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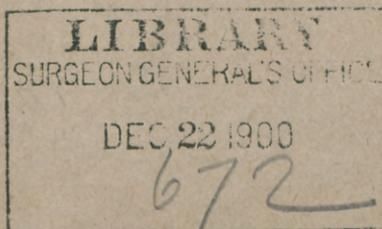
The Surgery of the Ureters; A Clinical, Literary and
Experimental Research.

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—BY—

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THE SURGERY OF THE URETERS: A CLINICAL, LITERARY AND EXPERIMENTAL RESEARCH.

BY WELLER VAN HOOK, A.B., M.D.
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Introduction.—The desirability of more readily applicable and more complete methods of dealing with the surgical conditions met with in connection with the excretory ducts of the kidneys is patent to every one who has given even the most cursory attention to the subject. The variety of "surgical" conditions brought about by accidents and diseases of the ureters is sufficiently large, and the number of cases met with is great enough to make the subject one of practical interest to every surgeon. The most obvious of these conditions, injury to the ureter by the penetration of a foreign body, as noted in the remarkable and historic case of the Archbishop of Paris in 1848, is nevertheless least frequent of occurrence.³¹ The practical surgeon is daily confronted with the horror of obstructing, rupturing, crushing or cutting a ureter in the course of some abdominal or pelvic operation.

Much has already been done in this field of ureteral surgery; and it would be farthest from the present desire to detract from the illustrious efforts of those who like Tuffier, Pozzi, Rydygier, and Kuester following the pathfinding footsteps of Simon,⁶¹ have disclosed by clinical and experimental research many important facts in this department of surgery.

The blunt necessity of closing a ureteral fistula and compelling the urine to traverse its natural channel, in the case of a boy who by congenital defect possessed but one kidney,

forced Kuester³⁰ to devise a means of reuniting the ureter to the pelvis of the kidney after preliminary resection. The consequent thought is irresistible, that kidneys are not to be sacrificed for fistulae, partial obstruction by valvular folds causing intermittent hydronephrosis and strictures of the ureter that interfere to greater or less extent with the functional activity of the ducts, without exhausting every effort to correct the morbid condition. The work of Simon in establishing the practicability of nephrectomy for fistulae, involving as it did the comforting demonstration of the great and sufficient vicarious activity of the kidney after removal of its fellow, has been followed all too literally by modern operators. But the time has now come when experimental research, coupled with clinical ingenuity, by demonstrating methods of restoring normal conditions, will render much more difficult the task of justifying the sacrifice of so important an organ as the kidney.

The work of those experimenters, Tuffier,⁶⁰ Novaro,³⁷ Gluck and Zeller,⁷⁷ Harvey Reed⁶² and others, who have tried to prove the feasibility of rectal implantation of the ureters, has met with only a limited and qualified success, and I shall show you by incontestable argument and experimental proof, that the implantation of the ureter into the rectum is in all cases unjustifiable.

Under these circumstances,—on the one hand, compelled by necessity to remove disgusting or perilous conditions, and on the other hand censured by conscience and a growing conservatism in respect to the important urinary glands, if we sacrifice the kidney,—surgery demands new and better methods of dealing with ureteral wounds and diseases. To these demands the writer has devoted the present work.

Anatomy.—The anatomical relations of the ureters have been especially studied by those who have considered means of diagnosis in ureteral and renal diseases. The names of Pawlik, H. A. Kelly,³⁶ Schultz,⁵⁸ Plique,⁵¹ Pantaloni,⁴¹ Poirier,⁴⁵ Perez,⁴² Hallé,²⁴ Fenwick,¹⁸ and G. Simon,⁶¹ are especially worthy of mention in this connection. These men have added much to our knowledge of the topographical anatomy of the ureters, so that, following the leadership of Pawlik, the ureters are now catheterized, especially in the female, to determine the character of the secretion of the kidneys individually; and operations are performed upon these ducts which would have been impossible a few years ago, if for no other reason, because of insufficient anatomic and diagnostic information.

The gross and microscopic anatomy of the tubes themselves has been well elucidated in the text-books accessible to all. An especially interesting account of the microscopic anatomy of the ureters is that of Roehard.⁵⁶ My friend, Dr. W. M. Tanquary, Professor of Anatomy in the College of Physicians and Surgeons, has kindly communicated to me several points which are not correctly or fully stated in the handbooks.

Thus he states, that upon examining the ureters of over twenty bodies he never found one over fifteen inches long, the average being between ten and twelve inches in length. The ureter when stripped from the peritoneum may be drawn out from two to four inches.

The curvature of the abdominal ureter has its convexity directed inward; while the convexity of the pelvic portion is turned outward. The pelvic portion of the ureter describes a very strong curve, almost the arc of a circle, since the duct hugs the bony wall of the pelvis very closely. Hence the portion of the ureter opposite the uterus is at some distance from that organ, and as the ureter approaches the base of the bladder (which it enters at a point near the

middle of the distance between the urinary meatus and the cervix), it curves rather sharply forward and inward, so that the point in the duct nearest the cervix is below and behind the posterior lip.

It must not be forgotten that the ureter has three points of diminution of caliber which may give rise to mistakes in the search for pathologic stenoses. The first is between one and a half and two and a half inches from the pelvis of the kidney, according to Dr. Tanquary's measurements. The second is at the junction of the pelvic and vesical portions. The third when present (found in three out of five subjects) is just where the ureter crosses the iliac artery.

Nature has protected the ureters in an exceedingly generous way. Scarcely another structure in the body is so little likely to be the subject of external violence. Poirier⁴⁵ has especially noted the distensibility and great resisting power of the ureters. Nevertheless such applications of force, as powerful compression of the trunk between two large bodies may rupture the duct. Cases of this kind are cited by numerous writers, among whom are Le Dentu,³¹ H. W. Allingham,¹ and Stanley.⁶³

Wounds of the Ureter.—From a study of the anatomy of the ureter, one may see that all the pre-requisites to rapid, active regeneration after injury are present. The cells of which the ureters are composed are supplied with large easily stainable nuclei; their functional activity being great, their metabolism must be vigorous; and we know that as a rule, cells that have very active metabolism proliferate very freely. Moreover, the blood supply of the ureters is everywhere most excellent, so that the growing cells are fully nourished.

An excellent demonstration of this vitality and vascularity of the ureter is furnished in a report by Chrobak¹² of a case in which the ureter, although laid bare for an extent of eight cm. in the removal of a sub-serous myoma, retained its function without an adverse symptom.

The function of the ureter, however, is productive of certain conditions which mechanically interfere with the rapid union of wounds. The contractions of the muscular layers of the ureter tend to displace the opposite wound surfaces, while the escape of the urine through the wound, if it be an open one, or the passage of the urine down the duct, if the wound has been sutured or is incomplete, conduces to the same result. Since the demonstration by Billroth of the innocuousness of the aseptic urine about twenty-five years ago, less importance has been attached to local, chemical irritation by that fluid.

As a temporary abrogation of function is usually impossible for the ureter, free exit for the urine either down the natural channel, or outward by way of the new opening, and usually through the posterior abdominal wall, must be of great advantage in healing. Drainage of the ureter and of the peri-ureteral space must be of special importance when micro-parasitic complications exist, whether this be simple putrefaction of the urine or active suppuration more or less generalized.

This condition of wound healing, drainage, can be perhaps most easily satisfied when the wound involves the pelvis of the kidney, since the lumen of the duct is there the greatest. When the injury to the pelvis is a perforative one, permitting the escape of urine into the surrounding connective tissue, external drainage is wellnigh imperative. This necessity, moreover, is absolute as soon as we have to do with a condition of suppuration or of putrefaction.

A study of anatomic conditions in the continuity of the ureteral duct and its outlet serves only to emphasize the importance of drainage, since in these parts of the ureter the lumen of the tube is smaller, and the topographic relations are more complicated.

Longitudinal Wounds.—Longitudinal rectilinear wounds of the ureter heal, as a rule, very readily, even when no sutures are applied, if they are uncomplicated and drained. The constant escape of urine from the wound, as is the case with the urethra, insures union of the lips of the wound by granulation. The mucous membrane acts as a barrier to prevent the growth of granulations at points within the lumen of the tube. And the proliferation of the epithelia over the granulations tends to increase the lumen of the tube. Subsequent contraction can not, therefore, result in injurious interference with the walls of the duct. A scar running lengthwise of the ureter could only under rare circumstances do injury by shortening.

Tuffier has made elaborate experiments to justify the application of sutures in longitudinal wounds of the ureter. He has succeeded in applying a row of delicate transverse interrupted sutures through the outer fibers of the tube, after the analogy of Lembert's intestinal sutures, and

has had good results, both as regards union of the wound and the subsequent function of the duct. But we can easily see that any suture of the ureter placed transversely and including even a minimum amount of connective tissue, must result in immediate though not necessarily dangerous stenosis, by diminishing the circumference of the tiny cylinder.

The practical inference is that longitudinal wounds of the ureter are best treated, *ceteris paribus*, by the method of open aseptic drainage.

The absolute clinical demonstration that this is a correct conclusion is furnished by the cases to be referred to hereafter in which Kuester and Fenger, in operations upon the upper part of the ureter, left open longitudinal wounds of the duct and with good posterior drainage obtained ultimate complete closure by granulation, with obliteration of the fistulae.

This rule can not be followed, however, when the wound involves not only the ureter but the neighboring overlying peritoneum, as, e. g., in accidental injuries occurring in laparotomy. Here, from ample experience in operating transperitoneally upon dogs' ureters, I would recommend the interrupted transverse suture advised by Tuffier, through the outer connective tissue layer of the ureter, including if necessary a minute quantity of the muscular coat of the duct. It is important that these sutures be made with very fine silk and very delicate needles. The writer uses the ordinary straight seamstress' needles, called No. 9, with silk twist selected to easily pass the eye of the needle.

The simple technique is as follows: Keep intestines and other viscera out of the way with suitable compress. Trendelenberg's position is indispensable in work within the pelvis. Expose the injured ureter and, if desirable and feasible, have an assistant support or elevate the tube. Apply the sutures as already suggested. Remove from the ureter the pressure and tension of the assistant's forefingers. If, after several waves of contraction have passed down the ureter, indicating the passage of the same number of drops of urine, there is observed to be no leakage, the peritoneum must be carefully adjusted about the ureter, with accurate sutures. This must be done for three reasons: First, the peritoneal coat immediately reinforces the line of sutures, steadies the ureter and assists in preventing leakage. Second, the peritoneal membrane very quickly unites to surrounding structures, so that in a few hours the ureteral wound is provisionally healed. Third, the rapid regeneration of the histologic elements of the peritoneum insures the speedy definitive healing of the peri-ureteral wound, so that the production of granulation tissue is limited to the utmost, and scar contraction is less likely, in the sequel, to interfere with the lumen of the tube. The envelopment of the ureter in peritoneum may be accomplished by either of two methods. The first and best is by lifting the tube gently into the cavity of the peritoneum, drawing the serous membrane carefully behind the ureter and, after pulling the peritoneum around the ureter, stitching it in a position to permanently enclose and protect the vessel. Secondly, the ureter may also be involved in a completely detached fold of omentum which is loosely attached by a stitch to the connective tissue about the ureter. This method is obviously less secure than the first, since the omentum is deprived of its blood supply. Tuffier complicates his technique, which does not include my suggestion of a peritoneal covering, by the temporary ligation of the ureter on the renal side of the wound, to prevent the escape of urine until the row of sutures is complete. Since the normal urine is not capable of setting up peritonitis or of causing suppuration, this precaution is unnecessary and undesirable. It must be carefully observed, however, in the rare abdominal operations upon the ureter, in which the urine is known to be septic.

Numerous pathologic conditions demand exploration of the ureter by longitudinal incision or treatment by drainage through such a wound. The scope of the present work does not permit a detailed study of the pathology of the ureters. The writer commends for study in this department, the works of Assmuth,² Neilson,³⁶ Biard de Bordeaux,⁷ Schmitt,⁶⁰ Le Dentu,³² Sutton,⁶⁴ Eve,¹⁶ Kobsko²⁸ and Tourneur.⁸⁷

Pozzi⁴⁹ recommends suture of the ureter in cases of accidental longitudinal injury.

The importance of these easily practicable methods can especially be realized when we consider the frequency with which calculi occur in the ureter. These bodies give rise to numerous grave symptoms of diagnostic significance which can not be discussed here. When their presence is recognized, they are removable by longitudinal ureterotomy as

has been practiced successfully in many cases. Numerous writers have reported cases and written papers on the subject. Of these Charles Paul Galland,¹⁹ Gargam,²⁰ Pousson,⁴⁷ Byford,⁹ Hall,²³ Lane,³⁰ Cullingworth,¹⁴ Terry,⁶⁵ Berg,⁶ Richmond,⁵⁵ Godlee,²² Pick,⁴⁴ Ralfe and Godlee,⁵⁴ and Twynam⁷² are to be named.

It must be remarked, in passing, that ureterotomy has been practiced by H. A. Kelly for stenosis of the ureter, the ureter being reached through a vaginal incision. This mode of reaching the ureter is of great value in treating such cases as those of Coe,¹³ in which the ducts were obstructed in the pelvis by inflammatory matter.

Transverse Wounds of the Ureter.—It requires no argument to prove that every incomplete transverse wound of the ureter, when closed by a cicatrix resulting from granulations or from primary union after direct suture, must have a tendency to result in a diminution of the circumference of the tube and consequently also of the lumen. This tendency may be resisted by retraction of the lips of the wound, which always occurs on account of muscular action, permitting proliferation of epithelial cells and allowing them to wander out over the granulations to temporarily and perhaps permanently prevent injurious stenosis. I believe, however, that until we have clinical observations to prove the limits which we can depend upon, we should treat every transverse wound of the ureter involving one-third or more of its circumference as immediately threatening stenosis. The treatment I propose is a modification of the procedure suggested and successfully practiced by Fenger in cases where stenosis had already occurred. The technique is the following: Make two longitudinal incisions, with small scissors, in the ureter beginning at the middle of the wound to be closed. These incisions should be equal in combined length to twice the transverse diameter of the tube. Round off the sharp angles of tissue with the scissors and suture longitudinally with the object of producing a very wide instead of a very contracted lumen. Scar contraction can not now reduce the caliber of the tube sufficiently to interfere with the passage of urine. If this operation has to be performed within the peritoneal cavity the ureter should be protected after the manner described for longitudinal wounds, by drawing about it a fold of peritoneal membrane.

Complete Transverse Wounds.—Many attempts have been made to unite the ureter, when transversely severed, by the ordinary methods of suture. Tuffier⁷⁰ of France, has published an elaborate account of his experiments upon dogs to determine the feasibility of the project. He claimed to have succeeded in getting union, but the amount and disposition of the cicatrix were such that when contraction of the scar occurred the tube was rendered useless as a duct.

Experimenters have hitherto been so much discouraged with the results of their trials that their recommendation has been to resort to such make-shifts as implantation into the rectum, the vagina or the skin.

In the JOURNAL OF THE AMERICAN MEDICAL ASSOCIATION for March 4, 1893, the writer published a method of uniting the ureter after transverse division which answers all the requirements of the conditions. It consists, briefly in the implantation of the upper cut end of the tube into an opening in the side of the lower end. The technique is as follows:

1. Ligate the lower portion of the tube one-eighth or one-fourth of an inch from the free end. Silk or catgut may be used. Make with fine sharp pointed scissors, a longitudinal incision twice as long as the diameter of the ureter, in the wall of the lower end, one-fourth of an inch below the ligature.

2. Make an incision, with the scissors, in the upper portion of the ureter, beginning at the open end of the duct and carrying it up one-fourth of an inch. This incision insures the patency of the tube.

3. Pass two very small cambric sewing needles armed with one thread of sterilized catgut through the wall of the upper end of the ureter, one-eighth of an inch from the extremity, from within outward, the needles being from one-sixteenth to one-eighth of an inch apart, and equidistant from the end of the duct. It will be seen that the loop of catgut between the needles firmly grasps the upper end of the ureter.

4. These needles are now carried through the slit in the side of the lower end of the ureter into and down the tube for one-half an inch where they are pushed through the wall of the duct, side by side.

5. It will now be seen that the traction upon this catgut loop passing through the wall of the ureter will draw the upper fragment of the duct into the lower portion. This

being done the ends of the loop are tied together securely and, as the catgut will be absorbed in a few days, calculi do not form to obstruct the passage of the urine.

6. The ureter is now enveloped carefully with peritoneum as already described in other operations, provided an intra-peritoneal operation has been done.

This method has many advantages, some of which are as follows:

1. The urine is made to pass through its normal channel.
2. Healing takes place at once without even temporary loss of function or a temporary fistula.
3. No stenosis occurs even after a long interval of time.
4. The ureter can always be united if accidentally injured, at any operation, with materials always at hand.
5. Leakage can not occur, because the upper extremity of the ureter acts as an obstructor to the lower portion of the tube.
6. Scar contraction can never injuriously diminish the lumen of the tube, because the scar which encircles the ureter after union by this method is equal in length to twice the extent of the incision in the side of the lower urethral stump.

Some months after the writer had thought out the above method theoretically, and several weeks after the publication of the preliminary communication, references were found to a method experimentally tried by Poggi⁵⁰ of Italy.

This method consists, briefly, in the end-in-end invagination of the upper into the lower portion of the ureter. I believe my lateral method is better for two reasons:

1. Because the invaginated end of the ureter is less likely to be compressed by muscular action of the invaginating portion in the lateral method, since the constricting force can not act so directly at the immediate point of union.
2. In the lateral method the line of permanent and firm union is not a circle, as in Pozzi's method, but an ellipse, so that senescence of the new connective tissue can not result in injurious contracture.

It is not necessary to detail the many experiments made to demonstrate the practicability of this procedure. The following will suffice:

Experiment.—Jan. 17, 1893. Bitch, medium sized, in good condition. Assisted by Dr. A. E. Halstead, I opened the abdomen in the median line through an extent of two and one-half inches beginning at a point one inch above the pubes. Gentle traction upon the bladder caused the ureters to stand out prominently beneath the posterior layer of peritoneum. Opening the posterior peritoneal wall with a snip of the scissors, the right ureter was drawn gently out and cut in two with the scissors at a point about an inch above the entrance into the bladder. The open end of the lower fragment was next closed with a ligature and a slit about seven millimeters long made in the side of the tube just below the ligature. Two needles, armed with a single thread of catgut, were then passed through the wall of the upper portion of the duct from within outward, opposite the slit in its wall which had been made to enlarge the opening. These needles were then passed through the slit in the side of the lower portion of the ureter and their points carried down the tube about one cm., where they were pushed through the wall of the ureter and brought out side by side. By gentle manipulation the upper extremity was drawn into the lower tube and the suture being tightened and tied, the slit was seen to be entirely occluded. Dogs have a very abundant omentum and to simplify the technique the omentum was gently drawn about the ureter and tacked down with two fine silk sutures. The abdomen was closed. Three weeks later the dog which had not been ill after recovering from the anesthetic, was killed. The abdominal wound was completely healed. Upon opening the abdominal cavity much fat was found in the usual places, showing good nutrition. The kidneys were perfectly normal and exactly equal in size and similar in appearance. There was no excess of urine in either pelvis. There was absolutely no evidence of inflammation at any point. The union of the ureter was found to be perfect, as can be seen by examining the specimen which I present and the accompanying cuts from photographs. The omentum surrounds the point of union. (See Figs. 1 and 2).

It is evident upon reflection, that this method of reuniting the ureter after transverse division can be utilized for restoring the continuity of the duct, not only after accidental division, but after division deliberately undertaken for the purpose of removing retro-ureteral morbid tissue in abdominal operations; and after removing a portion of the ureter by resection in continuity for strictures, and for ulcerations about calculi involving annular destruction of the mucous membrane which would eventually terminate in stenosis, if untreated.

That the ureter can sustain a resection involving a considerable amount of tissue is evident, since ureters measuring ten inches while in situ will easily measure twelve to fourteen inches when removed. The operator should remember that the longitudinal muscular fibers tend constantly to shorten the distance between the ends of the duct, so that when the ureter is cut transversely the ends retract considerably. Traction upon these ends is admissible to a very considerable extent, which can not be accurately determined until a larger amount of clinical experience in this direction has accumulated. Meanwhile we may

easily determine in individual cases the amount of material which we may remove from the longitudinal extent of the ureter, in deliberate resections. The force exercised should be moderate in amount but steadily applied for a considerable time, the surgeon remembering that he is overcoming muscular resistance. As the blood vessels ramify tortuously over the ureter, they are in no danger of it being injuriously stretched or lacerated. From these statements it must be seen that for the excision of a constricting band the ureter need not by any means be longer than normal.

That my operation is equally as applicable to human ureters as to those of lower animals has been proved by Dr. Howard Kelly of Johns Hopkins University, Baltimore. Dr. Kelly has informed me verbally that having seen my preliminary description of the method in the *JOURNAL OF THE AMERICAN MEDICAL ASSOCIATION*, he had an opportunity of applying it in a few days upon a patient suffering from a

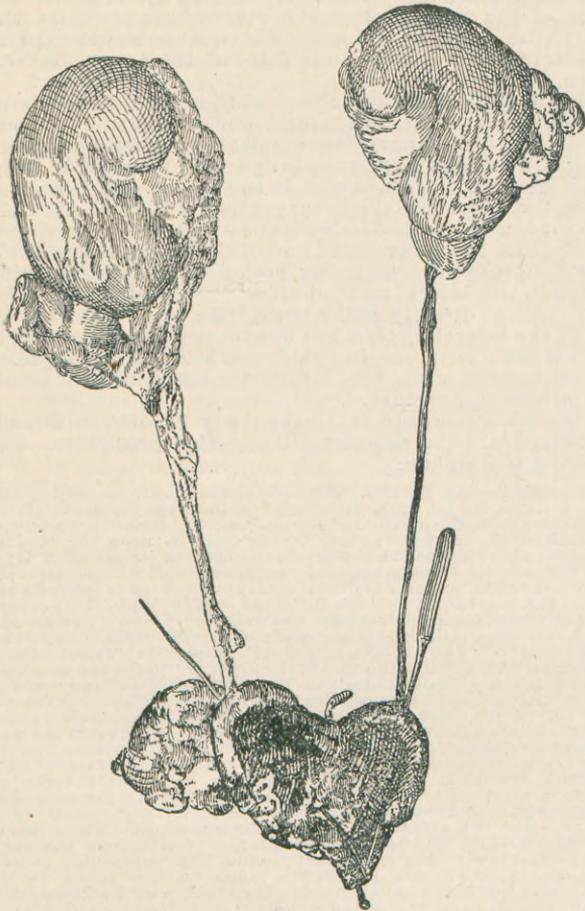


FIGURE 1.

large myoma of the uterus. One of the ureters having been injured during the operation, it was held by forceps until the myoma was removed when it was reunited by my method. The patient made an uneventful recovery. Dr. Kelly will shortly publish a detailed account of the case.¹

Complete transverse division of the ureter at the infundibulum offers conditions essentially different in many respects from those presented in the continuity of the duct. There the tube is much wider than at the lower part, a fact of which we can take advantage because of the greater mechanical ease with which we can insert sutures; but more especially because scar contraction, as a result of union after suture, is not so likely to prove destructive to the lumen of the tube.

Two pathfinding papers have recently appeared dealing with this subject.

The first of these, by Kuester,²⁹ described an operation upon a boy who had been operated upon previously for a hydronephrosis involving a solitary kidney. An abdominal renal fistula was left, through which all the urine was discharged. Kuester exposed the kidney and ureter by posterior incision, opened the ureter below the sacculated gland

and found two cm. below the kidney, a stricture. This condition he treated successfully by resecting the strictured portion of the tube and implanting it into the hydronephrotic sac. A lumbar fistula remained for several months but was finally cured by a secondary operation.

This instructive operation was borne in mind in the following case, which I briefly report in order to testify to the applicability of the method:

Boy aged 19, suffered from an attack of typical typhoid fever. Following this attack some weeks later he developed a pyonephrosis. Dr. A. E. Halstead, in whose practice the case occurred, invited me to see the case with him. We established a fistula upon the abdominal wall, the sac discharging a large amount of urine. As the fistula remained "permanent" I operated, upon the invitation of Dr. Halstead, for the purpose of restoring the normal channel for the discharge of the urine. The incision was practically that used by Kuester and others, beginning at a point two inches to the left of the posterior median line, carried down for an inch and a half almost straight and then curved forward toward the anterior superior iliac spine. As soon as the anterior lumbar fascia was opened the ureter was discovered without difficulty. It was smaller than normal and seemed to be atrophied. The kidney dilated on account of partial closure of the abdominal fistula, could easily be felt in its normal position. Upon opening the renal sac and allowing part of the fluid to escape, the finger could be easily passed into the pelvis of the kidney, but no stone was felt. I then made a ureterotomy and passed a probe up the ureter to meet the finger; but between the finger and the probe I could distinctly feel a valvular fold of mucous membrane. Concluding that this was the obstruction which had prevented the normal discharge of urine, I proceeded to resect after Kuester's method and succeeded in implanting the ureter into the sac much as he had done. It was now thought best to expose the ureter in the direction of the bladder. Upon passing a probe downward a short distance the ureter was found completely closed, and on careful investigation its lumen was found to be entirely obliterated for several inches. There was nothing left to do but to extirpate the kidney. The patient recovered.

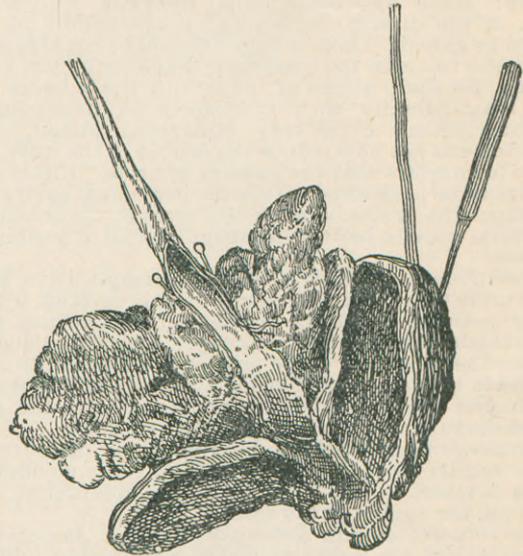


FIGURE 2.

This case, together with Kuester's, fully demonstrated the feasibility of this operation in this condition, and from it I concluded that kidneys should not be extirpated for simple obstruction at the infundibulum.

The second of these papers, that of Dr. Christian Fenger of Chicago, was read before the Chicago Medical Society, Feb. 6, 1893, and was published in the *Chicago Medical Recorder* of March, 1893. Dr. Fenger's first work on stenosis of the ureter was performed May 31, 1892.

In a case of intermittent pyonephrosis, the kidney was opened upon its convex surface and digital exploration made without the discovery of a stone. Catheterization of the ureter was impossible. The pelvis was now opened from its posterior surface. This revealed a valvular opening from the pelvis into the ureter. The valve was then divided transversely and the edges of the wound were united by a suture. A bougie was inserted through the wound in the kidney, brought down into the ureter and retained there for two days. The wound in the pelvis was united by sutures. The floating kidney was secured by nephrorrhaphy, the wound in the kidney drained and the usual dressings applied. The patient recovered without a fistula and had no return of the pyonephrosis.

This remarkable case, so ingeniously treated, is the first of its kind. The method is indeed worthy of commendation and study. It will be found applicable in many kidneys which heretofore would have been ruthlessly extirpated.

The second of Fenger's cases is briefly as follows:

Traumatic stricture of the ureter close to its entrance into the pelvis of the kidney; intermittent hydronephrosis. The patient, 47 years of age, had sustained an injury thirty-four years previously. After ten years the hydronephrosis developed. Operation—lumbar nephrotomy—disclosed no calculi. The ureteral entrance could not be found through

¹ This case has just been published in *The Johns Hopkins Bulletin*, October, 1893.

the renal opening. The dilated pelvis was opened, but still the opening of the ureter could not be found. The ureter was now isolated and its upper end found to be imbedded in cicatricial tissue for half an inch. Lower down, though small in caliber, the duct was normal. A longitudinal incision one cm. long was now made in the ureter just below the cicatrix. The stricture was one cm. long. It was incised upward into the pelvis. The ureteral wound was now stitched longitudinally, after the manner of the Heinecke-Mikulicz procedure for the treatment of pyloric strictures. No bougie was left in place. The patient made a good recovery without return of the hydronephrosis.

In the first case, Fenger has given us a method of successfully dealing with valvular obstructions at the infundibulum. In this second procedure he has added to our resources for doing away with stenoses of the ureter at the infundibulum. For this condition Fenger rightly claims for this operation the following advantages over the resection of Kuester:

1. It is an operation more economical of tissue and preferable when the elongation of the ureter is not sufficient to permit the two cut ends of the ureter, after excision of the stricture, to come in contact without stretching.

2. It is easier to secure union of a ureter which has been incompletely divided in a transverse direction.

Implantation into the Bladder.—When injury to the ureter at or very near the vesical end, occurs as a result of an accidental or surgical wound, it is feasible to implant the ureter into the bladder immediately, if permitted by circumstances such as asepsis, abundance of time, local anatomic conditions, etc.

Abundant clinical experience proves this statement. In addition, Paoli and Busachi⁴⁵ report successful implantations of the ureters into the bladder in dogs. Their success depended upon the splitting of the distal end of the ureter for a short distance and careful suture of this quadrangular opening into a slit in the bladder.

In the human subject the operation field should be left, whenever possible, outside the peritoneal cavity. This result can be secured under certain circumstances only by dissecting the peritoneum loose and stitching it down behind the site of operation, as directed in the description of the plastic extension of the bladder to meet the ureter. The bladder should be kept drained in some convenient manner to annihilate intra-vesical urinary pressure and to limit as much as possible the motion of the parts until union has occurred.

Bocchini⁸ has very recently reported an interesting case operated upon by Novaro, in which a vaginal ureteral fistula following hysterectomy was cured by abdominal incision and careful suture of the excised ureteral meatus into the bladder.

Complete transverse injury with loss of substance is evidently one of the gravest ureteral conditions with which the surgeon can be confronted. The methods by which this condition can be met may be arranged under three heads:

1. Methods by which the urine is still made to flow into the bladder.

2. Methods by which the urine is discharged extravasically, either into some cavity or directly into the outer air.

3. Methods by which the flow of urine is permanently arrested, either by destruction of the secretory power of the kidney or by its extirpation.

By injuries to the ureter with loss of substance, I would be understood as meaning wounds with a loss of substance too great to admit of utilizing my method of reuniting the tube when transversely divided.

Under the head of methods by which the urine is still made to enter the bladder, we must first consider the methods by which the ureter is substituted by a connective-tissue tube as in the case of Nussbaum.³⁸ In a case of fistula opening upon the abdominal wall after a laparotomy, Nussbaum passed a properly shaped glass tube into the bladder from the abdominal wound through the connective tissue about the bladder. After the tube had remained in position for some time it was withdrawn and the haphazard procedure was followed by success, although I can not find a record of an examination of the case after the lapse of any considerable time. There are many objections to such an attempt.

1. Infection of the connective tissue about the tube is liable to prove serious, or even fatal.

2. The operator depends upon the formation of a new connective tissue duct to carry the urine permanently into the bladder. This connective tissue is certain to contract as time passes and occlude the lumen of the tube.

3. The new tube can only be lined with epithelial cells when it is very short, since the epithelium of the mucous membrane can not proliferate beyond certain definite small limits.

4. Even if the tube becomes lined with mucous membrane the new epithelium will be poorly resistant, and will be likely to remain a nidus of disease.

5. The method is rarely applicable and is unlikely to be a primary success, on account of the difficulty of making the new tube (especially at the abdominal end) withstand the intra-vesical pressure.

This last point is well illustrated in the following experiment:

Nov. 24, 1892. Jersey calf, male, aged six days, weight cir. ninety pounds, in good condition. Chloroform anesthesia. The abdomen was opened and the right ureter cut in two about three inches above its cystic insertion. The cystic end was ligated. The upper end was carefully sutured into the end of a thoroughly decalcified turkey's wing bone. The urine at once began flowing from the lower end of the bone tube, showing a tight union. The lower end of the bone tube was then sutured as carefully as possible into the bladder. The peritoneum was somewhat imperfectly brought over the tube and the abdomen closed. The calf after recovering from the anesthesia seemed comfortable, drank abundantly of milk, slept and urinated normally for fourteen days when it appeared ill for two days and one morning was found dead. Postmortem. Adhesive general peritonitis was found to have been the cause of death. The kidneys were normal. The right ureter entered an enormous retro-peritoneal sac containing urine and fibrin from inflammation of its walls. The ureter was still fastened into the unchanged bone tube, around which was a perfect tube of new connective tissue. The bone tube was loosely inserted into the bladder and was freely patent. At the point where the ureter entered the bone tube there was an opening communicating with the large sac containing urine. The intra-cystic tonic pressure had caused the enlargement of the cyst until it contained a gallon of fluid.

This instructive though unsuccessful experiment was interesting especially on account of these points: 1, there was a patent canal from the pelvis of the kidney to the bladder; 2, there was no apparent attempt at absorption of the bone tube; 3, the intra-cystic pressure must be, at least temporarily, removed in attempts to replace the ureter by a connective tissue tube. The last very practical observation is especially applicable in case the ureter is implanted directly into the bladder, so that the valve action of the cystic opening of the duct is abolished.

Dr. Christian Fenger in personal conversation in February, 1893, suggested to the writer the use of an isolated knuckle of bowel to supply material for the replacement of ureteral losses. Dr. Joseph B. Bacon of Chicago, soon after published this same suggestion, which was original with him, in the *Chicago Medical Record*. Dr. Bacon proposes to isolate a sufficient length of small intestine, by cutting through the bowel at such points as will leave the isolated loop of intestine well supplied with blood vessels. He would then restore the continuity of the bowel by the use of Murphy's anastomosis button, and implant the ends of the injured ureter into the isolated portion of bowel after closing the ends of the bowel. The urine will then find a continuous channel from the pelvis of the kidney to the bladder.

This very ingenious method, apparently so plausible and captivating, is nevertheless open to the following theoretical objections which could scarcely be controverted by successfully practicing the plan in actual operations upon the human subject:

1. In most operations in which the ureters are injured the resources of the patient are taxed to such an extent that it is better surgical practice to resort to a very rapid procedure, as implantation upon the abdominal wall. This objection may be neglected when the operator is especially skillful in intestinal surgery.

2. The operation exposes the patient to all the risks of resection of the intestine, in addition to those naturally referable to the original operation.

3. The portion of intestine with which it is proposed to replace the lost ureteral substance is necessarily septic; and, as we shall see later on, this septic condition, by threatening the patient with uretero-pyelo-nephritis, absolutely contra-indicates this operation.

One great practical drawback to Dr. Bacon's suggestion lies in the fact that he proposes to do all this complicated work within the peritoneum. If the intestine is ever to be used to piece out the ureter, I would suggest an extra-peritoneal method of doing the operation so far as the ureteral work is concerned. This suggestion is based upon the experiments of Poggi and Tizzoni, an account of which was published in 1888. These investigators succeeded in replacing the excised bladder with a portion of intestine isolated for the purpose. And recently Dr. S. Rosenberg of Hamburg, has succeeded, experimentally, in increasing the size of the bladder by suturing to it a detached piece of intestine. I would suggest, as a method less dangerous than that of Dr. Bacon, bringing out the isolated loop of bowel upon the abdominal wall, suturing the peritoneum behind it sufficiently loosely to prevent strangulation of the vessels sup-

plying it, and making a ureteral fistula above the loop of isolated bowel. The bowel may now be embedded beneath the skin with adequate drainage. The secondary operation some time afterward will aim to direct the flow of urine into the now shrunken and far less septic intestine and thence into the bladder. The bladder must be temporarily drained.

This method by the use of intestinal loops can never be of practical consequence, except possibly in those very rare cases in which the ureteral fistula opens upon the abdomen at a point remote from the bladder, requiring on that account a large amount of tissue to fill in the space.

Where the ureteral injury occurs low down, near the bladder, the loss of substance must be considerable, indeed, if the ureter can not be implanted directly into the bladder. This can be accomplished, if the ureter can be drawn down and the bladder drawn up sufficiently, with great ease, as has been described under the head of complete transverse injuries without loss of substance.

The Writer's Plastic Methods for Making a Vesical Diverticulum.—When the ureter has been injured in intra-abdominal operations in such a way that the duct can not be there implanted into the bladder, or when morbid processes are found to have brought about the same result, I would recommend strongly the following procedure:

1. Implant the ureter upon the skin of the abdomen in the median line as near the bladder as possible. Close the abdominal walls as usual, except for the presence of the ureter.

muscles or fascia, and the end of the ureter is held in position by light catgut sutures which pass through loose peri-ureteral connective tissue, if possible, and through the muscular structures near at hand.

5. We are now in position to sew together the edges of the flap to form a tube, into the upper end of which the ureter is introduced, and to carry a similar row of light catgut sutures down the bladder wound itself. The lower angle of the vesical opening would best be left open for the sake of drainage. It will in all probability cause no trouble in healing. The upper part of the skin wound together with the fasciæ may be closed. Under careful antiseptic treatment this procedure ought to be as practicable and as easy as the majority of operations daily undertaken.

I have practiced the method only upon the cadaver. Fig. 8 shows the appearance of the parts after the flap is dissected up from the bladder. In this subject, a female of medium height, the distance from the pubes to the umbilicus was 17 cm.; from the pubes to the peritoneal reflection upon the bladder, 5 cm.; from the pubes to the upper end of the vesical flap, 10 cm. Hence we may safely say that without opening the peritoneum the bladder can be plastically extended to meet the ureter, when that duct is brought out upon the abdomen at any point more than 8 cm., (about three and one-fourth inches) inferior to the umbilicus.

This is not, however, the limit of such plastic procedures upon the bladder. For, if the peritoneum is opened, the flap can be considerably increased in size. The ureteral fistula

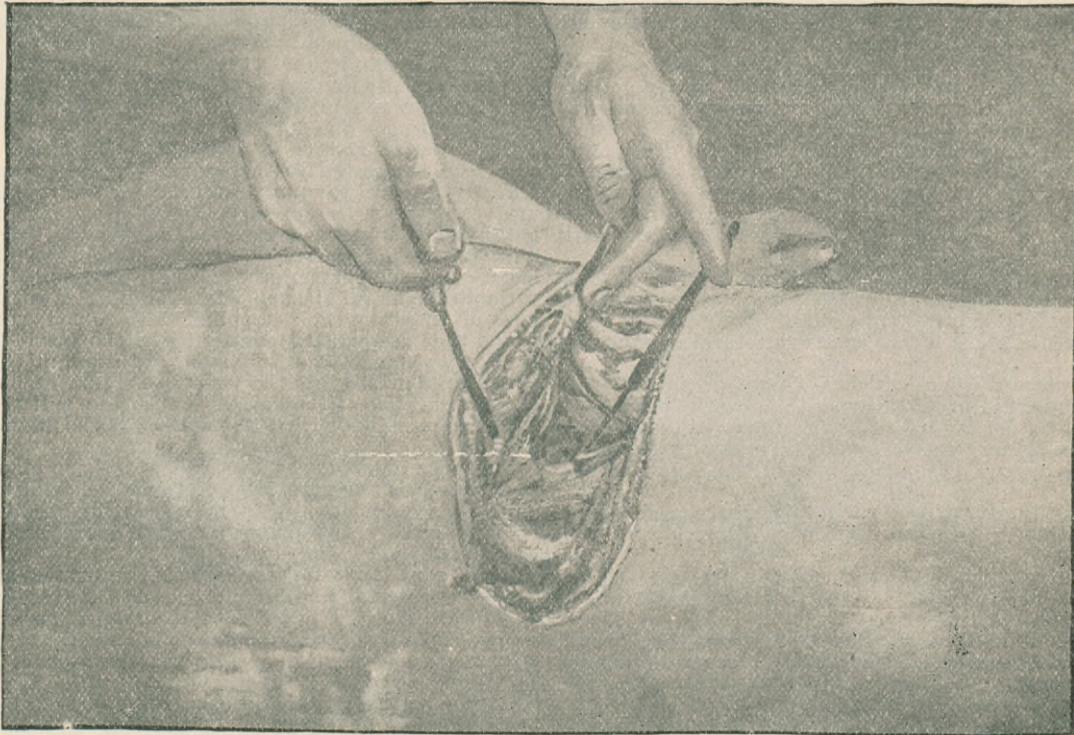


Fig. 3.—Cadaver lying on the left side. Incision made to expose the ureter, which is seen upon the hook at the right.

2. When the patient has fully recovered from the primary operation, open the structures composing the abdominal wall between the ureter and the pubes down to the peritoneum and bladder. The peritoneum must not be opened. The bladder may be distended and raised exactly as in supra-pubic cystotomy.

3. Make two incisions in the bladder parallel to the median line, beginning as near as possible to the peritoneum without prejudice to its integrity, carry them down at a distance of about 15 mm. apart towards the neck of the bladder under guidance of the finger. With scissors curved on the flat the two incisions are now united at the lowest point and hemorrhage is controlled with pressure forceps. It will be seen that we now have at our disposal a vesical flap of considerable extent hinged above by a nutrient pedicle.

4. The ureter is loosened from the skin and brought well down towards the flap which is simultaneously raised to meet it. The vesical flap is firmly fastened back in its new position by catgut sutures passing through the neighboring

having been established as before, as low down as possible the secondary operation is begun by (1) making an incision to expose the attachment of the peritoneum to bladder; (2) the peritoneum will then be opened transversely at or very near its vesical reflection, and fastened by some points of catgut suture (or by a continuous suture) to the fundus of the bladder as far back as possible. In other words, the peritoneum is transplanted backward upon the bladder. The point to which the peritoneum is transplanted must be marked by a silk suture, with ends left long if the operation is not completed at once. The remainder of the procedure may be performed at once if the urine is aseptic, and if the peritoneum has been well fastened down to the base of the bladder. If these conditions are absent, the final steps may be deferred some days. The remainder of the operation is the same as that already described except that the peritoneum being farther back, a much larger flap can be secured. Experiment upon the cadaver convinced me that with care the bladder flap may, by opening the peritoneum, be made to meet

the ureter at any point one inch (2.5 cm.) or more below the umbilicus.

This operation has the following advantages:

1. The normal relations of kidney and bladder are restored.
2. It is entirely safe, the technique annulling the dangers of peritonitis from the urine, if septic.
3. The bladder can be utilized by plastic procedure to make good a defect of several inches in the ureter.
4. No other viscus than those at first implicated is called upon to make good the loss.

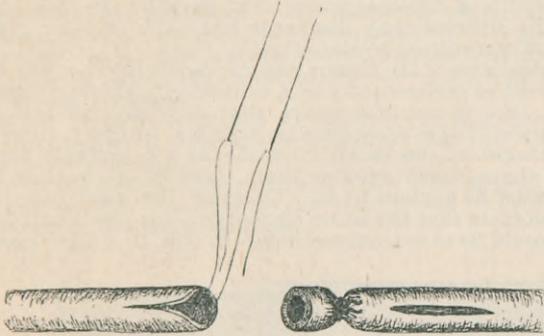


Fig. 4.—The suture armed with two needles holding the upper end of the ureter in its loop.

Symphiseotomy for exposure of the bladder to operation naturally suggests itself, since the attention of surgeons has been called to this method of reaching pelvic organs and of increasing intra-pelvic space. It has been formally proposed as a method of gaining access to the bladder by Wickhoff.⁶⁵ The bladder distended with six to twelve ounces of water, may be brought into view and be made easily accessible when the symphysis is divided. The harmlessness of the procedure when carefully performed would render it justifiable as a preliminary step in the writer's methods of making a vesical diverticulum to meet a shortened ureter.

Rydygier's Method.—An ingenious method of extra-peritoneal ureteroplasty was suggested by Ludwig Rydygier.⁵⁷ He advises that in cases of injury to the ureter during surgical operations, the two ends of the ureter be brought out through the abdominal wall and the wall be allowed to close about them. He would then prepare for the urine an artificial channel of skin by making two parallel incisions between the two openings, suturing together the edges of the isolated piece of skin so as to form a tube and depressing this tube by sewing over it the severed edges of skin drawn from each side.



Fig. 5.—The needles passed down the ureter through the slit and emerging from the ureteral wall.

The theoretical possibility of success by this method can not be doubted. For just as Rosenberg,⁵⁵ has shown that intestinal mucous membrane is speedily replaced by bladder epithelium when the bowel is implanted into the bladder, so Bardenheuer⁵ has shown that even very large masses of skin when transplanted into the oral cavity can speedily do full duty as mucous membrane by becoming overgrown with the epithelial cells peculiar to the oral mucous membranes. We would expect that in a comparatively short time after the turning in of the skin, according to the suggestion of Rydygier, the epithelium of the new tube would gain the essential characters of the ureteral mucous membrane. The plausibility of the plan is much diminished, however, when we remember how difficult it would be to overcome the influence of the urinary pressure at the points of desired junction. The method might be successful, however, by affording abundance of drainage at first, until healing had occurred at all points except those of junction.

In a case of this description (i. e., where the two ends of an injured ureter were implanted into the abdominal wall at some distance from one another) the writer suggested the formation of a new channel by implanting into a gutter between the two openings, a labium majus from the same patient. It was suggested that if this large piece of double mucous membrane were split after being removed it might be implanted by the Thiersch method and made to serve as mucosa for a new ureter. I am not aware that the suggestion was acted upon.

Vaginal Plastic Methods.—The ureter not infrequently

opens congenitally upon the vulva or within the vagina. These cases are usually amenable to treatment by making an incision around the orifice of the duct, at a distance from the ureter sufficiently great to leave a piece of mucous membrane attached to the tube. The ureter is then dissected back to the extent necessary to enable the operator to readily insert it into the bladder through an incision made for the purpose. Such a case is that of McArthur⁵⁵ which was entirely cured by this method.

The paper of Secheyron⁵⁹ upon the abnormal openings of the ureter upon the vulva and in the vagina should be mentioned in this connection.

Vaginal plastic methods, applicable when the ureter has been injured in surgical operations especially the modern kolpo-hysterectomy, have been frequently devised and put in practice. When the ureter discharges its fluid into the vagina and the duct itself can not be implanted directly into the bladder, two general plans are at our disposal:

1. The vaginal wall may be utilized to make a new channel to the bladder.
2. The vagina may be closed (kolpokleisis) particularly when the uterus has been extirpated.

The first of these plans has been repeatedly utilized and has given satisfactory results. The procedure was projected by T. A. Emmet,¹⁵ in a case in which the mouth of the ureter opened "on a line with the os uteri." Dr. Emmet formed a channel out of vaginal tissue to carry the urine from the mouth of the ureter to a point well beneath the bladder, intending to turn the new opening of urinary discharge into the bladder by a temporary vesico-vaginal fistula. The first part of the plan, the making of a new duct, was carried out without difficulty but the patient died of pneumonia in the interval between this and the final procedure.



Fig. 6.—The ends of the suture having been used to invaginate the upper in the lower fragment, are tied together.

Of course the lengthening of the ureter is unnecessary when it discharges into the vagina at a point well under the bladder. In this condition a vesico-vaginal fistula is made, and the ureteral opening is turned into the bladder. This was successfully accomplished by Dr. Wm. H. Baker of Boston, at the suggestion of Emmet, in a case in which the ureter opened congenitally into the vagina at a point near the urethral meatus.

The most interesting communication yet written upon the subject of vaginal ureteral fistula comes from Arie Geyl²¹ whose work appeared in 1892. He describes minutely a case in which, after a difficult forceps delivery a woman was found to have a fistula of both ureters, on one side emptying into the vagina near the uterus; on the other side discharging into the uterus at some unknown point. To get rid of the discharge from the uretero-vaginal fistula, Geyl used a portion of the vagina to form a pouch which he caused to communicate with the bladder by means of a permanent fistula. This was readily accomplished by first making a large opening into the bladder from the vagina and then removing an oval strip of vaginal mucous membrane surrounding this opening and the end of the ureter. By approximating the denuded surfaces from side to side the uretero-vaginal fistulae were made to communicate. This operation was a success. The subsequent attempt to close the uretero-uterine fistula failed and the patient declined further interference. The uretero-vaginal fistula was thus closed by a procedure easier and safer of execution and far more desirable than nephrectomy. Baum⁴ describes an ingenious procedure by which he succeeded in closing a supernumerary ureter opening into the vagina. He opened the bladder supra-pubically; then after incising the base of the bladder freely, he closed the peripheral end of the sacculated ureter thoroughly and stitched the edges of the ureteral dilatation to the edges of the wound in the base of the bladder. In other words, he used the *sectio alta* in order to turn the supernumerary ureter into that viscus.

Very interesting recent cases of uretero-vaginal fistulae have been studied by Weil.⁷⁵ Other cases have since been observed and operated upon, but it is not the purpose of this paper to make more than an allusion to this possibility, which readily does away with one of the commonest excuses for removing the kidney.

A ready conclusion from these considerations is to be found in the recommendation which I would unhesitatingly

and urgently make to those performing vaginal hysterectomy. When a ureter is injured during the course of the operation and the condition is realized, the ureter should be drawn down into the vagina and fastened to the vaginal wall well under the base of the bladder so that a subsequent plastic procedure may cause it to discharge normally. It should be covered by mucous membrane.

The second method of getting rid of uretero-vaginal fistulae, by closing the vagina permanently and establishing a vesico-vaginal communication, has been applied in several cases. It is not objectionable after kolpo-hysterectomy except in those cases in which marital relations would be interfered with by vaginal closure.

These two methods are so easily practicable and so nearly devoid of danger in their application that they should wholly supplant the destructive operation of nephrectomy for the relief of this form of ureteral fistula.

Urine Discharged Extra-Vesically.—It is within the experience of almost every surgeon to have seen cases of ureteral fistulae discharging upon the skin. It is also easily understood that such fistulae may readily be produced at will, when the ureter has been severed, by simply splitting the

one of these he sutured both ureters into the lateral abdominal walls. On the right side the abdominal wall suppurred and a pyelonephritis arose; on the left, more than five weeks after the operation the kidney was found healthy. In the second case, the same experiment being tried, the dog showed itself after several weeks to be perfectly well, with normal urine. From the first of these experiments we must conclude that bacterial activity about the mouth of the ureter is fraught with the gravest danger—a fact to which we shall frequently have to revert. The second experiment is a demonstration that even in the case of the dog the ureters may discharge upon the skin for a time without a resulting pyelonephritis.

Implantation of the Ureters into the Small Intestine has been practiced experimentally by a number of persons, in recent years. But I am not aware that any one now seriously recommends the procedure in practical surgery. The disadvantages of the small intestine as a receptacle for the urine are so much greater than those of the rectum that they must be obvious to all. Of these the most important are the facts that the urine discharged into the small intestine would have to traverse, before extrusion, a much greater

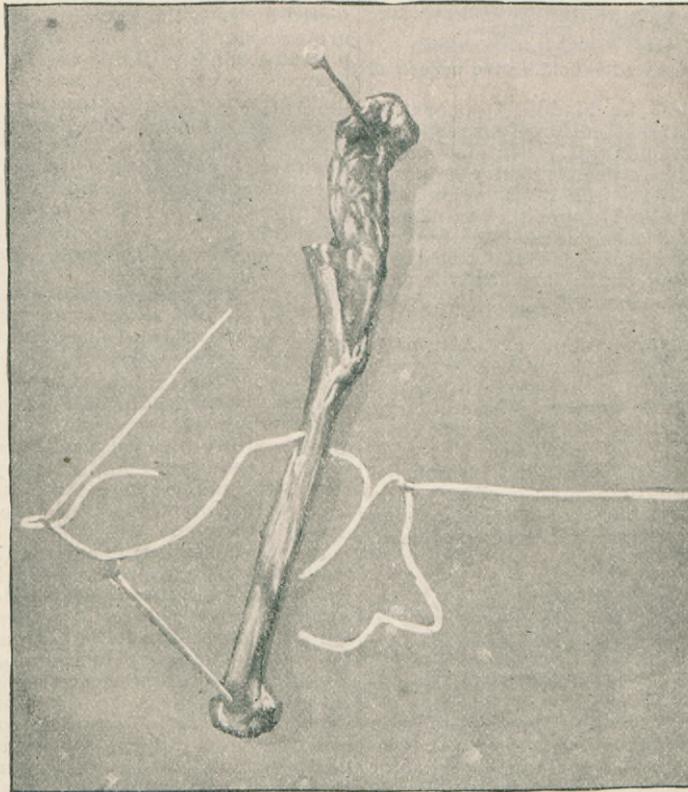


Fig. 7.—Writer's method of lateral implantation of the ureter, illustrated upon a piece of human ureter. The upper portion is being drawn into the lower by the two threads.

ureter slightly to enlarge its external opening and suturing it carefully upon the skin. Obviously, care must be taken that the ureter is not too sharply bent upon itself at any point in bringing it out of its natural bed, and that it is not compressed by other tissues or organs. It is not necessary to mention the many disastrous consequences which might arise as a result of compression in this way. The ureter has been purposely brought out upon the abdominal wall in this way, as in the cases of LeDentu³² and Pozzi.⁴⁸ Trekaki⁶⁸ goes so far as to recommend this operation in tumors of the bladder which compress the lumen of the ureter, in compression of the ureter by inoperable carcinomas and myomas of the ureters or inoperable tumors lying higher in the abdominal cavity. He regards partial lesions of the kidneys and not too extensive inflammations of these glands as by no means contra-indications for the procedure, but rather as indications, since they are more likely to recover when the urinary pressure is removed. He adds also that in complete ruptures of the ureters, after a trauma or surgical operation, suture of the ureter into the wound is indicated instead of nephrectomy. Trekaki supports his opinions by citing two experiments which he has made upon dogs. In

extent of intestine than would be the case with implantation into the rectum; and that the structure of the small intestine is still more complicated than that of the rectum.

I have made two experiments upon dogs to establish the value of the procedure. In both cases a single ureter was implanted into the bowel, about eighteen inches above the ileo-cecal valve. In both instances no serious inconvenience to the animal was observed. But upon killing the animals about ten days after the operation, the kidneys corresponding to the implanted ureters were found swollen and showed all the signs of pyelonephritis. The patency of the opening into the bowel was in both instances slightly compromised, so that there was a collection of a couple of drachms of purulent urine in the pelvis of the kidney and the ureter. As the result of these experiments does not differ from that of some of the implantations into the rectum, I would regard the upper portion of the intestine as less suitable than the rectum, solely on account of the a priori reasons already advanced.

Implantation of the Ureters into the Rectum was suggested by Roux and put in practice by John Simon in a case of exstrophy of the bladder, with an unfavorable result. Chaput

has, according to Rosenberg, recently practiced the method successfully in two cases. Morestin, according to the same writer, successfully practiced the operation in experiments upon the lower animals. Whether one or both ureters were implanted in the rectum is not stated.

Novaro,⁵⁷ an Italian, published in 1887 an elaborate account of an experiment upon a dog in which both ureters were implanted in the rectum. The dog recovered from the operation and was killed about thirty days afterward. The ureters were found neatly healed into the rectum and a microscopic examination of the kidneys was made. The testimony of the pathologist who made the examination is not absolutely unequivocal as to inflammatory changes, and no bacteriologic examination of the mucous membrane of the pelvis of the kidneys and the mucous membrane of the ureters was recorded.

Tuffier⁶⁰ describes his own experiments in this direction, and reached such unsuccessful results that he advised against the procedure.

Gluck and Zeller⁷⁷ experimented upon this subject without success, and emphasize the importance of stricture formation with hydronephrosis.

fore does not so easily undergo decomposition, and more important still, it can not mechanically carry bacteria to the kidneys, as is the case with fluids.

2. An amply sufficient argument in itself against a comparison of the species lies in the fact that birds' ureters are supplied with a mucous membrane evolutionally accustomed, as it were, to contact with infected solids and fluids; while the ureters of man are normally accustomed to the most absolute and perfect protection from the action of injurious microbic influences. This inherited ability of specialized tissues to resist invasion by micro-parasites is termed "resisting power," and is known to vary with the situation and needs of the different tissues. The ducts of all the secreting glands are more or less capable of repelling these invaders, as for example those of the liver and pancreas which normally open into the bacterially filthy bowel; the ducts of the salivary glands similarly open into an exceedingly "septic" cavity; the Bartholinian glands open upon the septic vulva. These various ducts rarely carry back to the glands which they supply the materials for their inflammatory destruction. It is true that some of them are protected by a slightly or relatively perfect valve action of

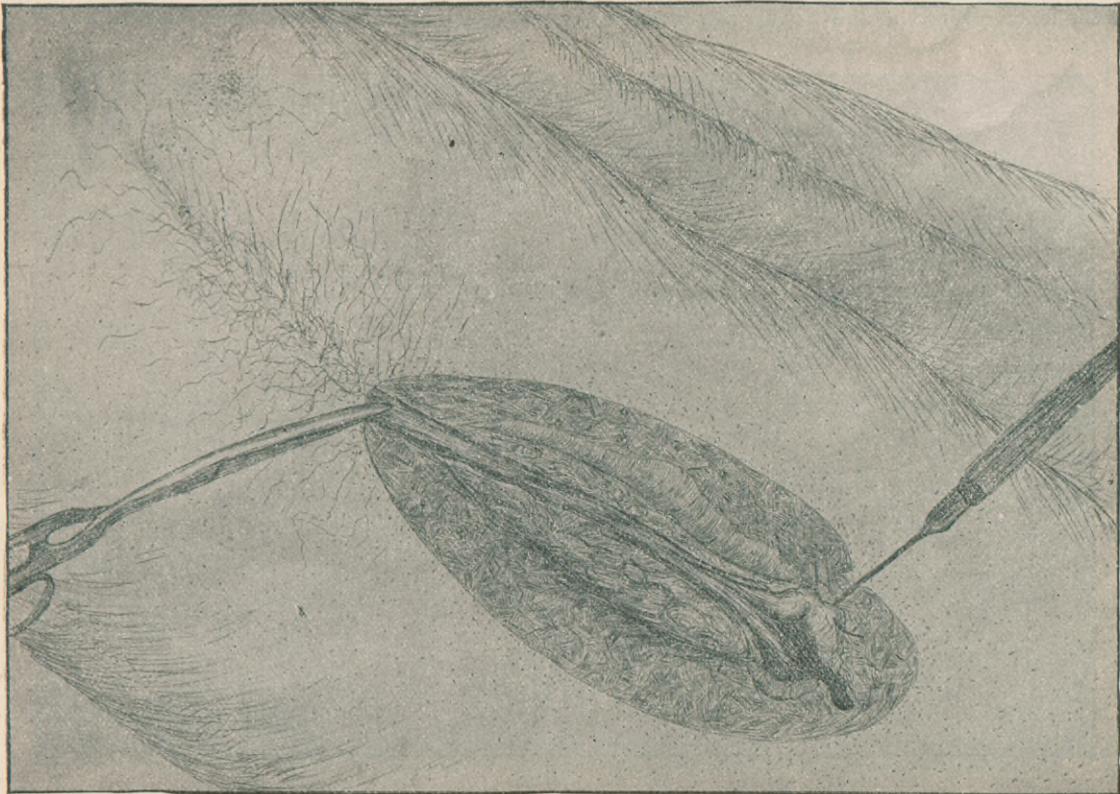


Fig. 8.—Writer's method of making a vesical flap to meet the ureter when the peritoneum is opened. The flap reaches to within an inch of the umbilicus, which is not shown in the drawing.

Bardenheuer⁵ studied the same questions with more encouraging results. Unfortunately his original work is not accessible to me.

In our own country, Dr. Harvey Reed⁵² of Mansfield, Ohio, presented before the AMERICAN MEDICAL ASSOCIATION in 1892, a paper recording twelve experiments upon this subject. Dr. Reed recommends the implantation of a single ureter in the rectum, but thinks we are not justified in attempting the operation upon both ureters at once.

The arguments in favor of the feasibility of implantation of the ureters in the rectum begins with the fallacious *a priori* reference to the urinary apparatus of birds. The argument is: (major premiss) birds urinate through the rectum (the usual loose statement); (minor premiss) man is a featherless biped; (conclusion) man should or may upon occasion urinate through the rectum.

But, neglecting the absurdity of the conclusion, the argument of analogy may be substantially controverted by these propositions:

1. The urine of birds is very slightly moistened. It there-

the mucous membrane at their outlets, but their main strength in opposing microbes must lie in their resisting power, acquired by evolutionary cycles of association with their enemies. The ureters, however, are among the most perfectly protected structures in the whole human anatomy. It is true that they stand in mechanical communication with the external filth. But the commerce of fluid is all in one direction—*nulla vestigia retrorsum!* Two powerful sets of gates close after the departing urine—first, the valve-like folds of the cystic mucous membrane at the mouths of the ureters; second, the sphincter vesicæ at the exit of the bladder. Each of these barriers is effective for a long time in repelling invaders. A violent urethritis often occurs without a cystitis. A violent cystitis often occurs without a urethritis. These well-protected ducts, the ureters, are therefore guarded so carefully that they need only in pathologic circumstances to meet microorganisms, and are therefore weak and well-nigh impotent to resist such enemies. How absurd and unthinking it is, then, to thrust the ends of these delicate tubes into the filthy rectum or small

intestine, filled with not only solid but liquid and gaseous materials to distend and defile the ureters and pelves of the kidneys.

The statement made by Dr. Reed that, in recto-vesical fistula, "the rectum usually becomes reconciled to the presence of the urine, and were it not for the escape of the feces into the bladder and the production of acute cystitis, there would be little to fear from this malady except some possible inconvenience," shows a pathetic regard for the powerful rectum, but no thought or consideration for the defenseless ureters. In vesico-rectal fistulae the feces might lie in contact for some time with the bladder wall without setting up inflammation of the ureters. But we all know from daily experience that the great danger in all cases of septic cystitis lies in possible uretero-pyelo-nephritis. In chronic cystitis this extension of inflammation does not always produce an immediately fatal result. The process may be slow and the patient may die months or years after the inception of the cystitis, from some acute exacerbation of the nephritis.

The arguments in favor of rectal implantation of the ureters from analogy and from pathology are therefore wholly fallacious.

Experimental evidence upon this subject has been, (1) negative, as in the work of Tuffier, one of the most reliable and accurate experimental surgeons; (2) incomplete, as in the case of Bardenheuer, Morestin and Novaro; or (3) incom-

plete and was killed eight or ten weeks later; specimen "rendered useless by wanton mutilation."

(2). Dog killed twenty-four days after operation; kidney "congested and shows evidence of acute nephritis," attributed to hydronephrosis caused by external adhesions.

(3). Dog killed twenty-five days after operation; no renal congestion, no hydronephrosis; patent opening into rectum.

The first of these experiments is not to be considered, as an examination of the specimen was not reported. The second is clearly demonstrative of the dangers of the procedure. The specimens of the third case, which is the most favorable, were not examined bacteriologically or even microscopically. Without these examinations we can not form an accurate judgment. Finer changes may contradict gross appearances, and the presence of bacteria, even if the kidney were normal, would obviously be a most serious menace to the future integrity and activity of the organ.

In six bilateral implantations, Dr. Reed reports three deaths from acute general peritonitis; one death from acute nephritis; one death from abscess of the abdominal wall; and one death from peritonitis and nephritis. In one-third of these cases, nephritis was confessedly present. No bacteriologic or microscopic examination of the pelves and kidneys of the other cases was made.

From this consideration of Dr. Reed's experiments we must conclude that, so far as the feasibility of rectal im-



Fig. 9.—Writer's method of turning upward a vesical flap to meet the ureter. Although the peritoneum is unopened, the flap reaches a point within three inches of the umbilicus, seen at the upper edge of the cut.

plete and imperfectly observed, as in the report of Dr. Reed already cited.

The first of these classes requires no discussion. The evidence of these surgeons is clearly against implantation of the ureter in the rectum.

By "incomplete evidence," I mean that while the results of these experimenters were favorable, their published trials of the procedure were too few in number to convince us that their successes were more than exceptional. We have no reason to believe that they could repeat the effort at will without disaster. Moreover, the observation of the strongest case yet recorded, that of Novaro, in which both ureters of a dog were implanted in the rectum and healing was found perfect after thirty days, is imperfect in that no bacteriologic examination of the pelves of the kidneys was made.

Dr. Reed reaches the strange conclusion, "that the unilateral implantation of the ureter in the rectum is a possible and practicable surgical procedure." He bases this conclusion upon a priori reasoning which I have already refuted, and upon three experiments upon dogs:

(1). Unilateral implantation—dog recovered from the ope-

plantation of the ureter is concerned, his researches are in part directly contradictory evidence, and in part entirely incomplete.

Tuffier's⁶⁹ experiments gave evidence contradictory to the possibility of utilizing the bowel as a receptacle for urine.

It seems to me that the feasibility of this operation rests upon a satisfactory answer to the following inquiries:

1. Does our mechanical technique assure us of reasonable safety in opening the septic rectum and fastening into it the ureter?

2. Does the rectum tolerate the urine and satisfactorily extrude it?

3. Do the ureter and the corresponding kidney tolerate the new anatomic arrangement?

4. Does our technique insure us against stenosis of the duct at the point of junction with the rectum?

The first of these questions can be answered with a hesitating affirmative. The trials of the procedure which have thus far been made upon human subjects have not all been published; of this I am assured by personal communications to which I am not at liberty to make specific reference. These unpublished failures are doubtless due to peritonitis

from infection through the rectal opening. Dr. Reed's technique is in the main good. There is no need of especial care in excluding the aseptic urine from the peritoneal cavity; it is in no such degree "irritating," as is the case with sublimate and other antiseptic solutions. The main immediate danger lies in the escape of fecal matter from the bowel. It is evidently proper, as Dr. Reed has done, to take up with the ureter a fold of peritoneum which is carried into the rectum. Dr. Reed passes a loop of thread over the end of the ureter, and by means of a needle threaded upon the loop carries the thread down the rectum a short distance and out through the rectal walls. Traction upon the thread draws the ureter well into the bowel, and after sutures are passed through the loose tissue about the ureter, the loop is released by cutting short the thread and allowing it to retract into the bowel.

Novaro's technique is very minutely described. It involves a V-shaped incision into the bowel, and seems to me unnecessarily complicated.

The method I have employed experimentally is as follows:

Raise an ample fold of peritoneum with the ureter. After severing the ureter, ligate the cystic end of the duct, and then split the opening of the renal portion of the tube with fine scissors upward for a distance equal to three times its diameter. Cause two small needles armed with a single

The second of these queries, as to the toleration of the urine by the rectum, can be quickly disposed of. Experience has amply proved that the rectum can easily maintain its integrity in the presence of the urine. And indeed, no one seems to have seriously raised the question except to answer it in the affirmative.

But the third question—involving the tolerance of the ureter and kidney for the new anatomic conditions—has not attracted the attention which it deserves, although infection has long been known to travel up the ureters with facility, as shown, for example, by Poirier.⁴⁵ For in reality this is the most important of all the questions. It is not to be expected that the rectum will refuse to submit to contact with the urine; but that the ureter, with its delicate mucous membrane leading to the easily inflamed pelvis, calyces and tubules of the kidney, should be expected to withstand the effect of being suddenly implanted into a reeking culture ground of the most various bacteria, is more than I can comprehend.

The experiments of previous investigators have not been directed to a solution of this question. From Dr. Reed's paper we gather that in two out of six unilateral implantations there were marked gross evidences of nephritis. It is probable that the number would have been much greater if the animals had been allowed to live longer.



Fig. 10.—A section from the junction of a knuckle of small intestine and the bladder wall. On the right the cylindrical cells of the implanted bowel; on the left the flat epithelial cells of the bladder displacing the cylindrical cells. Rosenberg, Virchow's Arch., Band 131.

fine silk or catgut thread to pass from within outward through the split end of the ureter. The ureter is thus grasped in the loop. Now pass the two needles into the bowel through a small longitudinal slit on the free border and carry them downward about one-half inch. When they are now pushed out through the rectal walls, the ends of the thread may be lightly tied together, drawing the ureter into position and permanently maintaining it there. The operation is completed by covering in the knot with two or more Lembert sutures, closing the rectal wound as well as possible without compressing the ureter, and applying a peritoneal graft. I made eight experiments by implanting a single ureter into the rectum after this manner. Three of these dogs died of general peritonitis. I have no hesitation in saying, however, that further practice would diminish this death rate. Still, it is apparent that the primary mortality from peritonitis must be high, since we are not at liberty to apply sutures tightly about the opening in the bowel, but must depend partly upon rapid peritoneal proliferation to close the wound. But even if closure could be perfectly secured at once, the escape of septic matter which almost inevitably occurs when the bowel is opened exposes the peritoneum to great risk of infection.

Of eight dogs in which I implanted one ureter in the rectum three died. In each of these three cases the kidney belonging to the implanted ureter was violently inflamed, being swollen, turgid and heavy, with muco-pus upon the mucous membrane of the pelvis. The following is a detailed account of one of the cases:

April 26.—Dog of thirty pounds weight; curly female. Following the technique already described the right ureter was implanted in the rectum. A small amount of fluid fecal matter escaped from the rectal wound, but was wiped away as carefully as possible. The operation was completed by a careful toilet of the peritoneum and closure of the abdomen. Forty-eight hours later the dog was found in a dying condition and was killed. A careful examination of the abdominal cavity showed a moderate amount of peritonitis about the site of implantation. There was no leakage from the bowel. The left kidney and ureter were normal in all particulars. The right ureter and kidney were in a state of violent inflammation. They were swollen and intensely red. In the pelvis of the kidney, which was opened with a red-hot knife, were a few drops of muco-purulent fluid with a tinge of blood in it. Cultures were made under all the indicated precautions. The patency of the ureteral canal was demonstrated by passing a small probe into the bowel. Microscopic examination shows violent hemorrhagic inflammation of the pelvis and pyramids of the kidney, as shown in the micro-photograph. Cultures of *staphylococcus pyogenes aureus* and other bacteria grew in the gelatin tubes inoculated, in a few days.

The five remaining dogs recovered from the immediate effects of the operation and were killed between the four-

teenth and twenty-first days after the operation. In three of these dogs the kidneys corresponding to the implanted ureters were in a state of morbid suppurative inflammation, pus being found in the pelves of the kidneys. The patency of the opening into the rectum was not so perfect in three cases as in those already described, as it required a small probe to pass into the rectum.

(Dr. Reed mentions in one case, (Exp. 11) of the implantation of both ureters that the right ureter was somewhat obstructed, the left freely open; nevertheless, there was violent inflammation of both kidneys.)

Implantation of both ureters in the rectum simultaneously, is an unmistakable test of the tolerance of the ureters and kidneys, provided the subject escape death by peritonitis. I performed six operations for the implantation of both ureters in the rectum. All the dogs died within six days. Four deaths were due to general peritonitis alone; the two other deaths were due to nephritis without compli-

the experiments thus far recorded, inasmuch as the dogs were killed too early to admit of scar contraction taking place at the point of implantation. But when we remember that the lumen of the ureter is exceedingly small; that this lumen is diminished rather than enlarged by the act of securing it in the rectum; that scar contraction must inevitably occur at the circle of cicatrization at the opening into the rectum; and above all that during the first few days of wound healing, as well as later, the constant tendency of the muscular fibers of the rectum is to lessen the circumference of the communicating opening between the ureter and rectum, we can not feel any confidence whatever in the permanent patency of the opening after the lapse of months and years. No implantation of a single ureter into the rectum either experimentally or in the human subject, should be accepted as favorable evidence, unless an autopsy has been made a long time after the operation.

Of all these arguments the readiest and most conclusive is

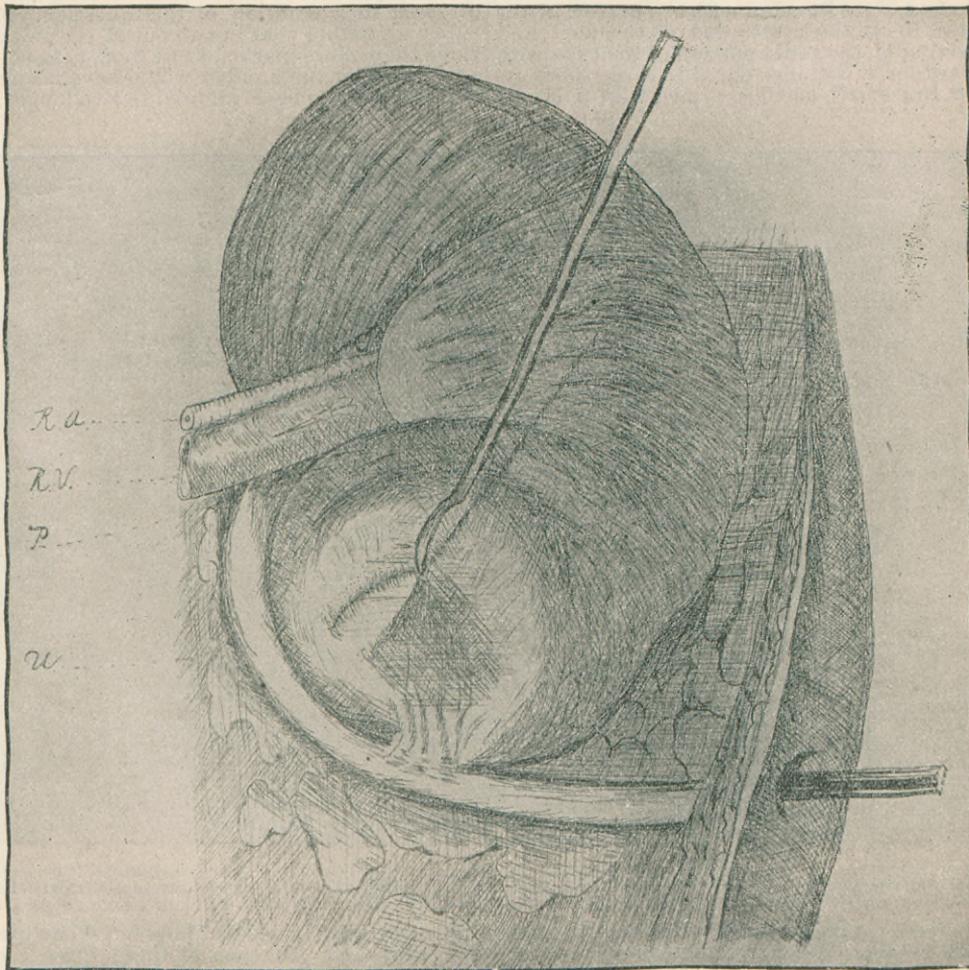


Fig. 11.—Implantation of the ureter upon the skin of the back. Le Dentu.

cating general peritonitis. In one of those dying of peritonitis and nephritis, there was moderate obstruction of the ureter causing retention of the urine in the pelves of the kidneys. The same thing occurred in one of those dying of nephritis. In none of these cases were the kidneys in such a condition that they could be expected to regain the performance of their functions in the face of so much infection.

It will thus be seen that in no single permanent introduction of the ureter into the rectum has it been demonstrated that inflammatory reaction on the part of the kidneys was absent. On the contrary, in a large majority of the implantations indications of pyelonephritis were glaringly evident even upon gross examination. My conclusion is, therefore, that the ureters and kidneys are absolutely intolerant of this interference.

The answer to the last question can not be gained from

that the infection of the upper urinary passages is inevitable. This is proved by the observation which I have recorded, showing that in one instance violent infection of the ureter and pelvis of the kidney occurred, with hemorrhagic purulent inflammation and the presence of abundant bacteria in the bloody pus at the end of forty-eight hours.

From this study of the possibility and practicability of implantation of the ureters in the rectum, the conclusion is inevitable that intestinal or rectal implantation of the ureter is primarily and remotely an extremely dangerous procedure unjustified by reason and condemned by experiment, and second that, inasmuch as the vital objections to this expedient are fundamental and not dependent upon criticism of a faulty technique, this operation must be regarded hereafter as unjustifiable in practice upon the human subject.

Stopping the Secretion of Urine may be accomplished by ligating the ureter, or by the obvious alternative of removing the kidney.

The immediate and remote consequences of complete ureteral obstruction have been the object of study by a number of physiologists as well as pathologists. Arnold Holste⁸ has given some study to this subject and finds that, after ligation, the pelvis of the kidney is first dilated, then the tubuli recti and finally the remaining tubules are distended.

When obstruction is complete, secretion stops as soon as extravascular urinary pressure equals intravascular blood pressure. The kidney, as a whole, becomes larger in all cases of obstruction, and especially is this the case when the stoppage is effected gradually or when it is intermittent, as is the case with compression of the ureters in carcinoma uteri or in intermittent hydronephrosis from calculi of the bladder or pelvis. Orth⁴⁰ formulates the rule that the more slowly the total obstruction is reached the greater will be the sacculation.

The facts that secretion stops entirely when the ureter is ligated, that sacculation is slight when there is absolutely no leakage, and that atrophy of the parenchyma of the kidney occurs later on, have led some authors to recommend ligation of the ureter as an expedient to be adopted when it is incapable of performing its function and when lesions are irreparable. This recommendation has been made by one of the French writers.

The idea seems chimerical for a number of reasons. LeDentu³² counsels against it for two reasons:

1. Because of antecedent infection (which is liable to convert a simple hydronephrosis into a pyonephrosis).
2. Because "grave accidents" are liable to occur.

These grave accidents which LeDentu does not specify are indeed sufficiently grave. One readily thinks of slipping of the ligature; infection of the ligature which would allow infected pent-up urine to escape into the retro-peritoneal space if not into the abdominal cavity itself; rupture of the distended kidney, etc. Again, the sudden stoppage of the ureter in experimental animals always produces an enormous venous congestion, especially of the veins upon the capsule of the organ. Rupture of these veins with dangerous hemorrhage would not be inconceivable in patients whose vascular systems are in an abnormal condition. An entirely different problem which the suggestion brings up, is as to the ability of the remaining kidney to bear the additional burden of secreting the urine which would have been discharged from the other kidney. This danger would be equal to that which we fear in primary nephrectomy.

To me the greatest objection to the method, except of possible infection, lies in the fact that the kidney is sacrificed as completely as if removed. The kidney is an organ which has heretofore been sacrificed for ureteral disease or injury far more frequently than it should have been—more frequently than the immediate future will justify.

Nephrectomy for simple ureteral fistulae has been performed many times, usually with success. It is unnecessary to refer to the many reports with which periodical medical literature abounds.

Kidneys have been sacrificed also for many other equally simple conditions, as intermittent hydronephrosis, cicatricial stenosis of the ureter, etc. But it is well-known that the process of compensatory hypertrophy of the remaining kidney always adds gravity to nephrectomy and, as one kidney is liable to many forms of disease while its fellow remains intact, it follows that the possession of two kidneys is a great safeguard to the patient. These facts are amply sufficient to make it unjustifiable to sacrifice a kidney, except when every means has been resorted to in order to repair the morbid condition. Indeed, it is just as improper to remove a kidney for remediable ureteral disease as to remove a kidney because it is movable.

CONCLUSIONS.

1. The extra-pelvic portion of the ureter is most readily and safely accessible for exploration and surgical treatment by the retro-peritoneal route.

2. Hence all operations upon the ureters above the crossing of the iliac arteries should be performed retro-peritoneally, except in those cases in which the necessity for the ureteral operation arises during laparotomy.

3. The intra-pelvic portion may be reached by incision through the ventral wall, the bladder, the rectum, the vagina in the female, the perineum in the male, or by Kraske's sacral method.

4. The ureter is not only exceptionally well protected from

injury, but by its elasticity and toughness resists violence to a remarkable degree.

5. The histology of the ureters furnishes most favorable conditions for the healing of wounds.

6. Longitudinal wounds of the ureter at any point, heal without difficulty in the absence of septic processes, under the influence of ample drainage.

7. In all injuries where the urine is septic before the operation, or where the wound is infected during the operation, drainage must be effected.

8. The chemic composition and reaction of the urine must be studied in all injuries to the ureter, the urine being rendered acid, if possible, and the specific gravity kept low.

9. The pelvis of the ureter is, *ceteris paribus*, the most favorable site for wounds of the ureter, since scar contraction is not so likely there to be productive of ill results.

10. In aseptic longitudinal wounds of the ureter occurring in the course of laparotomy, suture may be practiced and the peritoneum protected by suture.

11. Transverse wounds of the ureter involving less than one-third of the circumference of the duct, should be treated by free drainage (extra-peritoneal), and not by suture.

12. In transverse injuries in the continuity of the ureter, involving more than one-third of the circumference of the duct, stricture by subsequent scar contraction should be anticipated by converting the transverse into a longitudinal wound and introducing longitudinal sutures.

13. In complete transverse wounds of the ureter at the pelvis, sutures may be used if the line of union be made as great as possible.

14. In complete transverse injuries of the ureter in continuity, union must not be attempted by suture.

15. In complete transverse injuries of the ureter in continuity, union without subsequent scar contraction may be obtained by the writer's method of lateral implantation, as described.

16. In complete transverse injuries of the ureter very near the bladder, the duct may be implanted, but with less advantage, into the bladder directly.

17. At the pelvis of the ureter, continuity after complete transverse injury may be restored by Kuester's method of suture, providing the severed ends can be approximated by slightly loosening the ureter from its attachments.

18. Rydygier's method of ureteroplasty, in such injuries may be tried if other methods can not be utilized. The primary operation should at least fix the ends of the tube as nearly as possible together.

19. In both transperitoneal and retroperitoneal operations the ureteral ends can be approximated by my method even after the loss of about an inch of its substance.

20. The use of tubes of glass and other materials for the production of channels to do duty in place of destroyed ureteral substance must be rarely satisfactory, and even if temporarily successful, the duct is almost sure to be choked by scar contraction.

21. The implantation of the cut ends of a ureter into an isolated knuckle of bowel is objectionable; 1, because the bowel is not aseptic; 2, because the operation is too dangerous.

22. In injuries of the portion of the ureter within the pelvis, with loss of substance, the ureter should be treated as follows: if possible, the continuity of the ureter should be restored by the writer's method.

23. If this is not possible, the ureter if injured in vaginal operations should be sutured to the base of the bladder with a covering of mucous membrane as far forward as possible, with a view to a future implantation or formation of vesico-vaginal fistula with kolpocleisis.

24. In injuries to the pelvic ureter during laparotomy, where the continuity can not be restored, and where temporary vaginal implantation can not be effected in the female or vesical implantation in the male, the proximal extremity of the duct should be fastened to the skin at the nearest point to the bladder.

25. In ventral ureteral fistulae opening near the bladder, the ureteral extremity may in some instances be planted directly into the bladder without opening the peritoneum.

26. In such cases where the ureter will not reach the bladder a flap may be raised from the anterior vesical wall and reflected upward, extra-peritoneally, to meet the ureter and form a tubular diverticulum.

27. Such a flap may be so elongated by a preliminary operation to transplant the peritoneum back of the fundus, or by accurately suturing it there at a single sitting, that median ventral fistulae of the ureter may be cured if they open at any point an inch or more below the umbilicus.

28. Symphysectomy is a valuable and justifiable preliminary step in these plastic vesical operations.

29. It is legitimate when both ends of a cut ureter open upon the abdominal wall to try Rydygier's method.

30. Implantation of one or both ureters into the rectum is absolutely unjustifiable under all circumstances because: (1) the primary risk is too great; (2) there is great liability to stenosis of the duct at the point of implantation; (3) suppurative uretero-pyelo-nephritis is almost absolutely certain to occur, either immediately or after the lapse of months or years.

31. Ligation of the ureter to cause atrophy of the kidney is unjustifiable.

32. Extirpation of a normal kidney for injury or disease of the ureter is absolutely unjustifiable, except where the ureter can not be restored in one or other of the ways cited.

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