WILLIAMS (J. W.)
23

A CASE OF SPONDYLOLISTHESIS, WITH DESCRIPTION OF THE PELVIS.

BY

J. WHITRIDGE WILLIAMS, M.D.,

BALTIMORE.

LIBRARY
SURGEON GENERAL'S OFFICE
JUL -. -1905
767

REPRINTED FROM VOL. XXIV.,
GYNECOLOGICAL TRANSACTIONS.
1899.

A CASE OF SPONDYLOLISTHESIS, WITH DESCRIPTION OF THE PELVIS.

By J. Whitridge Williams, M.D.,
Baltimore.

Last July one of my assistants saw a woman in the dispensary of the Johns Hopkins Hospital who had a curvature of the spine, and one of whose hips was apparently higher than the other. He had not examined her, but thought from her appearance that she might have a Naegele pelvis, and brought her to me for examination.

She was a colored woman, J. T., aged twenty-two years, 149.5 centimetres tall (4 feet 10 inches), who stated that she was in the ninth month of her first pregnancy, her last menses having occurred on November 15, 1897. The pregnancy had been uneventful, and she had come to the dispensary to ask the care of the Out-patient Obstetrical Department in her approaching confinement.

On external palpation I found the fundus of the uterus three fingers' breadth beneath the ensiform cartilage. The fœtus was felt with its head in the right iliac fossa, its small parts on the left side and its back extending across the upper part of the abdomen. The fœtal heart was heard on the right side of the mother, midway between the costal margin and the umbilicus. The external pelvic measurements were 24, 27, 29, and 18 cm.

The patient was then undressed and examined in the upright position. When viewed from the front it was noticed that her abdomen was markedly pendulous and that there

LIBRARY
SURGEON GENERAL'S OFFICE
JUL 7 1900
267

was apparently a slight asymmetry between the hips, the right being larger and more prominent than the left. Just above the right hip there was a slight concavity, while on the left side the body extended in practically a straight line from the thorax to the trochanter. At first glance it appeared that the pelvis was tilted obliquely upward on the right side, but actual measurement showed that this was not the case, as the distance from the crest of the right ilium to the floor was 94 cm. and the corresponding distance on the left side 93.5 cm. On placing the hands upon the iliac crests it was noticed that they were almost in contact with the costal margins, though the patient's body did not appear markedly shortened.

When the patient was viewed from behind I noticed a slight scoliosis involving the lower dorsal and the entire lumbar portion of the vertebral column, with its convexity directed to the left, and a compensatory curve in the opposite direction in the upper part of the vertebral column. Just above the buttocks a rounded protuberance, 2 cm. wide and 1.5 cm. high, projected from the middle line of the vertebral column. The skin was freely movable over it, and it was thought to represent the spine of the last lumbar or the first sacral vertebra.

When viewed from the side (Fig. 1) the patient presented a moderate degree of lumbar lordosis, and the above-mentioned protuberance was clearly seen. The abdomen was markedly pendulous, and at once suggested that a greater disproportion existed between the child's head and the pelvic canal than was indicated by the external pelvic measurements.

Although the possibility of an obliquely contracted pelvis had been dismissed upon finding the crests of the ilium at the same level, the various measurements, which were recommended by Naegele for its detection, were made and found to be alike on both sides.

On vaginal examination the vaginal outlet was large and there was no trace of a hymen, its place being taken by

several carunculæ myrtiformes. The cervix was bilaterally torn, especially on the left side.

The lower portion of the sacrum was palpable and was concave in both directions. What appeared to be the promontory was readily reached, and my attention was immediately arrested by the sharp angle which it formed with the rest of the sacrum. The finger was then passed upward over the anterior surface of the sacrum, and, instead of coming in contact with its promontory, was arrested by a structure which overhung it and formed a triangular space in front of it.

On further examination it was found that this structure was the body of the fifth lumbar vertebra, which had been so displaced downward as to cover completely the anterior surface of the first sacral vertebra, its lower margin being opposite the articulation between the first and second sacral vertebræ. On passing the finger further upward the bodies of the fifth and fourth lumbar vertebræ could be palpated. The bifurcation of the aorta, however, could not be felt.

A spondylolisthetic pelvis was thought of at once, and the diagnosis assured by sweeping the finger along the linea innominata, when it came in contact with the displaced last lumbar vertebra, instead of continuing on the promontory of the sacrum. As the promontory was covered by the last lumbar vertebra the oblique conjugate could not be measured, but the distance from the upper margin of the last lumbar vertebra to the lower margin of the symphysis pubis was 9.5 cm. (pseudoconjugata obliqua). The pelvic outlet was somewhat contracted, but, unfortunately, accurate measurements were not made.

Having diagnosed a spondylolisthetic pelvis, I asked Dr. L. C. Neale, Professor of Obstetrics in the University of Maryland, to see the case with me, and the following day we examined her under anesthesia and completely confirmed the findings of the previous examination.

In view of the lacerated condition of the cervix the prob-

ability of a previous pregnancy was considered, but the patient repeatedly and positively denied its occurrence.

Having made the diagnosis, we attempted to obtain the past history of the patient, in the hope of finding some clue to the etiology of the deformity, and found that she had been perfectly healthy until her thirteenth year, when she had fallen on the ice while skating and injured her right hip. At that time she did not appear to be much hurt, and walked home and was not confined to bed. She recovered rapidly, and in a few days was perfectly well. About six months later she had rheumatic pains in both hips and knees. She did not go to bed, nor did she think that she had fever or that her joints were swollen. Some time after this she noticed that her right hip was higher than the left. During the next two or three years this deformity gradually increased, but has remained stationary for the past five or six years.

She states that ordinarily she has no discomfort from her deformity, but occasionally in damp weather her hips are painful. She has always been accustomed to hard work, and often carries baskets of clothes or bundles of wood, which she carries on her right side, allowing them to rest on the hip, as it is difficult for her to carry anything in front of her without falling forward. On making her walk it was found that she had the characteristic gait to which Neugebauer first called our attention.

After diagnosing the pelvic deformity and considering that the pelvic inlet was probably still more encroached upon by the forward displacement of the lower portion of the vertebral column than was indicated by the pseudo-oblique conjugate, both Dr. Neale and myself agreed that the most conservative method of delivery would be by Cæsarean section at or about term. The operation was proposed to the patient and her friends, but they positively refused to allow its performance, and persisted in their refusal in spite of all our efforts.

As the patient would not consent to the operation, I went away for my vacation and left the case in charge of my

assistant, Dr. Dobbin, expecting to return and do a Cæsarean section after she had gone into labor, when in all probability she would be more amenable to persuasion.

A few days later the patient admitted to Dr. Dobbin that she had given birth to a child four and a half years previously, when she was about eighteen years of age. The labor was conducted by a midwife, and was spontaneous and comparatively easy, the child being alive at the present time. When Dr. Dobbin informed me of this, I concluded that the vertebral column did not obstruct the pelvic inlet to so great an extent as we had supposed, and wrote him that I believed that she could be delivered by symphyseotomy.

She went into labor on the evening of August 29th, and upon vaginal examination a few hours later Dr. Dobbin found the cervix almost completely dilated, with the membranes bulging into the vagina. The head presented by the brow, and was freely movable above the pelvic brim, the external examination giving the same results as at the first examination. In my absence Dr. Dobbin asked Dr. W. W. Russell to see the case with him, and they both agreed that she could probably be delivered by symphyseotomy.

She was anesthetized and the operation performed by Dr. Dobbin. After cutting through the symphysis in the usual way, the right leg of the child was seized and version performed with considerable difficulty. The body was then slowly extracted and the head delivered with great difficulty by the Mauriceau manœuvre. While delivering the child there was considerable hemorrhage, and the symphyseotomy wound tore into the vagina, necessitating packing it firmly with gauze; and consequently the exact amount of separation between the ends of the pubic bones could not be ascertained, but Dr. Dobbin estimated that it was between 8 and 9 cm. during the extraction. The child was born asphyxiated, but was soon resuscitated. The vaginal tear was closed with catgut sutures and the symphyseotomy wound closed in the usual way.

The patient was considerably shocked after the operation, but rallied well. On the third day there was marked abdominal distention, and the greatest difficulty was experienced in getting the bowels to act. The distention continued, but was relieved by the use of the rectal tube. The patient did fairly well for the first five or six days, but at no time was her condition perfectly satisfactory, the bowels always remaining sluggish and the abdomen more or less distended. On the fifth day the dressings were removed and the wound appeared in good condition. On the seventh day the wound was again inspected, when it was found to have broken down to a great extent. Half an hour afterward the patient began to complain of air-hunger, and died within half an hour, presumably from pulmonary embolism. At no time during the puerperium were there any symptoms of peritonitis, and only twice did the temperature reach 102°. The pulse remained persistently high from the time of operation, and averaged about 130.

Unfortunately, the autopsy could not be performed until four or five days after death, on account of the difficulty experienced in communicating with her relatives, who lived in an inaccessible place on the Eastern Shore of Maryland, so that the body was markedly decomposed when it was performed, and only the grossest lesions could be made out. It was found that nearly all of the stitches had pulled out, only the lowest silver suture through the anterior pubic ligament having remained in place. The entire space between the bladder and the symphysis pubis was converted into a large pus-cavity. There was a deep laceration extending from the left side of the cervix up into the broad ligament, which extended behind the cervix over to the right side. There were no signs of peritonitis, but, owing to the marked decomposition, no trace of an embolus could be found.

The pelvis was examined *in situ*, and, after bringing the ends of the pubic bones together, the following measurements were made: Superior strait: pseudo-conjugata obliqua, 9.5

cm. (which exactly corresponds with the measurements made during life); pseudo-conjugata vera, 7.5 cm.; narrowest part of the superior strait, from the superior margin of the pubis to the lower margin of the third lumbar vertebra, 6.5 cm.; transverse diameter, 12.1 cm.; right oblique, 12 cm.; left oblique, 12 cm. Inferior strait: antero-posterior diameter, 10.75 cm.; between ischial spines, 9.5 cm.; transverse diameter (tuberosities), 8.5 cm.

The entire pelvis was then removed with the last three lumbar vertebræ and the upper portions of the femora.

Description of the Pelvis. The pelvis, after maceration, impresses one as being somewhat smaller than usual; but its striking feature is the relation which the vertebral column bears to the sacrum; for the body of the last lumbar vertebra, instead of articulating with it in the usual manner, is displaced downward and forward to such an extent as to completely cover the anterior surface of the first sacral vertebra (Fig. 2). And, consequently, the vertebral column appears to have prolapsed into the pelvis and encroaches markedly upon its cavity, giving the superior strait a distinctly reniform appearance. The pubic arch is somewhat narrower than usual, and the inferior strait is markedly contracted in its transverse diameter, thereby giving the pelvis a funnel shape.

The pelvic measurements are as follows: Superior strait: antero-posterior diameter, 7.6 cm. (from symphysis pubis to lower margin of fourth lumbar); transverse, 12.1 cm.; right oblique, 12 cm.; left oblique, 12 cm. Inferior strait: antero-posterior diameter, 10.75 cm.; transverse, 8.5 cm.; distance between the ischial spines, 9.5 cm. Plane of greatest pelvic dimensions (*Beckenweite*): antero-posterior diameter, 12.8 cm.; transverse, 11.9 cm.

The antero-posterior diameter of the superior strait (7.6 cm.), from the posterior and upper margin of the symphysis pubis to the lower margin of the fourth lumbar vertebra, was not the shortest distance between the symphysis and the ver-

tebral column; but this was found between the upper and posterior margin of the symphysis and the lower margin of the third lumbar, which measures 6.5 cm., while the distance to its upper margin is 7 cm.

The distance between the lower margin of the symphysis and the upper and lower margins of the fifth lumbar vertebra measures 9.5 and 11 cm. respectively.

The pelvic inclination is entirely obliterated, and, on placing the pelvis in such a position as to give the vertebral column an upright direction, the plane of the superior strait is parallel to the horizon, and a line drawn horizontally backward from the upper margin of the symphysis impinges upon the anterior surface of the fourth lumbar vertebra about 1 cm. above its lower margin. On giving the pelvis its normal inclination, with the cotyloid notches directed downward, we find that the vertebral column assumes a horizontal position; so that the woman would have been obliged to walk on all-fours had the normal pelvic inclination been retained.

Owing to the change in the pelvic inclination, the ileofemoral ligaments were under marked tension, as is indicated by the prominence of the anterior inferior spines of the ilium and the markedly corrugated and eburnated condition of the external surface of the iliac bones just posterior to them.

The posterior surface of the sacrum presents a normal appearance, there being no defects in the sacral arches. The entire vertebral column is slightly deflected to the left, so that the centre of the superior surface of the third lumbar vertebra lies 0.5 cm. to the left of the median line. The spine of the fifth lumbar vertebra projects 1.3 cm. beyond the spines of the other lumbar vertebræ, and on examination we find that the former occupies its usual position, while the latter are displaced forward. On looking at the sacrum and vertebral column from the side (Fig. 3), we find that the body of the fifth lumbar has assumed a triangular form and that the intervertebral foramina have undergone marked changes in shape; the foramina between the third and fourth

vertebræ presenting their usual appearance, and those between the fourth and fifth vertebræ being somewhat compressed antero-posteriorly, while the foramina between the last lumbar and first sacral vertebræ are almost obliterated and are converted into mere slits, about 0.3 cm. in vertical diameter.

We also notice that the lower articular processes of the last lumbar vertebra are firmly synostosed with the upper articular processes of the first sacral vertebra, so that no trace of the original joints can be found. The superior articular processes of the fifth and the inferior articular processes of the fourth lumbar vertebræ are also densely fused together.

Instead of being in the same vertical line, the inferior and superior articular processes of the last lumbar vertebra are widely separated from one another, the former occupying their normal position, while the latter are situated about 2 cm. anterior to them.

On looking at Fig. 3, which represents the sacrum and the last three lumbar vertebræ, seen from the left side, we find that this separation is due to a marked lengthening and flattening of the interarticular portion of the vertebra, which is converted into a plate of bone 1.8 cm. long, which varies from 0.35 to 0.5 cm. in thickness. In the centre of the left interarticular processes (Fig. 3, *c*) is a vertical fissure less than 1 m. in width, with prominent raised margins. This constitutes the thickest part of this portion of the vertebra. One-half of a centimetre posterior from its upper margin is a second fissure (Fig. 3, *d*), whose margins are in close apposition, and which appears to extend obliquely downward and forward through the entire thickness of the interarticular portion, which is accordingly divided into three parts. The same conditions are observed on the right side, except that the interarticular portion is traversed by only a single vertical fissure, which divides it into two equal parts.

A vertical mesial section was then made through the sacrum and lumbar vertebræ (Fig. 4), which shows very clearly the salient features of the deformity. Here we see

that the entire fifth lumbar vertebra is lengthened and that its body is triangular in shape and lies almost entirely in front of the first sacral vertebra. Its neural canal is increased in its antero-posterior diameter, its interarticular portion thinned out and lengthened, and the entire vertebra bent over the superior surface of the sacrum, so that we can designate it as a dolicho-kyrto-platy-spondylus (Lambl).

Upon closer examination we find that the only portion of the body of the last lumbar vertebra which has retained anything like the normal appearance is its anterior surface, which is straight, in place of being concave from above downward. Its superior surface, instead of being concave throughout, is concave anteriorly and flat posteriorly. And, on glancing at the drawing, it is apparent that the body-weight was transmitted to the anterior part of the sacrum through this flattened posterior portion. The greater part of its posterior and inferior surface has been worn away where they come in contact with the promontory of the sacrum, so that only 0.8 cm. of the former and 1 cm. of the latter have been preserved.

Coincident with these changes, the anterior and superior surfaces of the first sacral vertebra have also become involved, but to a less marked degree, so that all trace of the promontory has disappeared and its place taken by an irregularly shaped depression, the lower margin of which roughly fits into a corresponding concavity upon the posterior and inferior surface of the last lumbar vertebra. And it appears that the upper margin of this concavity—a plate of bone 0.5 cm. long and 0.25 cm. thick—is all that serves to connect the bodies of the two vertebræ.

The greater portion of the body of the last lumbar vertebra presents its typical spongy structure on section; but the margins of the concavity are dense and white and appear sclerotic and eburnated. This condition is still more marked in the first sacral vertebra, whose anterior portion presents an almost ivory-like appearance over an area 1.5 by 1 cm.

There is no trace of an intervertebral cartilage where the

two bones are in contact. Before cleaning the pelvis, however, there was a considerable amount of fibrous tissue in the triangular space between the inferior surface of the body of the last lumbar and the anterior surface of the first sacral vertebra, which probably represents all that was left of it.

The neural canal of the last lumbar is markedly lengthened and measures 3.5 cm. in its antero-posterior diameter. This disproportion is due to a lengthening of the interarticular portion, which on the left side presents a vertical fissure in its central part (Fig. 4, *a*), while on the right side two fissures are apparent, one about the centre and the other at its anterior end. The margins of all the fissures are in close apposition (Fig. 6).

The body of the fourth lumbar vertebra appears to have undergone pressure changes, as its anterior surface is 0.9 cm. higher than its posterior. Its neural canal is likewise somewhat elongated, measuring 1.5 cm. in its greatest antero-posterior diameter. Its interarticular portions, however, do not appear to have undergone any change.

On the superior surface of each lamina of the fifth lumbar, vertically above the inferior articular process, is a slight bony prominence (Fig. 5, *j*), which lies in apposition with a flattened surface upon the lower margin of the lamina of the fourth lumbar vertebra (Fig. 5, *d*).

In order to make a more careful preparation, the left half of the sacrum and vertebral column was soaked for a few minutes in warm water, when it was found that a certain amount of motility existed between the anterior and posterior portion of the last lumbar vertebra, and on making pressure upon the vertebral column the body of the last lumbar vertebra could be still further displaced over the anterior surface of the sacrum. This was rendered possible by motility at the fissures in the interarticular portion; and upon pressure, the margins of the fissures could be seen to separate for several millimetres, when the space between them was found to be filled by a fibrous mass. No trace of a joint cavity

could be observed, and we believe that the union between them was syndesmotic in character.

Upon further preparation the left half of the specimen was readily separated into two parts—an anterior, consisting of the third and fourth lumbar vertebræ and the anterior portion of the fifth, and a posterior, consisting of the sacrum and the posterior part of the last lumbar vertebra. The anterior half of the last lumbar consists of its body and the greater part of its interarticular portions, while the posterior half consists of its spine, laminæ, and the remainder of the interarticular portions.

The left interarticular portion is then seen to be a quadrilateral plate of bone 2 cm. in diameter, with a large opening in its centre, through which projects the lower articular process of the fourth lumbar vertebra. This opening is oval in shape and measures 1.5 by 1 cm., with its greatest diameter extending antero-posteriorly. Its outer margin measures 0.5 cm. at its thickest part, and is divided into three portions by the two fissures already mentioned. The inner margin is slightly thicker, and is divided into two portions by an oblique fissure (Fig. 6). The interarticular portion, posterior to the margin of this opening, is firmly synostosed with the superior surface of the sacrum.

The right side of the specimen presents, after soaking, the same motility as the left, and, like it, could have been separated into two parts. This was not done, as we wished to preserve the specimen. By cleaning out the tissue, however, which lay between the last lumbar vertebra and the base of the sacrum, we were enabled to study the condition of the right interarticular portion, which we found measured 2 and 0.5 cm. in its widest and thickest parts, respectively. Just as on the left side, its centre was occupied by an oval opening, through which the lower articular process of the fourth lumbar protruded, the apex of which reached to within 0.2 cm. of the base of the sacrum; while on the left side the lower articular processes rested upon the base of the sacrum,

and had worn away the outer compact layer of the latter, producing a depressed oval area, 0.5 by 0.8 cm., whose base was composed of spongy bone. This area is 1.3 cm. from the median line, and its long axis corresponds with the anteroposterior diameter of the body of the sacrum. This condition of the lower articular processes of the fourth lumbar affords a satisfactory explanation for the scoliosis which was noted during life.

Fig. 6 represents a reconstruction of the last lumbar vertebra, looked at from below, and clearly shows the condition of the left interarticular portion.

Fig. 5 represents the fourth and fifth lumbar vertebræ, which we have imagined separated from the synostoses which firmly unite them. At the lower margin of the left lower articular process of the fourth lumbar we note a depression, which was produced where it came in contact with the margin of the opening in the interarticular process of the fifth lumbar.

History. The specimen which I have just described is a marked example of spondylolisthesis, and is of interest, not only because of its rarity, but especially on account of the peculiar change in the shape of the last lumbar vertebra, concerning whose production so much has been written.

We shall, accordingly, study the etiology of our case, and attempt, if possible, to discover the factors which played a part in its production; but before doing so we shall briefly consider the history of spondylolisthesis, especially from an etiological point of view.

The term spondylolisthesis (from *σπόνδυλος, vertebra,* and *ὀλίσθησις, sliding*) was first used by Kilian in 1853, and applied by him to two pelves, which were markedly deformed by the downward and forward displacement of the lower lumbar vertebræ into the pelvis. One of the cases occurred in Paderborn and the other in Prague, and in both the pelvic deformity was so marked as to necessitate the performance of Cæsarean section. Kilian attributed the deformity in both cases to a downward and forward displacement of the fifth

lumbar vertebra over the promontory of the sacrum, which he believed was rendered possible by an inflammatory softening of the last intervertebral cartilage and the surrounding ligaments, as well as of the vertebra itself.

In 1854 he published his *Schilderungen neuer Beckenformen*, in which he again described the Paderborn and Prague pelves, and added the description of two other pelves which Rokitansky had previously described as "kyphotic." Kilian considered that the deformity in one of them was probably congenital in origin; while in the other he was inclined to attribute it to the presence of a hydrorrhachis in the lower lumbar and upper sacral portion of the vertebral column.

Kilian's first communication was reviewed by Ritgen, who suggested that the increased size of the neural canal of the fifth lumbar was possibly the result of a hydrorrhachis. Kilian, however, in his second article, did not accept this suggestion for his first two cases, but, as we have already indicated, admitted its possibility in one of Rokitansky's cases.

In 1855, Breslau described a case of spondylolisthesis from the Pathological Museum of Munich, and, like Kilian, attributed its production to degenerative changes in and about the last intervertebral cartilage; and, six years later, when describing another case, found no reason to modify his original opinion.

Robert, in the same year, described a very marked case of lumbar lordosis in a four-year-old girl, which had existed from the time she began to walk, and which he considered was of spondylolisthetic origin, though he was unable to make a positive diagnosis, as a vaginal or rectal examination could not be made.

He also considered the mechanism by which spondylolisthesis may be produced, and stated that in such cases too little attention had been paid to the condition of the posterior part of the last lumbar vertebra.

He then performed a number of experiments upon cadavers, by which he demonstrated that softening or even destruction

of the intervertebral cartilages and the various ligaments would not permit a forward displacement of the entire last lumbar vertebra, so long as the articulations between its lower articular processes and the upper articular processes of the sacrum were preserved. And he stated "That it is impossible for the fifth lumbar to be displaced forward as long as these processes remain intact, and it can only occur as a result of pathological changes by which the articular processes of one or other vertebra are destroyed or broken off; or by the upper articular processes of the sacrum becoming so widely spread apart that those of the last lumbar can pass between them; or, finally, by the articular processes of the last lumbar being completely dislocated over the tips of the sacral processes. A further possibility for the displacement of the body of the last lumbar over the anterior surface of the first sacral vertebra may be afforded by a general increase in the size of the intervertebral arch or the neural canal, by which the lower articular processes become so far removed from the body of the vertebra that it can slide forward without impairing the integrity of the joints between the articular processes."

Lambl, in his monograph upon the subject in 1858, thoroughly reviewed the work of his predecessors and personally examined the pelves which they had described, and concluded, as the result of his studies, that the cause of the deformity in the Prague and Munich pelves was to be found in an accessory and rudimentary sixth lumbar vertebra, which was developed only in its posterior portion, and which was interpolated between the fifth lumbar and first sacral vertebræ in such a manner as to facilitate the dislocation of the inferior articular processes of the former over the tips of the superior articular processes of the latter. In the other three pelves, which had been described up to that time, he demonstrated a marked enlargement of the neural canal and a lengthening and thinning of the interarticular portion of the fifth lumbar vertebra, which readily explained the production of the

deformity. He believed that these changes in shape were secondary to a hydrorrhachis, which in some instances so interfered with the ossification of the interarticular portion that each vertebral arch consisted of two pieces of bone, which were united by a pseudo-arthrosis or syndesmosis. This condition he designated as spondylolysis, and pointed out that it did not occur infrequently, as he had observed it in several vertebræ, which otherwise appeared perfectly normal.

While believing that hydrorrhachis was the essential and primary factor in the vast majority of cases, Lambl admitted theoretically that a fracture of the interarticular portion might occasionally be the starting-point of the deformity.

Blake, of San Francisco, in 1867, described the first American case, and did not hesitate to make a positive diagnosis from the clinical examination of the patient. He attributed the deformity to a very rapid increase in the weight of the patient, who gained ninety-eight pounds in the course of her first pregnancy.

Hugenberger, in a clinical observation, attributed the production of the deformity to a luxation of the last lumbar vertebra or a fracture of its articular processes, as the patient dated her trouble from a fall out of bed; and Weber-Ebenhof likewise considered that luxation was the essential etiological factor in two cases which he observed in Prague.

A considerable number of observers, on the other hand, among whom may be mentioned Blasius, Ender, Didier, Herrgot, and Van der Bosch, sought the primary cause of spondylolisthesis in a carious process in and about the sacrum and the last lumbar vertebra.

By far the most important of the earlier contributions to the etiology of the affection is to be found in the Marburg dissertation of Königstein, which appeared in 1871. Königstein became interested in the subject after the examination of a small collection of vertebræ in Marburg, all of which presented areas of deficient ossification in their interarticular portions. He also performed a number of experiments upon

cadavers, which completely confirmed Roberts' previous work, and enabled him to state that forward dislocation of the entire last lumbar vertebra could not occur so long as the joints between the articular processes of the last lumbar and first sacral vertebræ remained intact. He also stated, as far as he could see, that there was nothing about the various pelves which he had examined to lend the slightest support to Lambl's hydrorrhachis theory; and he concluded that the causative factor, in most cases at least, was to be found in a softened condition of the interarticular portion of the last lumbar vertebra, depending upon deficient ossification, which, under the influence of the body-weight, permitted an elongation of that portion of the vertebra and the subsequent development of spondylolisthesis.

From this brief summary, it is apparent that no unanimity existed among the authors concerning the etiology of the affection, and that practically the number of theories advanced to explain its production was limited only by the number of authors who wrote upon the subject. Thus we find that the deformity was variously believed to depend upon a softening of the intervertebral cartilages or the surrounding ligaments, hydrorrhachis of the lumbar region, the development of an accessory sixth lumbar vertebra, luxation of the inferior articular processes of the fifth lumbar vertebra, fracture of the articular processes of the last lumbar or first sacral vertebra, rapid increase in the body-weight, and, finally, lengthening and thinning of the interarticular portion of the fifth lumbar, as the result of faulty ossification or fracture.

These theories were thoroughly sifted and criticised by Neugebauer in his monograph *Zur Entwickelungsgeschichte des spondylolisthetischen Beckens und seiner Diagnose*, which appeared in 1882, and in which he collected everything which was then known concerning the deformity. At that time he was able to collect from all sources twenty-six cases of spondylolisthesis, fifteen of which were anatomical specimens and eleven clinical observations.

After personal examination of many of the anatomical specimens, and careful study of the descriptions of the pelves which he had not seen, he stated that in no instance was the fifth lumbar vertebra dislocated forward *in toto*, but that the deformity was due to a lengthening of the vertebra in its interarticular portion, by which its body was enabled to slip forward over the promontory of the sacrum, while its inferior articular processes retained their normal relation with the upper articular processes of the sacrum.

He attributed the change in shape of the vertebra to the action of the body-weight upon an interarticular portion, which was weakened by a solution of continuity (spondylolysis), which was either of congenital or fractural origin, and believed that the latter was more frequent, as there was a history of traumatism in at least fifteen of the cases. He accordingly defined spondylolisthesis as "a deformity which is produced in extra-uterine life by the action of the body-weight under certain predisposing conditions."

Neugebauer's work upon the subject did not stop with the publication of his monograph, as he practically devoted years of his life to its study, and in the eleven years following its appearance published fifteen journal articles and three monographs upon the subject, which altogether covered 898 pages, not to speak of various demonstrations and discussions before medical societies.

During this period he examined personally the great majority of the anatomical specimens and clinical cases in Europe, and his increased experience naturally led to a modification of some of his original views; so that in an article which appeared in 1885 upon the etiology of spondylolisthesis, he stated that in the great majority of cases the changes in the interarticular portion were of congenital rather than fractural origin, as he had at first believed. This, however, did not necessarily imply that traumatism played no part in the production of the deformity, as it might readily cause a tearing apart of the syndesmosis in the interarticular portion, and so

permit the body of the last lumbar vertebra to begin to slide forward.

He likewise modified his original conception by stating that in one case, at least (Strasser), there were no changes in the interarticular portion, but that the deformity was due to a forward displacement of the entire vertebra, which was rendered possible by the fracture of the superior articular process of the sacrum.

In 1892, he published a French monograph upon the subject, in which he gave a short résumé of his previous work and a complete bibliography of the subject, which showed that 100 cases had been more or less accurately observed up to that time.

In 1884 and 1885, Arbuthnot Lane, of London, wrote several very interesting articles upon the subject, in which he stated that spondylolisthesis was not so rare a deformity as was usually supposed, but that he had observed it quite frequently in the skeletons of men who had spent their lives as coal-heavers.

He attributed the deformity not to a congenital spondylolisthesis, but simply to a flattening of the interarticular portion of the last lumbar vertebra, by the pressure exerted upon it by the lower articular processes by the vertebra just above it, as the result of excessive weight transmitted through the vertebral column; and he believed that the examination of the skeletons of hard-working men would show that the deformity in question was far from infrequent.

In 1892, Chiari published a most excellent article upon the etiology of spondylolisthesis, in which he collected in a comparatively small space all that was worth knowing upon the subject. He admitted the great services of Neugebauer in the study of the deformity, but believed that he had probably taken an extreme position in attempting to demonstrate a single etiological factor for all cases, as he considered that a number of factors might lead to its production, and that spondylolisthesis was not only due to a sliding forward of the

body of the last lumbar, but also that the entire vertebra might be displaced forward in rare cases.

He accordingly divided the possible causes of spondylolisthesis into two categories, according as the entire vertebra or only its anterior half was displaced forward, as follows:

First category: Abnormal conditions in the lumbo-sacral articular processes, which may permit the entire last lumbar vertebra to slide forward: (1) Abnormalities in development, (2) destruction by disease, (3) fracture, (4) luxation.

Second category: Abnormal conditions by which the body-weight acting upon the last lumbar vertebra may lead to its elongation, so that its anterior portion can slide forward: (1) Abnormalities in the development of the arch of the last lumbar vertebra; (2) pathological softening or destruction of the same; (3) fracture of the same; (4) changes in shape of the normal last lumbar vertebra resulting from excessive action of the body-weight as transmitted through the vertebral column.

He stated that only two of the possibilities mentioned in the first category have as yet been observed—namely, abnormalities in development and fracture; while in the second category the only possibility which has not been conclusively demonstrated is the primary pathological softening or destruction by disease of the interarticular portion of the last lumbar vertebra.

This has never been demonstrated in rhachitis or osteomalacia, and is out of the question in caries. For, while it is perfectly possible for this portion of the vertebra to be destroyed in tuberculous affections, it is hardly probable that it could result in a lengthening of the vertebra, as the patient would be confined to bed during the acute stage of the disease, when the elongation might theoretically occur, and would not be able to sit up until ankylosis had taken place. After which the deformity could not develop.

Chiari concludes his article with the description of four pelves, which substantiate the correctness of his conclusions.

In the first and fourth pelves there was a displacement of the entire last lumbar vertebra; the first case being due to abnormalities in the development of the lumbo-sacral articular processes, while in the last case the etiological factor could not be definitely ascertained. In the other two cases only the anterior half of the vertebra was displaced forward; and in each the predisposing cause was found in a spondylolysis, which in one case was present only on one side.

We would refer those who are especially interested in the history of spondylolisthesis to the articles of Lambl, Neugebauer, Chiari, and Buchheister.

ETIOLOGY. From this short résumé of the literature, it is apparent that in the vast majority of cases the deformity is produced by the forward displacement of the anterior half of the fifth lumbar vertebra, while its posterior portion retains its normal relation at the lumbo-sacral articulation. In a few cases, however, the entire vertebra may be displaced forward.

In the first class of cases there is no doubt that the etiological factor is usually found in a unilateral or bilateral spondylolysis. This condition has been conclusively demonstrated in a number of specimens of spondylolisthesis; and Neugebauer, in his monograph of 1892, states that he has observed it in 240 vertebræ which were otherwise normal, and also adds that he discovered it in the last lumbar vertebra of an apparently normal skeleton in Farabeuf's study in Paris. In view of the frequency with which spondylolysis is observed, it appears strange that more cases of spondylolisthesis have not been noted.

In a certain number of specimens the lengthening of the vertebra is simply due to a separation between the two ends of the spondylolytic interarticular portion, the space between them being filled by a mass of fibrous tissue, probably syndesmotic in character. This condition was beautifully illustrated in the case of the Hottentot Venus, which Lambl described, and also in two other cases, described by Krukenberg and Chiari. In each of these specimens there was a

separation of at least 1 cm. between the ends of the interarticular processes, and on removing the tissue between them they could be placed in apposition, when the vertebra would resume its normal appearance. In such cases the olisthesis (slipping forward) is clearly due to a stretching of the fibrous union between the ends of the interarticular portion.

In other specimens a distinct fissure may be noted in the thinned-out and lengthened interarticular portion, whose ends are held in close apposition by a thin layer of fibrous tissue; and it is often impossible to determine whether this condition is due to a congenital spondylolysis or to a secondary fracture of an abnormal interarticular portion.

In a few cases in which no fissure is apparent the condition can be readily explained by supposing that a fracture of the interarticular portion had occurred at some time, and that the callus which united the ends of the bones had undergone stretching under the influence of the body-weight.

In a small number of cases, however, the deformity can be explained neither by the supposition of a congenital spondylolysis nor of a fracture; and under such circumstances the theory of Lane would appear to afford the most satisfactory explanation for its production.

Thus far only three cases have been described in which it was satisfactorily demonstrated that the entire vertebra has been displaced forward—namely, the cases of Strasser, Meyer, and Chiari; and in all of them the deformity was due either to a fracture or some abnormality about the articular processes.

The mere existence of the anatomical predisposing cause does not lead to the production of spondylolisthesis, unless there is added to it some abnormality in the transmission of the body-weight through the vertebral column. For Neugebauer has pointed out that it is frequently present, and may persist through life without producing the slightest suspicion of deformity; or, as Chiari puts it, "The etiological factor gives rise only to a disposition to the affection, which, accord-

ing to our experience, does not always eventuate in an olisthesis."

One of the interesting features in connection with the deformity is that it occurs far more frequently in women than in men—and, indeed, for a long time was considered peculiar to the female sex. As we shall see when we come to consider the frequency of the affection, only 6.5 per cent. of the cases thus far described have been observed in men, and many theories have been advanced to explain this fact.

In a few instances the first indication of the deformity was noted in early childhood, as in the cases of Breslau, Firnig, Von Herff, and Jellinghaus; but in the vast majority of cases it appeared about the age of puberty, but more especially in women who have had several children. So that Olshausen suggested that the circulatory changes incident to menstruation and pregnancy may possibly produce certain changes in the structure of the bones which render them less resistant. The vast majority of the cases have been observed in women who perform hard manual labor, often in the fields; and it has, therefore, been suggested that the appearance of the deformity about the time of puberty is due to the fact that girls usually begin to work hard about that time.

Both of these explanations would seem to apply equally well to both sexes; while the affection occurs far more frequently among women. Von Herff has attempted to explain this apparent contradiction by stating that the sedentary life which is led by young girls manifests itself in a faulty development of their dorsal muscles, so that when they suddenly begin to do hard work the vertebral column does not receive the same support as in boys, who have been accustomed to active exercise from early childhood.

Returning once more to the consideration of our specimen, we find that its most characteristic feature is the marked lengthening and flattening of the interarticular portions of the last lumbar vertebra, so that its upper and lower articular processes, instead of being in the same vertical line, are 2 cm. apart.

We also find that each interarticular portion is divided by three fissures into three pieces, and is perforated by an oval opening through which passes the lower articular process of the fourth lumbar. The portions of bone composing the interarticular portions are held in close apposition by a slight amount of fibrous tissue. The fissures between them, however, are not at all of the same character; for the margins of the fissure on the outer side of the right interarticular portion and the anterior fissure on the outer side of the left interarticular portion (Fig. 6) are somewhat thicker than the adjoining portions of bone, and present a markedly nodulated appearance, as if for the attachment of a joint surface; while the margins of the other four fissures are not thickened and present an irregularly fractured appearance.

In considering the etiology of our specimen we must, therefore, study the nature of these fissures and ascertain, if possible, whether they were concerned in the production of the elongation of the interarticular portion. A glance at Figs. 5 and 6 shows clearly that the deformity is not due to a mere stretching of the fibrous tissue between the ends of a spondylolytic vertebra, as the margins of all the fissures in our specimen are in close apposition. And it is extremely difficult to reach a satisfactory conclusion as to the nature of the various fissures; but we are inclined to believe that the two which have nodular margins (Fig. 6) are due to deficient ossification, and, therefore, represent a congenital spondylolysis, while we are unable to express a positive opinion concerning the nature of the other four. Their sharp, jagged margins are very suggestive of recent fracture, but the absence of callus and the presence of fibrous tissue between them speaks against this view.

The mode of origin of the oval openings in the interarticular portions is, likewise, not perfectly clear, and it is impossible to state positively whether they are congenital in origin and are part of a spondylolysis, or are the result of pressure exerted upon an imperfectly ossified interarticular

portion by the lower articular processes of the fourth lumbar vertebra. We incline somewhat to the latter view, as the horizontal furrow upon the lower portion of the inferior articular process of the fourth lumbar vertebra (Fig. 5) clearly indicates that the corresponding portion of the fifth lumbar vertebra was subjected to abnormal pressure.

As the conception of a congenital spondylolysis, without separation of the ends of the vertebra, does not appear to afford a satisfactory explanation for the elongation of the interarticular portions in our specimen, and as there is nothing about it to indicate that it is due to the stretching of callus after fracture of this part of the vertebra, we are inclined to follow the example of Arbuthnot Lane and attribute at least a part of the deformity to the transmission of abnormal pressure through the vertebral column; and we believe that the change in the shape of the vertebra, which permitted the forward displacement of its body, is the result of abnormal pressure exerted upon an imperfectly ossified interarticular portion (spondylolysis) by the lower articular processes of the fourth lumbar vertebra.

This supposition is strengthened by the fact that our patient was in the habit of carrying heavy loads, and also by Lane having observed an almost identical condition in the last lumbar vertebra in one of his cases, in which he attributed the deformity to abnormal pressure, and considered that he could definitely eliminate its congenital origin.

From the history of our case it appears that the deformity had become more marked during the last four years of the patient's life. Her first labor had terminated spontaneously, while at the autopsy, four years later, the pelvis was found to be so contracted as to render spontaneous labor impossible. The increase in deformity was manifestly due to still further elongation of the interarticular portion of the last lumbar vertebra; and as its fragments still remained in apposition, the change in shape could not be directly attributed to the presence of the spondylolysis, and we are, there-

fore, compelled to seek its explanation in continued and abnormal pressure.

The destruction of the lower part of the body of the last lumbar vertebra and the upper part of the sacrum appears to be simply the result of abnormal pressure, which is also indicated by the eburnated condition of the bone. And the synostoses between the articulations of the last lumbar with the vertebræ above and below it must likewise be attributed to the same cause. Nowhere in the pelvis can we find any other signs of disease, and we believe that we can positively eliminate tuberculosis as a cause of the destruction of the body of the last lumbar vertebra.

The other changes in the pelvis, notably the obliteration of its inclination and its marked funnel-shape, are readily explained—the former being brought about by the patient maintaining the erect position, while the latter was due to marked tension of the iliofemoral ligaments and the retropulsion of the base of the sacrum.

Turning now to the consideration of the frequency of the deformity, we find that increased interest in the subject has brought many new cases to light. Neugebauer, in his original monograph in 1882, collected 26 cases from all sources; but in the next ten years the number had so increased that he was able to find 100 cases, 47 of which were clinical observations, while the balance were anatomical preparations. In 42 of the latter the last lumbar vertebra was the part affected; in 10 the fourth lumbar, and in 1 the first sacral vertebra. Five of these cases occurred in men and the rest in women.

In the following year (1893) he was able to collect 15 more cases, 8 of which were clinical observations and 2 of which occurred in men. Neugebauer, therefore, has collected from the literature 115 cases of the deformity, 7 of which were in men (6 per cent.).

Since the appearance of Neugebauer's work I have been able to collect 8 other cases from the literature, 1 of which

was in a man, thus making a total of 123 cases, 6.5 per cent. of which were in males.

With the exception of the specimen described by Jellinghaus and later by Wedekind, all the other cases were observed clinically and were described by R. von Braun, Bar and Keim, Lovett, Flint, Ludwig and Savor, and Vedeler. All of these cases were more or less carefully described, except those of Flint and Ludwig and Savor, which were merely mentioned in their articles upon contracted pelves. As none of the cases, however, presented any particularly new features, we shall not consider them in detail.

On looking over the total number of cases which have been reported, we find that five occurred in this country—namely, those of Blake, Lombard, Flint, Gibney, and Lovett. The last two cases occurred in men, and in both the diagnosis appears quite doubtful; as in neither of them was the displaced body of the last lumbar felt by rectal examination, the diagnosis having been based upon a certain amount of lumbar lordosis following traumatism.

The cases of Blake and Lombard, however, were apparently well-marked examples of spondylolisthesis, though the description of each leaves a good deal to be desired. Flint's case is simply mentioned in his statistics, without an attempt at description, so that we are unable to make any statements concerning it.

So far as we can learn from the literature, the present case appears to be the only one which has thus far come to autopsy in this country, and accordingly is the only specimen which has been described in detail, and we regret extremely that we are unable to express more positive opinions concerning its etiology.

It is quite likely that many such cases have escaped observation, or have not been reported, as Dr. Arthur Dean Bevan, of Chicago, informed me some months ago that he had observed the deformity several times in the dissecting-room.

When we come to consider the treatment which was pur-

sued in our case, we are perfectly free to confess that symphyseotomy was an ill-chosen operation, and that a Cæsarean section would probably have given much better results. We were led to the operation, however, by the persistent refusal of the patient to consent to a Cæsarean section, and also by the fact that her previous labor had been spontaneous. In view, however, of the marked deformity of the pelvis (6.5 cm.), the operation was clearly contraindicated, and, like the only other operation of its kind (Morisani) performed for this deformity, ended fatally.

DESCRIPTION OF PLATES.

FIG. 1.—Patient seen from the left side; drawing from a photograph.

FIG. 2.—Sacrum and last three lumbar vertebræ seen from the front.

FIG. 3.—Sacrum and last three lumbar vertebræ seen from the left side. *a*, last intervertebral foramen; *b*, transverse process of fifth lumbar vertebra; *c*, anterior fissure on outer side of left interarticular portion; *d*, posterior fissure on outer side of left interarticular portion; *e*, articulation between inferior articular process of the fifth lumbar vertebra and the superior articular process of the first sacral vertebra.

FIG. 4.—Vertical mesial section through sacrum and last three lumbar vertebræ. *a*, fissure on inner side of left interarticular portion.

FIG. 5.—Fourth and fifth lumbar vertebræ as they would appear if completely separated. *a*, superior articular process of fourth lumbar vertebra; *b*, transverse process of same; *c*, inferior articular process of same with depression on its lower margin; *d*, portion of the lamina of the fourth lumbar which articulates with superior surface of the lamina of the fifth lumbar vertebra; *e*, superior articular process of the fifth lumbar vertebra; *f*, inferior articular process of same; *g*, transverse process of same; *h*, anterior fissure on the outer side of the left interarticular portion; *i*, posterior fissure on outer side of left interarticular portion; *j*, flattened surface on the lamina of the fifth lumbar which articulates with *d* on the fourth lumbar vertebra.

FIG. 6.—Reconstruction of the left side of the fifth lumbar vertebra as seen from below. *a*, body of vertebra; *b*, transverse process; *c*, inferior articular process; *d*, spinous processes; *e*, fissure on the inner margin of the left interarticular portion; *f*, anterior fissure on the outer margin of the left interarticular portion; *g*, posterior fissure on the outer margin of the left interarticular portion.

FIG. 1

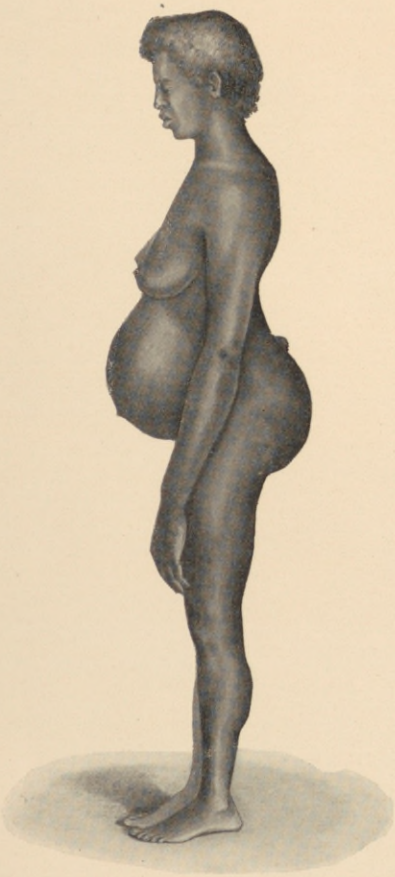
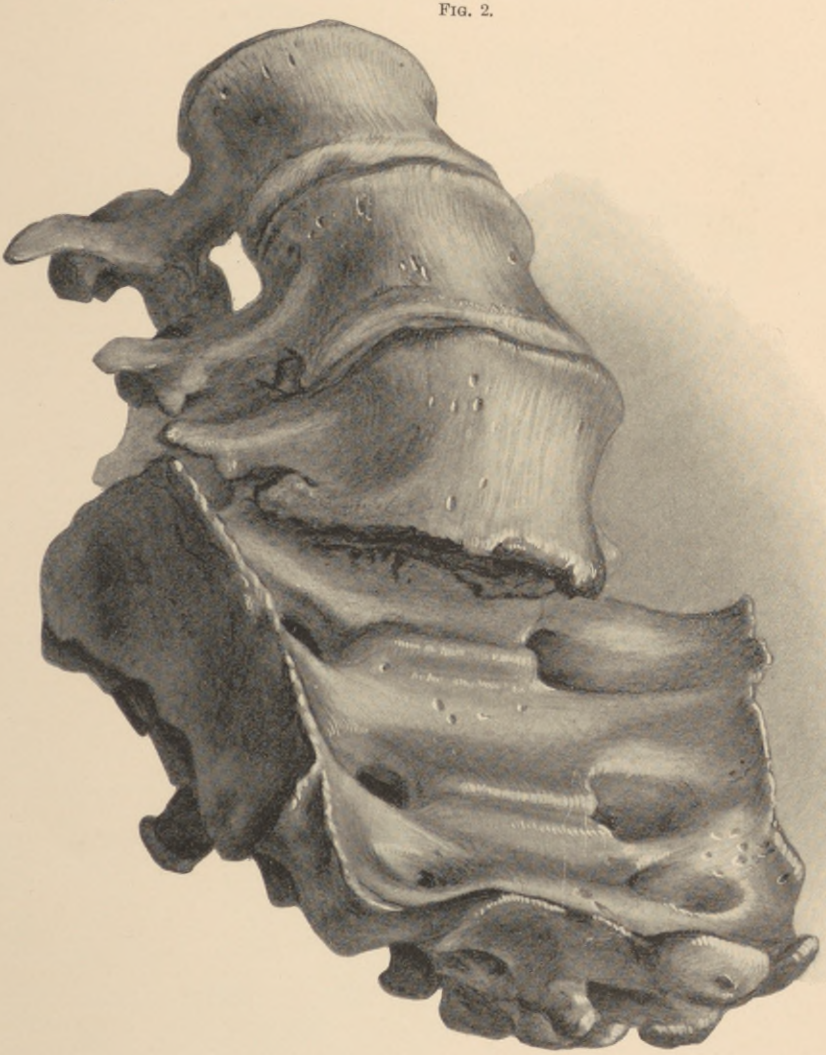


FIG. 2.



R. Montague fec.

FIG. 3.

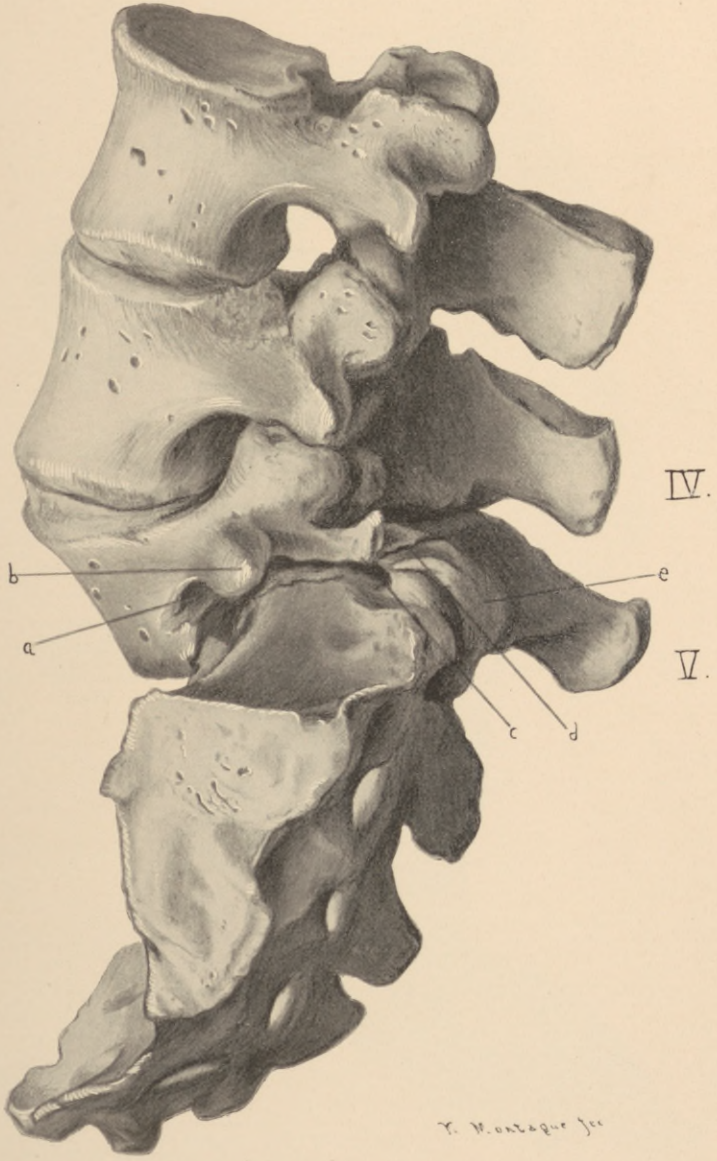


FIG. 4.

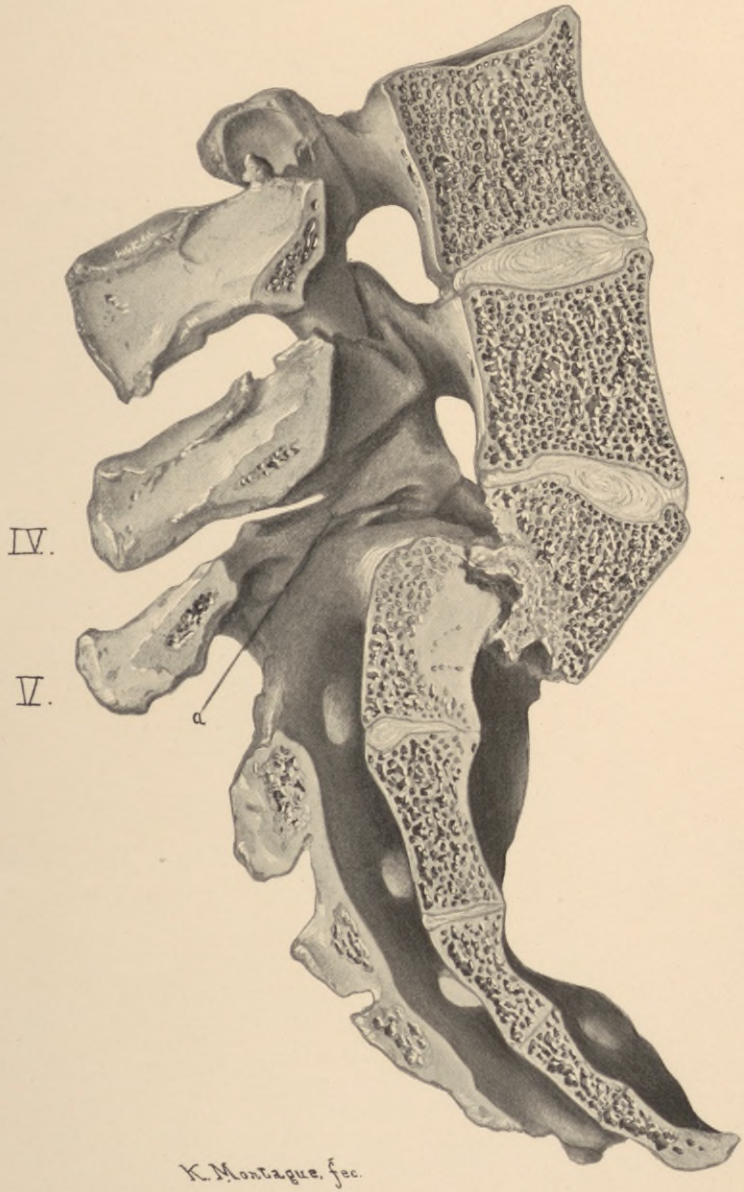
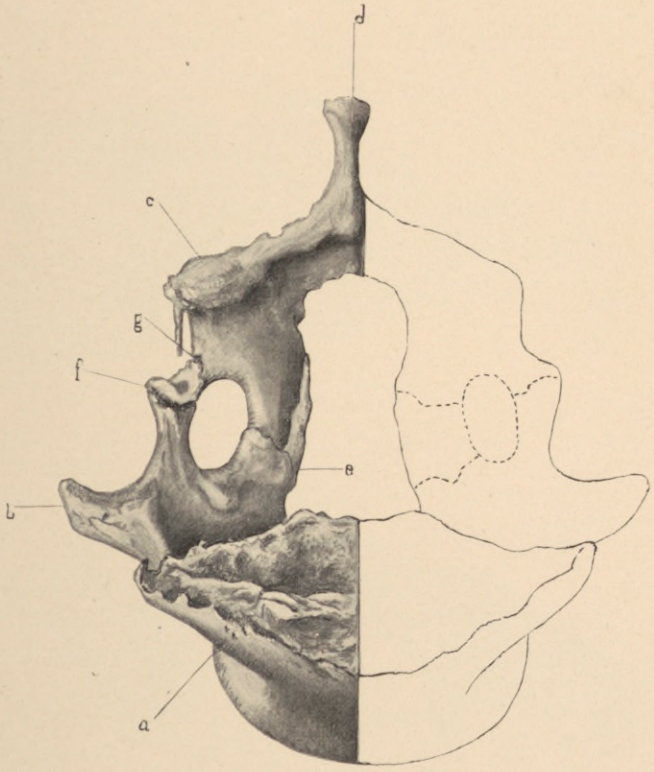
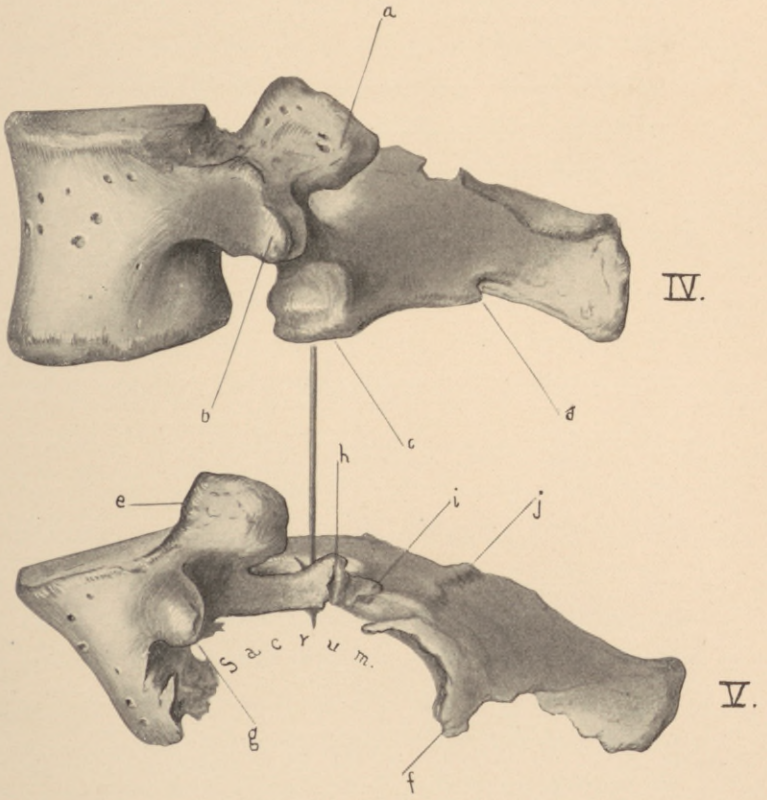


FIG. 5.



K. Montague

FIG. 6.



K. Montague. fec

Bibliography.

1. Bar and Keim. Femme atteinte de Spondylolisthesis. Bull. Soc. d'Obst. de Paris, 1898, pp. 141–46.

2. Blake. Spondylolisthesis Causing Difficult Labor. Pacific Med. and Surg. Journ., Feb., 1867. Ref. Amer. Journ. Med. Sciences, 1867, vol. liv. p. 285.

3. Blasius. Spondylolisthesis im Folge von Caries lumbo-sacralis. Monats. für Geb., 1868, vol. xxxi. pp. 241–48.

4. Braun-Fernwald. Ein Beitrag zur Kenntniss des spondylolisthetischen Beckens. Arch. f. Gyn., 1896, vol. lii. pp. 78–133.

5. Breslau. Ein neuer Fall von Spondylolisthesis. Scanzoni's Beiträge, 1855, vol. ii. pp. 1–9.

6. Breslau. Neuer Fall von Spondylolisthesis des Beckens. Monats. f. Geburtsk., 1861, vol. xviii. pp. 411–28.

7. Buchheister. Geschichte der Aetiologie des Spondylolisthesis. D. I. Strassburg, 1894.

8. Chiari. Die Aetiologie und Genese der sogenannten Spondylolisthesis lumbo-sacralis. Zeit. f. Heilkunde, 1892.

9. Didier. De la Kyphose angulaire sacro-vertébrale. Thèse de Nancy, 1874.

10. Ender. Spondylolisthesis. Monats. f. Geburtsk., 1869, vol. xxxiii. pp. 247–55.

11. Firnig. Demonstration eines spondylolisthetischen Beckens. Verh. der deut. Ges. f. Gyn., 1886, p. 276.

12. Flint. Deformed Pelvis. Report of the Society of the Lying-in Hospital in New York, 1897, p. 264.

13. Gibney. Spondylolisthesis of Traumatic Origin. Medical Record, 1889, vol. xxxv. p. 347.

14. Von Herff. Ein neuer Fall eines spondylolisthetischen, sowie eines sacral-kyphotischen Beckens. Zeit. f. G. u. G., 1889, vol. xvii. pp. 283–98.

15. Herrgott. Le spondylizème ou affaisement vertébral. Arch. de Tocologie, 1877

16. Hugenberger. Bericht aus dem Hebammeninstitute, etc. St. Petersburger Med. Zeitschrift, 1863, p. 121. Ref. Monats. f. Geburtsk., 1863, vol. xxii. p. 228–41.

17. Jellinghaus. Ein neuer klinisch beobachteter Fall von Spondylolisthesis. Arch. f. Gyn., 1896, vol. liii. pp. 428–34.

18 Jellinghaus. Zur Casuistik des spondylolisthetischen Beckens. Arch. f. Gyn., 1898, vol. lv. pp. 439–45.

19. Kilian. De spondylolisthesi gravissimæ pelvangustiæ caussa nuper detecta. Bonn, 1853.

20. Kilian. Schilderungen neuer Beckenformen und ihres Verhaltens im Leben. Mannheim, 1854.

21. Königstein. Entstehungsweise spondylolisthetischer Becken. D. I. Marburg, 1871.

22. Krukenberg. Beschreibung drier spondylolisthetischer Becken. Arch. f. Gyn., 1885, vol. xxv. pp. 12–30.

23. Lambl. Das Wesen und die Enstehung der Spondylolisthesis. Scanzoni's Beiträge, 1855, vol. iii. pp. 1–77.

24. Lambl. Primitive Spondylolysis und deren Verhältniss zur Steatopyga an der hottentottischen Venus. Cent. f. Gyn., 1881, pp. 256–59 and 281–87.

25. Lane. Some of the Changes which are Produced by Pressure in the Lower Part of the Spinal Column, Spondylolisthesis, Displacement Backward of the Fifth Lumbar Vertebra, etc. Trans. London Pathological Society, 1885, vol. xxxvi. pp. 364–78.

26. Lane. Fracture and Dislocation of the Pelvis, etc. Lancet, 1892, vol. i. p. 867.

27. Lane. Case of Spondylolisthesis Associated with Progressive Paraplegia; Laminectomy. Lancet, 1893, vol. i. pp. 991–92.

28. Lombard. A Case of Labor in a Woman with Spondylolisthetic Pelvis. Boston Med. and Surg. Journ., 1885, vol. cxiii. pp. 169–72.

29. Lovett. Spondylolisthesis, with Description of a Case. Trans. Amer. Orthopedic Association, 1897, vol. x. pp. 20–35.

30. Ludwig and Savor. Klin. Bericht über die Geburten beim engen Becken. Chrobak's Berichte, Wien, 1897, p. 283.

31. Meyer. Zur Lehre von der Spondylolisthesis. Arch. f. Gyn., 1887, vol. xxxi. pp. 86–102.

32. Morisani. Ancora della Sinfisiotomia. Annali di Ost. e Gin., 1886, vol. viii. pp. 345–91.

33. Neugebauer. Die Entstehung von Spondylolisthesis. Cent. f. Gyn., 1881, pp. 260–61.

34. Neugebauer. Zur Entwickelungsgeschichte des spondylolisthetischen Beckens und seiner Diagnose. Halle and Dorpat, 1882, p. 294

35. Neugebauer. Zur Casuistik des sogenannten spondylolisthetischen Beckens. Arch. f. Gyn., 1882, vol. xix. pp. 441–75.

36. Neugebauer. Aetiologie der sogenannten Spondylolisthesis. Arch. f. Gyn., 1882, vol. xx. pp. 135–85.

37. Neugebauer. Ein zweiter Fall von sogenannter Spondylolisthesis am vorletzten Lendenwirbel. Arch. f. Gyn., 1883, vol. xxi. pp. 196–205.

38. Neugebauer. Ein neuer Beitrag zur Casuistik und Aetiologie der Spondylolisthesis. Arch. f. Gyn., 1884, vol. xxii. pp. 347–407.

39. Neugebauer. Neuer Beitrag zur Aetiologie und Casuistik der Spondylolisthesis. Arch. f. Gyn., 1885, vol. xxv. pp. 185–252.

40. Neugebauer. French translation of the article of Prof. Simon Thomas: Rétrécissement du bassin par glissement vertébral (spondylolisthesis). Annales de Gyn. et d'Obstet., 1886, vol. xxvi. pp. 168–89.

41. Neugebauer. Spondylizema oder Spondylolisthesis. Cent. f. Gyn., 1889, pp. 65–70.

42. Neugebauer. Referat über die Arbeit von Fellerer. Cent. f. Gyn., 1889, pp. 299–301.

43. Neugebauer. Referat über die Arbeit von Hector Treub. Cent. f. Gyn., 1889, 387–90.

44. Neugebauer. Audiatur et altera pars. Leipzig, 1889, p. 78.

45. Neugebauer. Das neue Breslauer spondylolisthetische Becken. Arch. f. Gyn., 1889, vol. xxxv., pp. 375–85.

46. Neugebauer. Selbstmord einer Schwangeren. Beilage zum Cent. f. Gyn., 1890, pp. 88–97.

47. Neugebauer. Spondylolisthesis et Spondylizème. Paris, 1892, p. 176. Steinheil.

48. Neugebauer. Berichte über die neuste Casuistik und Literatur über Spondylolisthesis. Zeit. f. Geb. und Gyn., 1893, vol. xxvii. 348–448.

49. Olshausen. Ein neuer Fall von spondylolisthetischen Becken. Monats f. Geb., 1864, vol. xxiii. pp. 190–205.

50. Ritgen. Referat über die Arbeit von Kilian. Monats. f. Geburtsk., 1853, vol. ii. pp. 315–20.

51. Robert. Eine eigenthümliche angeborene Lordose wahrscheinlich bedingt durch eine Verschiebung des Körpers des letzten Lendenwirbels auf die vordere Fläche des I. Kreuzbeinwirbels (Spondylolisthesis Kilian) nebst Bemerkungen über de Mechanik dieser Beckendeformation. Monats. f. Geburtsk., 1885, vol. v. pp. 81–94.

52. Rokitansky. Beiträge zur Kenntniss der Rückgratskrümmungen und der mit denselben zusammentreffenden Abweichungen des Brustkorbs und Beckens. Med. Jahrbücher d. öst. Staates, 1833, vol. xxviii. p. 202. Also, Lehrbuch der path. Anatomie, 1856, vol. ii. p. 186.

53. Strasser. Ueber Spondylolisthesis. Breslauer ärztl. Zeitschrift, 1882, No. 3 und 4.

54. Van der Bosch. Description d'un bassin spondylolisthetique. Bull. de l'Acad. roy. de Méd. Belge, vol. xiii., No. 6.

55. Vedeler. Et Tilfaelde af spondylolisthesisk Baekken. Norsk. Mag. f. Laegevidenskaben, 57 Jahrg., 4 R. Bd. x. pp. 833-35. Referat Frommels Jahresbericht, 1896, vol. x. p. 689.

56. Weber-Ebenhof. Zwei neue spondylolisthetische Becken. Prager Vierteljahresschrift f. prakt. Heilkunde, 1874, vol. cxxi.

57. Wedekind. Ein neuer klinischer und anat. beobachteter Fall von Spondylolisthesis. D. I. Halle, 1897.