being rendered tense by the thumb and fingers of one hand, carefully scrape away the epithelium over at least two small surfaces of skin about one-eighth of an inch square until a slight bloody serous oozing occurs, and then with the lancet cover these spots with the dried scab reduced to a creamy consistence as just described, or thoroughly rub them

with the quill or ivory point charged with bovine virus previously dipped in tepid water: any of these methods is rendered more certain by tattooing the lymph into the abraded surface by the lancet or ivory point. A more rapid and equally effective plan is to make with a lancet or the previously moistened ivory point three or four short parallel scratches very close together, crossing these with others similarly disposed, and then applying the lymph as directed. Arm-to-arm vaccination can be done by puncturing the vesicle on the eighth day with the lancet point, and then entering the instrument obliquely well into the cutis at one or more points. The exuded blood and serum must be allowed to dry thoroughly before replacing the clothing, and means must be employed to prevent local irritation or scratching after the formation of the vesicle: exposure to cold and damp must also be avoided. The indications for revaccination can be found in medical treatises, the operation being like the primary one.

XIII. Electricity.—This is used in the form of the *induced current* (faradism) to exercise and improve the nutrition of muscles, and in the form of the *constant current* (galvanism) along the course of nerve-trunks to excite their conducting power or act as a sedative in neuralgia; and the same current is used to induce chemical decomposition (electrolysis) or to cauterize and destroy tissue by heating an encircling wire or a galvanic knife. *Franklinic* or *static* electricity is also occasionally used. For electrolysis a galvanic battery of thirty or more medium-sized cells is required, with needle electrodes insulated except near their points. The operation consists in introducing into the aneurysm or tumor two needles a short distance apart, each connected with a pole of the battery; then, commencing with a weak current, this must be cautiously increased, the sitting lasting from a half-hour to one hour, after which the needles are to be removed and the punctures sealed by collodion.

XIV. Galvano-cautery.—This requires a battery of a few large elements closely coupled, and various curettes, knives, and écraseurs fitting into an insulated handle. The chief advantage of this form of cautery is the possibility of placing the instrument in position *while cold*, and then heating it. Where hemorrhage is undesirable, a dull red heat should be maintained, for at a white heat the tissues are divided as if with a knife and bleeding follows. When the écraseur is used, needles must be passed at right angles through the healthy tissues, the platinum wire placed behind these, and the wire—at a dull red heat—slowly tightened.

XV. Massage.—This is employed to stimulate the circulation in the part mechanically, to loosen tissues bound down by adhesions, to diffuse inflammatory exudates over a wider area, thus favoring their absorption, and to change the rate of the circulation to a point compatible with rapid absorption and normal nutrition. Four distinct varieties of manipulation are found to be most generally useful: viz. rubbing or stroking; kneading; tapping or percussion; passive and active movements. *Stroking* consists in gentle rubbing directed from the periphery upward, commencing the process above the inflamed part and continuing it over the diseased area; the pressure at first light, but finally firmer, will force the exudates into the tissues above, which have been emptied by the preparatory rubbing. *Kneading* means rubbing the part circularly with the pulps of the fingers and the thumb or the palm of the hand, and is best combined with pinching up of the skin or muscles singly or together and gently rolling them between the fingers and palm. *Percussion* is effected by

tapping the surface over the diseased part with the tips of all the fingers held on a level, or with the ulnar side of the hands, or, after covering the part with a towel, three parallel pieces of stiff rubber tubing fixed in a handle (a muscle-beater) may be employed, gently striking the part transversely to its long axis. *Passive movements* should be made at the close of each sitting if a joint is concerned. Massage is sometimes advisable twice daily, but often once a day or every other day is better; each sitting may last from fifteen minutes to one hour.

XVI. Clinical Thermometers.—The best are straight self-registering instruments, generally graduated in this country on the tube in degrees and fractions of degrees of the Fahrenheit scale. Only "certified" thermometers should be used. These have been tested as to their accuracy, and a certificate of the error comes with each. No good thermometer ought to vary more than $\frac{2}{10}°$. To use one, the register must be shaken below 95° by holding the instrument bulb downward and swinging it sharply at arm's length, or, holding it in the same manner with one hand, jar it down by striking the lower side of the hand grasping it against the wrist of the other hand: the bulb must now be placed beneath the patient's tongue with the lips gently closed over the stem, observing that this is directed upward, or in the axilla, the arm being brought up and across the chest to maintain apposition of the axillary surfaces with the bulb. The instrument must ordinarily be retained about five minutes, but one-, two-, and three-minute thermometers are now made. The same thermometer should always be used, and for the same length of time, in any given case. Carefully cleanse the thermometer in water or with some disinfectant immediately after removing, especially if it has been in the mouth, the vagina, or the rectum, where it is sometimes placed.

Thermometers should not be used in the mouth in young children, in the insane, or in delirious patients, lest they bite them and injure their mouths with the fragments of glass.

Surface thermometers, the bulbs of which are spiral or coiled, are sometimes employed for noting the difference in temperature of corresponding parts of the body, but the ordinary clinical thermometer, held in place by a grooved cork, or covered with a layer of absorbent cotton, by the ends of which it is held in position by the examiner's fingers applied at some distance, will often suffice.

XVII. Applications of Heat and Cold.—*Dry heat* may be applied by means of hot-water bags, hot sand- or salt-bags, heated bricks, or bottles or cans filled with hot water: again, by coils of block-tin pipes arranged as caps for the head or flat pads, a constant current of water at any temperature can be employed. Always interpose one or more layers of flannel or clothing between the skin and the heated applications, exercising great care lest the heat be too great or leakage occur, because in either event serious burning or scalding may result. Old hot-water bags should not be used, lest they burst. *Moist heat* is employed in the form of poultices or fomentations as described below; or by hot affusion or the douche—that is to say, pouring it from a height; or, finally, by hot baths. When moist heat is to be applied to a joint, the best way is to extend the limb and wrap the joint with a long flannel bandage 10 or 12 inches wide. This is passed four or five times around the joint, the end hanging down into a slop-jar or bucket to carry off the water. Very hot water may then be poured over the flannel by a tablespoon or cup, the part being thus kept continuously at as high a temperature as can be borne.

Prolonged (hot) Baths may be of service in shock where the injury will admit of this, which is seldom. Locally, as for a sprained ankle, the temperature must be as high as can be borne, and kept up for half an hour or more by adding freshly-heated water. As a substitute for the relaxation better effected by anesthesia, a general warm bath, prolonged until faintness is induced, may be employed in strangulated hernia, while a warm hip-bath often proves of value in cystitis, vaginitis, and in retention of urine, when the patient should endeavor to pass his urine while in the bath.

Poultices are merely vehicles for heat and moisture, being made preferably of such substances as will cohere. When heat is the chief indication, Indian-corn meal mixed to a proper consistence with hot water and placed in properly-shaped bags of old muslin is excellent. Ground flaxseed meal is most often used, being mixed of a proper consistence with hot water, spread about three-eighths of an inch thick on muslin, the margins of this turned over on all sides for half an inch, and a little oil or melted lard diffused over the surface to prevent adhesion to the inflamed part. To further this end a piece of gauze should always be laid between the poultice and the skin. *Yeast* or beer-grounds, added either to corn meal or to flaxseed meal and kept for some hours in a warm place, forms the "fermenting poultice," while powdered charcoal, placed in a thick layer on a flaxseed-meal poultice and directly applied to the sloughing or gangrenous part, constitutes the "charcoal poultice." Bread-crumbs moistened with water or milk are sometimes employed, but are very objectionable (especially with the latter), because they quickly ferment, becoming sour and a source of irritation. All poultices must be covered with some substance impermeable to moisture, as "rubber dam," oiled silk, greased paper, etc., and only thus can they be maintained at the temperature of the surface and moist. To keep them warm a hot-water bag should be used. They should be changed at least three or four times a day. Poultices are much less frequently employed than formerly. While they may still be used occasionally when the skin is unbroken, if there is any lesion of the skin ANTISEPTIC FOMENTATIONS by gauze moistened with a hot antiseptic solution, covered with rubber dam, and kept warm by a hot-water bag, should generally be used instead.

Dry cold, applied by means of crushed ice in bladders or rubber bags, or ice-water passed through coils of tubing, is an important agent: several yards of small rubber tubing coiled around and secured to a night-cap, one end of the tubing being connected with an ice-water receptacle above and by the other emptying into a vessel below, is a good substitute for the metallic coils, while mats for the abdomen and other parts can also be similarly made. *Moist cold* may be applied by compresses wet in ice-water, by irrigation, or by cold affusions. Irrigation can readily be carried on by a constant current of water conveyed from an elevated receptacle by the capillary attraction of a few narrow strips of lint, gauze, or lampwick extending from the reservoir to a moistened cloth covering the diseased area. The alternate affusion or douche of hot and cold water, poured from a height, is often serviceable by improving the sluggish circulation in chronic joint affections,thus favoring the absorption of exudates.

XVIII. ADHESIVE PLASTER is cut or torn of appropriate width. Rubber adhesive plaster does not require heat to make it adhere, but the old form of plaster does. When used to coaptate wounds, one end is fixed a short distance from one side of the wound: the strip is firmly drawn across the wound, more or less at right angles to it, while the fingers on the opposite side exercise counter-

pressure; the free extremity must then be applied. Intervals must be left between the strips for the escape of discharges, except when strapping ulcers, where each strip should overlap its fellow by one-third. When removing strips of adhesive plaster always loosen *both* ends, and draw them equally toward the line of the wound, thus removing them without straining the union.

XIX. COLLODION may be used to seal a puncture, either by merely painting it on or by the application of a morsel of absorbent cotton soaked with it. By fixing one end of a strip of gauze or a long shred of absorbent cotton by collodion on one side of a wound it may be drawn together, the free end being similarly fixed on the opposite side: this is excellent for scalp and face wounds.

XX. OINTMENTS should be spread with a spatula or table knife in a thin layer upon lint or muslin, nicked here and there to give exit to discharges.

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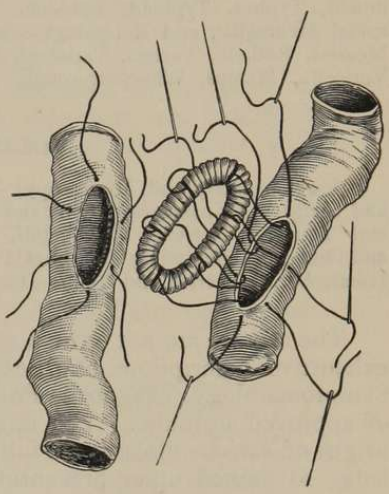

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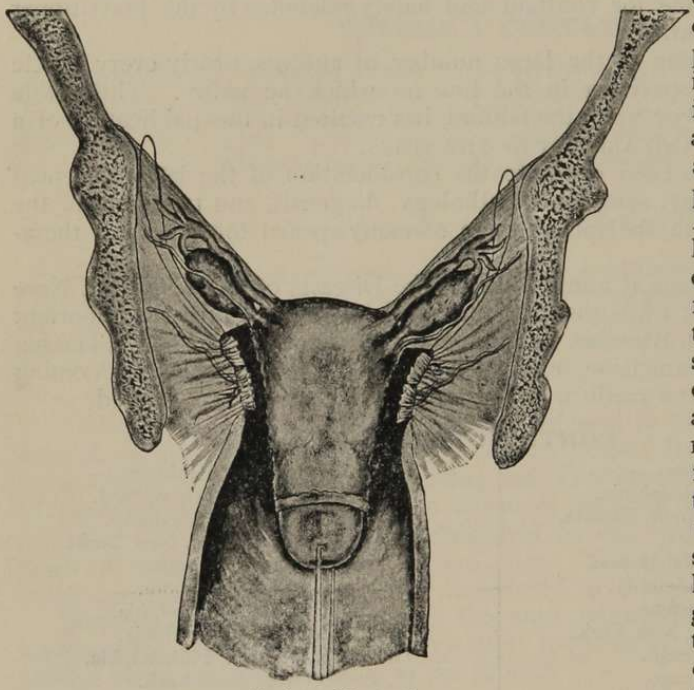

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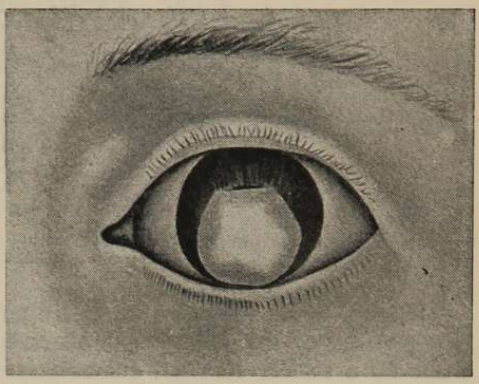

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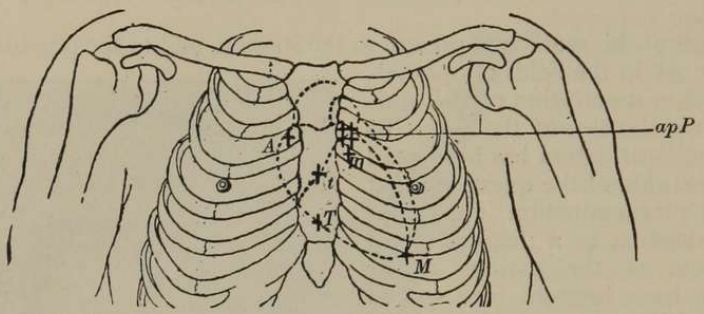

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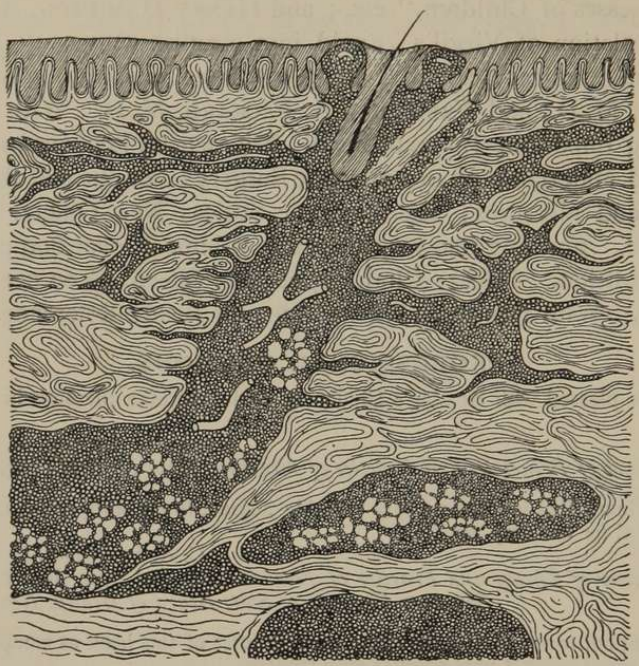

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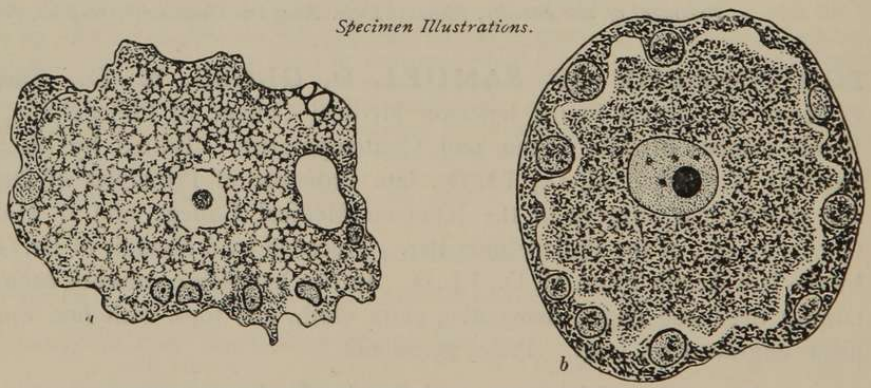

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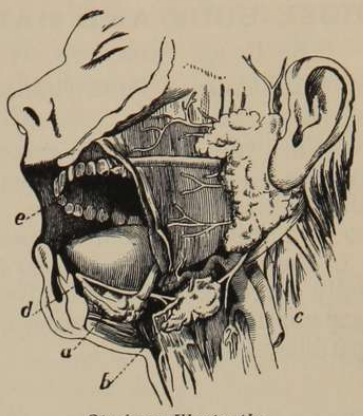

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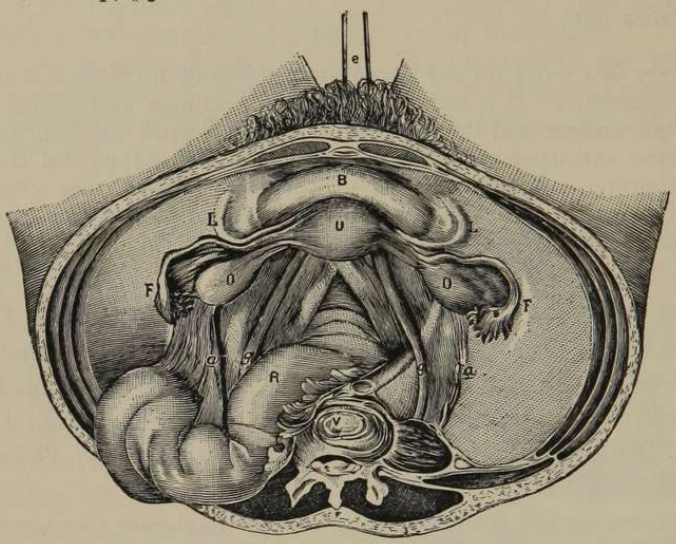

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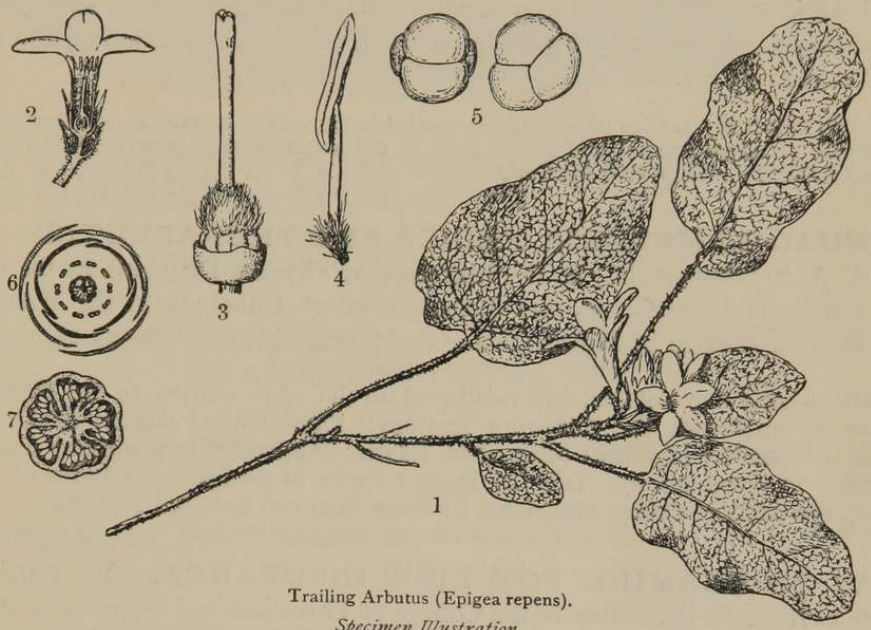

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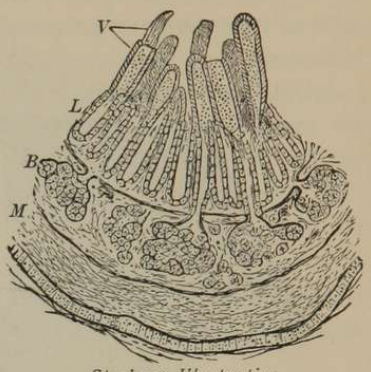

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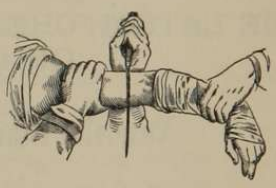
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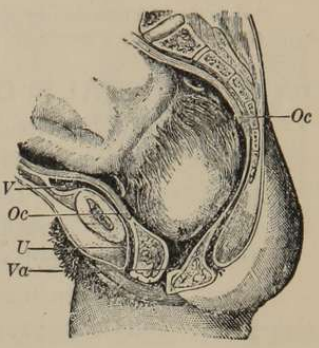

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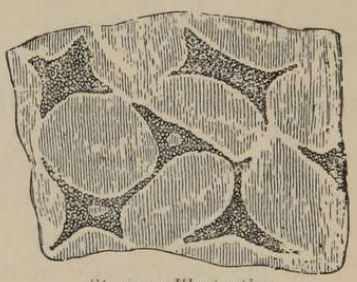
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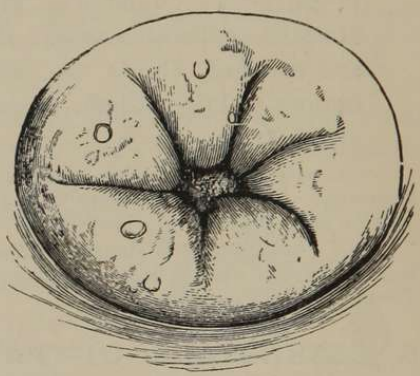

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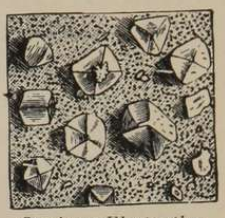

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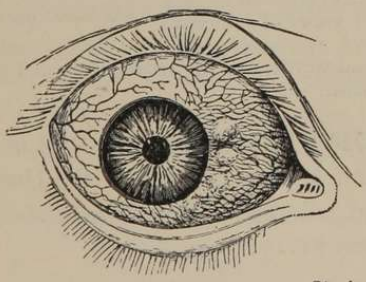

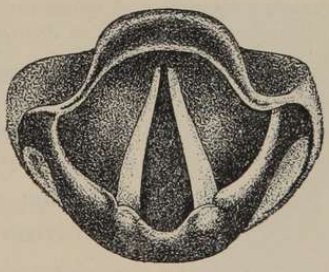

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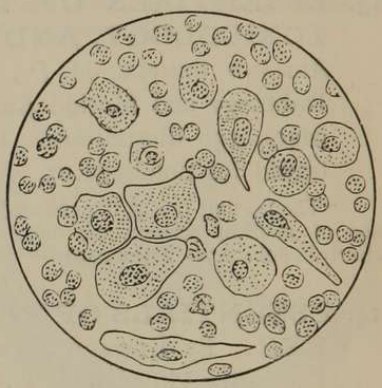

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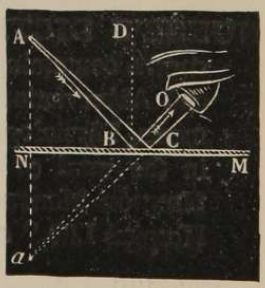

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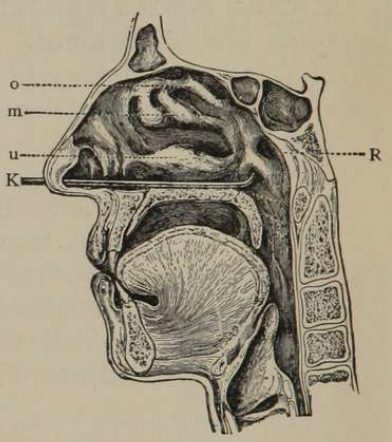

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