

THE MANAGEMENT OF SURGICAL INJURIES TO THE URETERS.

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ANIMAL experimentation on the ureters has been of great value in laying the foundation for the management of surgical ureteral injuries. The very small size of the dog's ureter, the difficulty with which it is handled, surgically, and the frequent occurrence of sepsis, should, however, prevent us from drawing too unfavorable conclusions from the result of this work. Our choice of procedure in the future must be based upon the results obtained on man, and my own cases are reported to add, if possible, to the elucidation of this subject.

On looking up the reported cases of ureteral injuries my sources of reference were so limited that I have been compelled to consult the foreign literature largely through those who have had better facilities, and have quoted from their abstracts liberally.

Early work on the ureter for the relief of uretero-vaginal and uretero-uterine fistulæ was done entirely by the vaginal route.

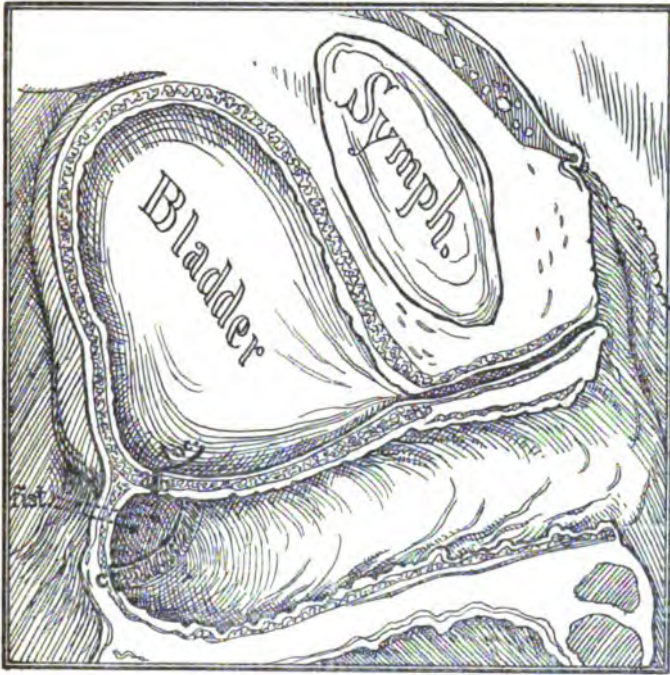
We are all well acquainted with the classical operations as performed by Sims, Simon, Landau, Schaede, Pozzi, Bandel, Emmet, Dührssen and others.

In the case which I report later in this paper I followed the excellent method advised and successfully performed by Kelly, April 27, 1897. In his case both the right and left

ureter entered the vaginal vault, as will be seen in the accompanying diagrams illustrating his operation.

Many methods have been adopted to secure the continuity of the ureter after injury resulting from surgical operations,

FIG. 1.



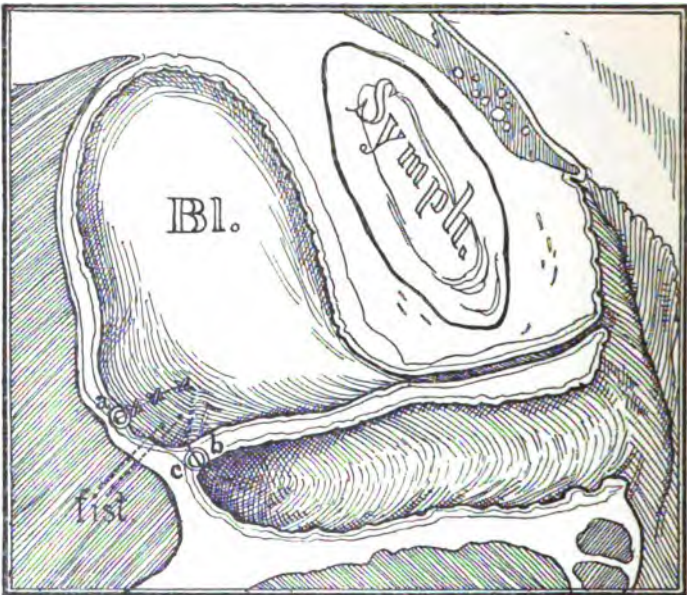
Kelly's operation for uretero-vaginal fistula. The fistulous orifices of both ureters are seen in the vaginal vault; below them is a semicircular denudation extending across the vagina from side to side. The bladder is cut open at the vault of the vagina, *a b*, from side to side, the ends of the incision terminating at the vaginal denudation.

which may be conveniently arranged under the following heads :

1. Invagination of the proximal into the distal end.
2. Transverse end-to-end anastomosis.
3. End-to-side anastomosis (Van Hook).

4. Oblique end-to-end anastomosis (Bovée).
5. Implantation into the bladder.
6. Implantation into the bowel.
7. Crossed anastomosis—i. e., stitching the ureter into its fellow of the other side.

FIG. 2.

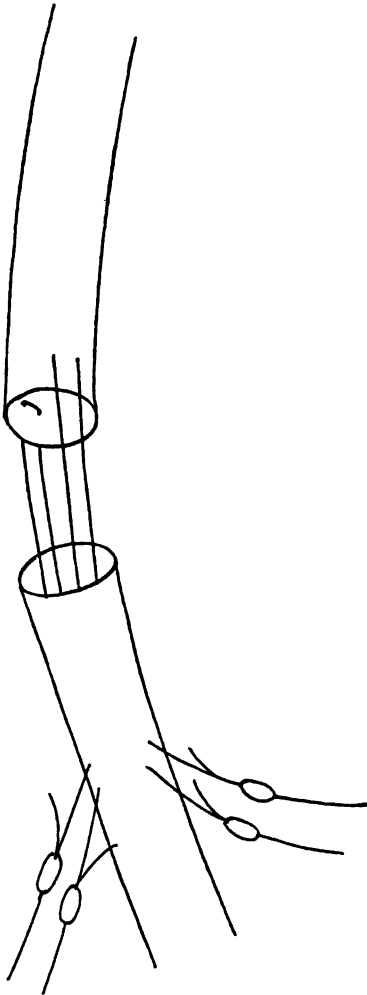


After cutting open the bladder the upper edges of the incision, *a*, are stitched, uniting vesical to vaginal mucosa at *a*, while the lower edge, *b*, is united to the vaginal denudation at *c* (see also Fig. 1), in this way intercalating the piece of the vagina, including the ureteral orifices into the floor of the bladder without forming a cul-de-sac.

Poggi (*Riforma Medica*, 1887), in 1887, successfully anastomosed the ureters in two dogs by invaginating the proximal into the lower end and covering the field with peritoneum. In one dog both ureters were so anastomosed. The first dog was killed at the end of fifteen days, the other at the end of three and one-half months. There had been no leakage, and the lumen of the ducts was continuous and without constrict-

tion. These favorable results from invagination have not been obtained by other experimenters on animals.

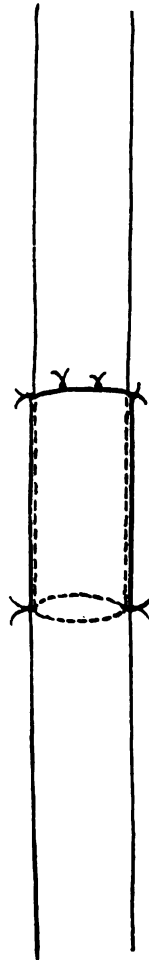
FIG. 3.



Anastomosis by invagination, without splitting the distal end of the ureter. Sutures are placed preparatory to invagination.

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FIG. 4.



Invagination of the upper into the lower end of the ureter. Stitches tied.

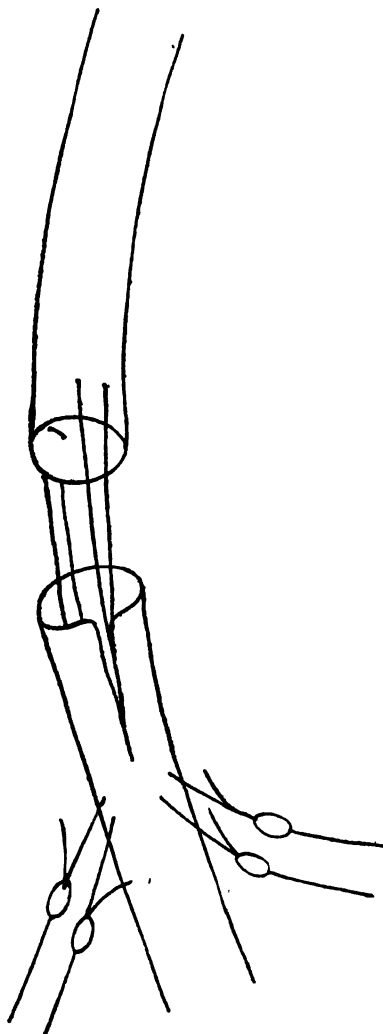
Both Tuffier (*Centralblatt f. Chir.*, 1893, p. 3) and Budinger (*Archiv f. Chir.*, 1894, vol. xlviii. Heft 3), repeating these experiments, reported failures in every instance. Tuffier thought that the peristaltic action of the ureter caused the upper to slip out of the lower end. Many of his animals died of peritonitis, and in those in which union occurred he found the tube surrounded by a cicatrix, producing a tendency to stenosis. Budinger's results were equally unsatisfactory. Bovée points out that fault may be found with both these latter operators, in that they tied the ducts before operation and untied them afterward, thus injuring them and encouraging constrictions and fistulæ.

Aside from my own cases, three in number, in which this method was carried out, I can find but two other cases in which it was adopted on man. These are reported by Robson (*Internat. Med. Ann.*, 1896, p. 602) and by Winslow (*Annals of Surgery*, 1898, vol. xxvii. p. 47). Both of these operators followed the same plan, but differed from me, in that they made a short, longitudinal slit in the distal end of the ureter, to facilitate invagination of the upper end. In my cases this expedient was not necessary, as the tube was considerably dilated and invagination made easy. Their technic consisted in slitting the distal end of the ureter; with a cat-gut suture threaded on both ends each needle was passed through the wall of the proximal end of the ureter about one-eighth of an inch apart, from within outward. The two ends of the suture were now carried through the wall of the lower end just below and to the outside of the longitudinal slit. A similar suture was placed on the other side. Invagination of the upper into the lower end of the ureter was procured by traction of these sutures. The raw end of the ureter and the slit portion were sutured, and the entire operative field covered with peritoneum. Both of these cases made good recoveries.

Transverse end-to-end anastomosis has been carried out in seven cases reported by Schopf, Pawlik, Tauffer (two cases), Fritsch, Hochenegg, and Cushing.

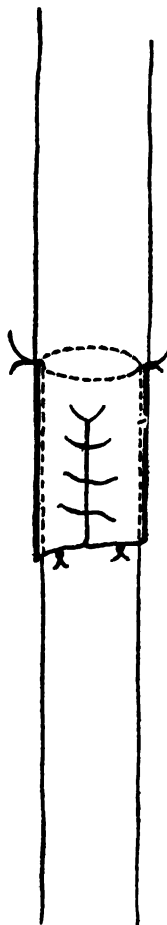
Schopf (*Allgemeine Wien. med. Zeitschr.*, 1888, and *Centralblatt f. Gyn.*, 1897, No. 30) performed the first operation

FIG. 5.



Anastomosis by invagination, facilitated by a slit in the distal end of the ureter. The sutures are shown as they should be inserted.

FIG. 6.

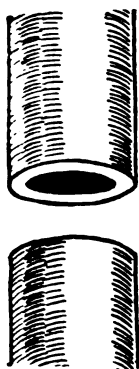


The proximal has been invaginated into the distal end of the ureter and the stitches tied.

June 12, 1886. The patient died of tuberculosis seven weeks after operation. The post-mortem showed that good union had taken place in the ureter, which was, however, constricted and surrounded by dense cicatricial tissue.

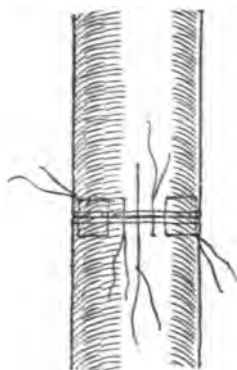
Pawlik (*Ueber Pseudointraligamentöse Eiderstocksgeschwülste Wien.*, 1891, p. 31) united the ureter over an elastic catheter, which held both ends together and passed out through the bladder and urethra. Two layers of silk sutures were applied and the peritoneum closed over the tube. The patient died

FIG. 7.



Transverse end-to-end anastomosis.
The transversely cut tubes ready for
anastomosis.

FIG. 8.



Transverse end-to-end anastomosis.
Stitches placed and tied—rectangular
and interrupted.

fourteen hours after the operation from peritonitis. The sutured ureter was patulous, and did not allow leakage of fluid even under high pressure with a syringe.

Tauffer (*Pesth. Med. Chir. Presse*, Budapesth, 1893, vol. xxxix. p. 993) placed a catheter (English, No. 8) with a string tied about its middle in each end of the ureter. Six to eight sutures were inserted, the catheter being withdrawn by the string before tying the last three stitches. Tauffer followed this method in both of his cases, and obtained good results.

Fritsch (*Ueber die Gyn. Operationen des Jahrgang's*, 1891, 1892, Berlin, 1895, 8vo. p. 287), by end-to-end anastomosis, obtained a successful result.

Hochenegg (*Wien. klin. Wochenschrift*, 1893, vol. vi. pp. 740, 755, 812, 864) unfortunately lost his patient on the twentieth day from a fatal hemorrhage. The autopsy showed the ureteral sutures to be intact. The origin of the hemorrhage was not ascertained.

Cushing (*Ann. Gyn. Paed.*, 1893, vol. vi. p. 277) reports his patient as doing well two years after the operation, although there was a slight discharge of urine from the wound for two weeks subsequent to the operation.

End-to-side anastomosis of the ureter was conceived and most ably and successfully experimented with upon dogs by Van Hook (*Journal of the American Medical Association*, 1893, vol. xxi. p. 911). Bloodgood (*Johns Hopkins Bulletin*, 1893, vol. iv. p. 89) repeated Van Hook's experiments successfully on a large dog, verifying all that Van Hook had claimed for this method. He found on killing the dog, two and a half months later, that the ureter had perfectly healed, with no constrictions of its calibre.

The method as described by Van Hook consists of the following steps :

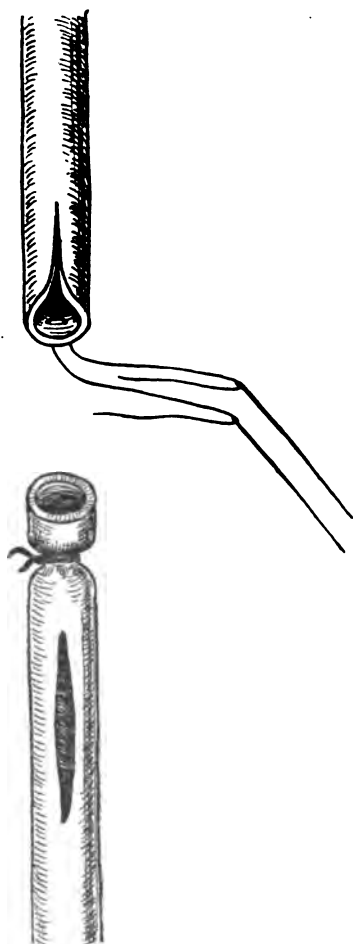
1. Ligate the lower portion of the tube one-eighth or one-quarter of an inch from the free end. Silk or catgut may be used. Make with sharp, fine-pointed scissors a longitudinal incision twice as long as the diameter of the ureter in the wall of the lower end, one-quarter of an inch below the ligature.

2. Make an incision with the scissors in the upper part of the ureter, beginning at the upper end of the duct and carrying it up one-quarter of an inch. This incision ensures the patency of the tube.

3. Pass two very small cambric sewing needles armed with one thread of sterilized catgut through the walls 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.

FIG. 9.



End-to-side anastomosis. (VAN HOOK.)
The distal end of the ureter ligated and slit longitudinally, the proximal end slit, and the first suture passed.

FIG. 10.



End-to-side anastomosis. (VAN HOOK.)
The needle passed down through the slit in the distal end, emerging from the ureteral wall just below. This is used as a traction suture, to invaginate the upper into the lower end.

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.

FIG. 11.



End-to-side anastomosis. (VAN HOOK.) The traction suture has been tied after the ends have been invaginated.

5. It will now be seen that traction upon this catgut loop passing through the walls 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 urine.

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

On man this method of anastomosing the ureters has been carried out in three cases: By Kelly (*Annals of Surgery*, January, 1894, p. 70), Emmet (*American Journal of Obstetrics*, 1895, vol. xxxi. p. 499), and Doherty (quoted by Van Hook).

Kelly performed the first operation by this method May 1, 1893, using two traction sutures of catgut instead of one, as advised by Van Hook.

Emmet found when he came to make the implantation in his case that the upper cut-off extremity of the ureter was considerably larger than the lower end. He overcame this difficulty by making a long slit in the lower tube and by inserting three double sutures at three equidistant points in the circumference of the upper extremity of the tube, about $\frac{1}{2}$ cm. from its end. Pulling upon the sutures the tube was puckered at these three points. He now carried the sutures into the slit of the lower tube, as recommended by Van Hook, and was enabled to invaginate the upper larger end into the lower one. In other respects these operators followed the plan described by Van Hook, and obtained good results.

Oblique end-to-end anastomosis was originated by Bovée (*Annals of Surgery*, 1897, vol. xxv. p. 52), who used this method successfully on a case April 30, 1896. He afterward carried out experiments on dogs, which were negative in results, owing to infection of the peritoneal cavity at the time of the operation. The animals died too early to decide whether or not constriction would have taken place.

The technic of Bovée is as follows:

1. Cutting the ends of the ureters obliquely, they were dilated for an inch and their edges accurately approximated with No. 1 silk, mounted on a fine, round, straight needle. A rectangular suture was inserted and not very tightly tied; two interrupted sutures followed this, and the process of alternating continued until the whole circumference of the duct had been sutured. Great care was taken to procure an even and exact approximation of the ends without puck-

ering, which was facilitated by the two kinds of sutures used.

2. Over these sutures were placed a few interrupted stitches reaching a little further up and down the duct. No sutures were allowed to penetrate the mucosa.

FIG. 12.

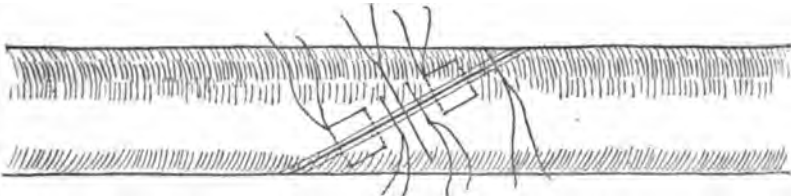


Oblique end-to-end anastomosis (Bovée), showing obliquely cut ends of ureter preparatory to anastomosis.

3. The peritoneum was now carefully brought over the injured portion of the duct and sutured, so as to wall off the ureter from the peritoneal cavity.

Bovée reports, four months after performing this operation, that a sound could be freely passed into the ureter, and no constriction seemed to be present. Eleven months after the operation the patient continues to do well.

FIG. 13.



Shows the placing of alternate rectangular and interrupted stitches.

Implantation of the ureter into the bladder has been done both intraperitoneally and extraperitoneally. The intraperitoneal operation has been performed by Novaro, Penrose, Krug, Kelly, Krause, Boldt, MacMonagle, Ferguson, Baldy, and Fullerton.

The first successful experiments on animals were performed by Paoli and Busachi in 1888 (*Ann. des Maladies des Org.*

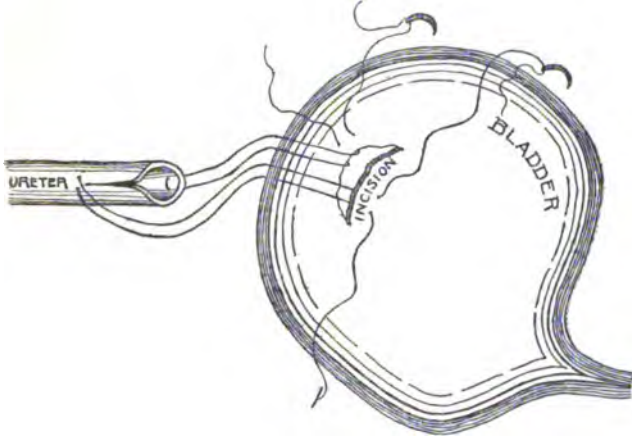
Genito.-Urin., 1888). The end of the ureter was split before suturing it into the bladder.

Novaro (*Centralblatt f. Chir.*, 1893, vol. xxvii. p. 596), following their method, performed the first operation on man. He made a V-shaped slit 1 cm. in length in the end of the ureter. The two limbs of the V were sewed to the edges of the incision in the bladder and the knots tied on the inside. The remaining side of the V was sutured to the bladder by Lembert sutures and a gauze drain inserted. Although there was some leakage for a few days, a successful result was obtained.

Penrose (*University Medical Magazine*, April, 1894), Krug (*Journ. Obstet. and Gyn.*, N. Y., 1894, p. 495), and Baldy (*American Journal of Obstetrics*, 1896, vol. xxxiii. p. 362) performed similar operations, following the idea suggested by Van Hook in his anastomosis operation.

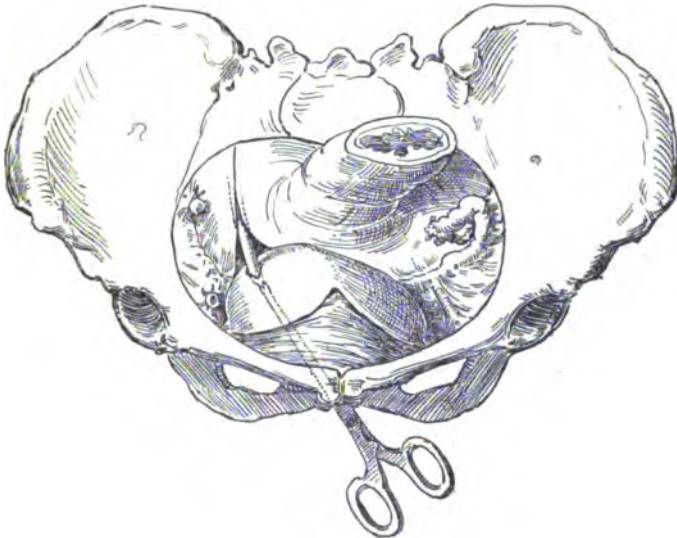
The distal end of the ureter was tied off, except in Baldy's case, where it was bound down in dense adhesions and could not be readily found. An incision one to two inches long was made in the bladder at a point nearest the cut ureter. The proximal end of the ureter was slit and a traction suture of fine silk (Penrose) or catgut (Baldy and Krug), threaded on both ends, was passed through the wall of the ureter from within out, forming a loop on its inner side. Both ends were now carried through the slit in the bladder and passed through the bladder walls from within out, coming out on one side of the incision. A similar suture was placed on the other side, and the ureter drawn into the bladder opening by traction on this stitch, and fixed there by tying. The bladder wall was then stitched to the ureter wall with fine silk, including all the layers except the mucosa. All the spare surrounding peritoneum was now brought together and made to cover the field of operation. There was so much tension of the sutures in Baldy's case, on account of the shortness of the proximal end of the ureter, that in order to relieve the strain he fixed the bladder with two stout catgut stitches to the pelvic wall

FIG. 14.



Implantation into the bladder (intraperitoneal). The ureter is slit to prevent stenosis. The stitches are placed similar to the manner advised by Van Hook in end-to-side anastomosis.

FIG. 15.



Kelly's case. Bladder lengthened, right ureter implanted into its wall. The ureter has been dissected out of its bed and cut off close to the base of the right broad ligament, it was too short to reach the bladder, so the bladder was loosened from its attachments to the anterior pelvic wall and thrown back three centimetres to meet the ureter.

at the point of the stump of the ovarian artery. A permanent catheter was left in the bladder for several days after the operation, and the urine withdrawn every four hours for the following three or four days.

Kelly (*Johns Hopkins Bulletin*, February, 1895) performed a very ingenious operation to bring the bladder within reach of the ureter. He found in his case that the ureter was too short to implant successfully into the bladder, and to overcome the difficulty the bladder was dissected free from its attachments to the horizontal rami of the pubis on both sides with scissors and fingers, and dropped back into the pelvis, so as to extend it and carry it more into the back part of the pelvis, gaining at least 3 cm. in this way. By this means he easily approximated the ureter and bladder. A small incision was made in the bladder, the ureter was slit and its calibre enlarged. A long pair of forceps passed through the urethra and bladder incision grasped the ureter and drew it into the bladder incision, where it was held by six interrupted silk sutures. Drainage was inserted, but no leakage occurred, and the patient made a good recovery.

Krause's operation was similar to Kelly's in method, except that he did not have to loosen the bladder from its moorings (*Centralblatt f. Chir.*, 1895, No. 9).

Boldt (*American Journal of Obstetrics*, 1896, vol. xxxiii. p. 844), in a case of uretero-vaginal fistula, passed a ureteral catheter, to act as a guide, before opening the abdomen. The ureter was cut, and the catheter, removed from the distal end, was passed through the bladder incision and out of the urethra, the other end of the catheter still remaining in the proximal end of the ureter. The distal end of the ureter was ligated. Three fine silk sutures were now placed through the walls of the bladder and ureter down to the mucosa. The ureteral catheter was allowed to remain and a permanent catheter placed in the bladder alongside of it for a few days.

Ferguson (*Amer. Gyn. and Obstet. Journ.*, vol. xxii. p.

629), in a case of uretero-abdominal fistula, found the ureter entering a small cavity at the bottom of the fistula. The walls of the fistula and the cavity were dissected out. The bladder was incised, its upper lip raised, and placed over the mass at the end of the ureter and sutured. A gauze drain was inserted; leakage of urine occurred four or five days, but did not interfere with a favorable result.

Fullerton (*Kelly's Operative Gynecology*, vol. i. p. 463) severed a double ureter on the right side during a difficult operation for removal of adherent ovaries. The distal ends were ligated and both proximal ends were inserted and sutured in a common opening in the bladder. The results of all these operations, as well as my own, were highly favorable in every instance.

Extraperitoneal implantation of the ureter into the bladder has been performed by Baumm, Witzel, Veit, and Kelly.

Baumm (*Centralblatt f. Gyn.*, 1892, No. 17, p. 336), in a case of double ureter, one ending at the mouth of the urethra, made a suprapubic operation, cut through the bottom of the bladder, and connected it with the proximal end of the accessory ureter, the distal end of which was ligated.

The extraperitoneal devised by Witzel (*Centralblatt f. Gyn.*, 1896, No. 11) was performed by him as follows: The bladder was detached and drawn out much the same as in Kelly's case. The thickened ureter was severed at about the middle of its course through the broad ligament, the lower end closed by sutures, and the upper end brought to the upper part of the incision at the brim of the pelvis, drawn down beneath the peritoneum above the innominate line by a pair of long forceps started upward under the peritoneum to the right of the bladder.

The incisions in the pelvic peritoneum and median line of the abdomen were closed and the remainder of the operation performed extraperitoneally. The bladder was then brought above the middle of the iliac fossa, where it was fastened with catgut sutures. The obliquely cut ureter was now inserted

into the incision made in the bladder. The mucosa of the bladder and ureter were united with fine catgut, and another row outside of this attached to the ureteral and vesical walls. An oblique channel through the bladder was formed by uniting the bladder walls over the ureter on both sides. A glass drain was inserted through a separate opening in the abdominal wall and the incision closed. A permanent catheter was left in the bladder four days. A perfect recovery resulted.

Veit (*Zeitschrift f. Geb. and Gyn.*, vol. xxxi. p. 462) performed an extraperitoneal operation in which he followed a different technic. The injured ureter was brought out of the abdominal incision at the point where the ureter passed the abdominal wound. It was fixed by two sutures, avoiding its lumen, between the parietal peritoneum and fascia. The skin incision was carried to the symphysis and the bladder opened extraperitoneally on its anterior surface; the ureter was cut obliquely and sewed into the bladder. Eventual recovery was satisfactory.

An improvement on these methods, when the operation is performed at a later date, is that suggested by Fritsch and carried out for the first time by Kelly, January 26, 1898, in a case of uretero-vaginal fistula, as follows: An abdominal incision was made inside of the right anterior superior spine of the ilium, ending near the spine of the pubis. The peritoneum, inadvertently opened and at once closed, was then dissected loose from the right pelvic wall down to the thick ureter, 12 mm. in diameter. The bladder was freed from its peritoneal attachments on the right side and easily brought over the end of the ureter. The discharge from the ureter was infected, and it was impossible to keep it from contaminating the field of operation. The ureter was then split open on the dorsum and anastomosed into the bladder, uniting mucosa to mucosa and ureteral wall to bladder wall. The patient died in six days from sepsis. The sutures had, however, held.

Quoting from de Forrest's excellent abstract in the *Annals of Surgery*, 1894, vol. xx. p. 193, of Chaput's article (*Archiv Gen. de Med.*, January, 1894), we find that the first attempts to suture the ureter into the bowel were made in cases of exstrophy of the bladder.

Simon (*London Lancet*, 1852) endeavored to do this by passing a loop of thread through the walls of both the ureter and rectum, tying them tightly together. He thus formed a communication by producing necrosis of their walls. The patient died of pyelonephritis.

Thomas Smith (*St. Bartholomew's Hospital Reports*, 1879) sutured both ureters into the colon. The second operation was followed by death. Autopsy showed complete stenosis on the first side operated, causing a hydronephrosis. On the other side the ureter was inflamed and an acute septic pyelonephritis set up. Following these very unfortunate results, experiments were begun on animals.

Glücke and Zoller's (*Berlin. klin. Wochenschrift*, 1881) experiments were all unsuccessful. Bardenheuer implanted a single ureter into the intestines. All of the animals recovered from the operations, but autopsy revealed a hydronephrosis in each case, due to constriction of the ureteral orifice.

Novaro (reported before the Italian Society, 1887) produced an anastomosis of both ureters in three dogs. Two died. One recovered and was able to urinate through the anus for some time.

Paoli and Busachi (*Med. Congress*, Pavia, 1888) reported a number of experiments. Constriction of the ureteral orifice occurred in nearly every case, pyelonephritis, hydronephrosis, and infiltration of urine resulting. One case made a good recovery.

Tuffier (*loc. cit.*) tried twice to anastomose the ureter with the rectum; both animals died of pyelonephritis.

Reed (*Annals of Surgery*, 1892) performed a large series of experiments. In six bilateral implantations there were six deaths, either from peritonitis or hydronephrosis. Three

unilateral implantations were performed. In one case union failed ; in a second, acute nephritis resulted, and in the third, a perfect cure was obtained without nephritis or dilatation of the ureter.

Moreston (*Soc. Anatom.*, 1892) performed the bilateral operation ten times. All the cases died from peritonitis, pyelonephritis, or hydronephrosis. In six unilateral operations three died from peritonitis and three from hydronephrosis. Chaput tried numerous experiments on dogs, but with no better success than his predecessors.

Küster (*Langenbeck's Archives*, 1891) was the first among the later operators to anastomose the ureter with the rectum. The operation consisted of a complete cystotomy for cancer of the prostate. The patient died upon the fifth day, showing evidence of purulent peritonitis and renal infection. The sutures between the rectum and ureters had not held.

Chaput operated upon the next case for the relief of uretero-vaginal fistula left after an incomplete vaginal hysterectomy, which had been performed for purulent salpingitis. The fistula was so high up and the orifice so surrounded by a mass of distorted cicatricial tissue that the idea of causing an opening to communicate directly with the bladder had to be abandoned. The ureter was implanted into the colon September 13, 1892. At the end of a year the left kidney was not apparently enlarged, and the amount of urine excreted was fairly abundant.

Chaput's second operation was performed November 25, 1892, for a patient with tuberculosis of the bladder, having a vesical fistula which resisted all attempts at healing. The left ureter was sutured into the colon. Three months later the right ureter was anastomosed with the cecum. The patient died soon after the second operation, probably from suppression of urine.

In performing anastomosis with the ascending and descending colon, Chaput recommends the use of the following incision and technic, which he used in his three operations : Com-

mencing above, at the border of the costal cartilages, about 8 cm. from the median line, he carries it to the level of the anterior spine of the ilium, and then curves to within 2 cm. within the median line. The peritoneum is opened, the large intestine recognized and held aside, together with the small intestine. The posterior parietal peritoneum is then incised for a distance of 10 cm. in the iliac region. The internal peritoneal lip is seized with hemostatic forceps, and with the fingers it is easy to strip up the peritoneum as far as the vertebral column. The ureter can then usually be recognized without difficulty. It is grasped between two hooked forceps and cut between them. The inferior portion is at once ligated and replaced. The superior portion is then held in contact with the posterior internal aspect of the descending colon and the sutures inserted as follows: The posterior lip of the ureteral orifice is first fastened to the still intact intestine by three or four sutures passed through the muscular layers only. The intestine is then incised for about 1 cm., several centimetres below the preceding row of sutures. The mucous layers of the posterior lip of the two orifices are immediately sutured together, and finally the anterior lips are united by a row of sutures through the muscular walls. Some supplementary sutures are next placed at the extremities of the incision, which gaps a little. The entire end of the ureter should then be buried at the bottom of a fold of the intestinal wall by means of two rows of seroserous sutures so placed that it will be completely covered for a distance of 2 cm. The exposed surface is drained and the abdominal wall closed.

Fowler (*The American Journal of the Medical Sciences*, vol. xxv., March, 1898) reports the successful implantation of both ureters into the rectum in a case of exstrophy of the bladder. He cut the ureter obliquely, to prevent stenosis, and ingeniously formed a flap of the mucous membrane of the bowel, to which he attached the ureters. The flap hanging in the bowel acted as a valve and closed during the passage

of feces. Fourteen months after the operation the patient presented no renal disturbance.

In my own practice I have had five cases of ureteral injury to deal with as a result of surgical operations by myself and others. In two of these anastomosis by invagination was done during the operation, and in one twenty-four hours later. Intraperitoneal implantation into the bladder was performed in another case, and a vaginal operation according to Kelly's method for uretero-vaginal fistula in a fifth case.

CASE I.—While operating for abscess of the left ovary and fibroid of the uterus, September 24, 1894, the left ureter was tied and cut transversely just above the brim of the pelvis. When the ovary was drawn up, what appeared to be a large vein showed, and did not bleed. A probe was inserted into it and passed down over the fibroid into the bladder, proving it to be the ureter, pushed up by the growth of the fibroid and passing over it under the ovarian abscess. The proximal end of the ureter was found included in the ligature that held the ovarian vessels. The distal end was secured with artery forceps and carefully separated from the fibroid. The tumor and uterus were drawn to the right side, and the ureter, with all the peritoneal attachment possible, separated and drawn to the left. I then completed a panhysterectomy as rapidly as possible. Turning to the injured ureter again I found it quite dilated, and, freeing the proximal end, cut off the part injured by the ligature and passed two fine catgut stitches through it, so that when both ends of either stitch were drawn on the loop became taut against the mucous surface of the proximal end of the ureter. The stitches were now passed into the distal end of the ureter and brought out about half an inch lower down the ureteral wall. When drawn on the proximal end was invaginated into the distal end and the stitches were tied. Four fine silk stitches were now taken, joining the distal end to the muscular and serous coat of the proximal end. The peritoneum was brought together over the ureter, where it was joined and sewed with fine silk. An iodoform gauze drain was placed over the ureteral joint and down into the vagina. The abdomen was closed

after the usual toilet. The operation took two hours and fifteen minutes. During the first forty-eight hours a retention catheter was used, and after this the urine was drawn every four hours for forty-eight hours; then every six hours for seven days. After this the patient passed urine voluntarily. The iodoform gauze was removed on the fifth day, no urine having leaked, so far as I could ascertain. The recovery was uneventful. The patient is now living, and claims to be in good health.

CASE II.—On December 2, 1894, while operating to remove multiple fibroma, which extended to the ensiform cartilage and were extensively adherent to the viscera and omentum, I tied the left ureter and tied and cut off the right. These grave injuries were not discovered until twenty-four hours after the operation, when I again opened the abdomen and located the ligature, tying the uterine artery and left ureter. This was freed and the artery secured in another ligature. The right ureter was now located, the proximal end found tied and the distal end curled down under the peritoneum. I found no trouble in uniting them in the same way as described in Case I., but as the cervix had not been removed, I placed a glass drainage-tube in the abdomen. The second operation lasted one hour, and was more than the patient could bear. She gradually failed from shock, and died in about ten hours.

CASE III.—On March 10, 1895, I was assisting a colleague to remove a large fibroid that was extensively adherent, when he tied and cut the left ureter in with the round and part of the broad ligament. I noticed what appeared to be a large vein that did not bleed, and on calling his attention he passed a probe into it and proved that it was the ureter. I suggested the procedure that had succeeded so well for me in Case I., and my colleague asked me to carry it out. I proceeded with the operation exactly as I had in Case I. The drainage was placed in similarly. The after-treatment was about the same, and the patient made a good recovery.

One year after the operation a cystoscopic examination was made, and the urine was found coming from the ureter that had been injured and repaired. In 1898 she reported to me in good health.

CASE IV.—In 1895 a patient came to me with uretero-vaginal fistula, which she claimed resulted from a vaginal hysterectomy two years previous. She further claimed that eight attempts had been made at repair through the vagina. By means of Kelly's cystoscope and bougies I proved that the right ureter was the one that had been injured. On October 12, 1895, I opened the abdomen and made a very careful search for the end of the ureter. The free oozing of blood obscured the field and made the search most difficult. I finally went up to where the ureter crossed the iliac vessels, raised and cut through the posterior peritoneal surface. After a little search I found the ureter. By now pulling it taut I could trace it into the pelvis, but was unable to find the distal end. I slit the peritoneum as far as I could be guided by the tension, and cut free and raised the ureter. Splitting the end, I implanted it into the bladder in the same way that Penrose and Krug had practised so successfully, placing the traction suture as advised by Van Hook in his method of anastomosis. The patient's condition was poor, and I could not take time to cover the ureter that I had laid bare. I hurriedly opened through the vagina, inserted an iodoform gauze drain, and finished the operation. The patient went off the table very low. A retention catheter was kept in the bladder, and every means known to me were constantly employed for days to keep the patient alive. On the sixth day drainage was removed. There was no leakage of urine. A very slow recovery was made, and after five months the patient left my care. I have seen her from time to time, and she seems and claims to be in very good health, but will not consent to a cystoscopic examination.

CASE V.—Miss J. T., aged thirty-nine years. In December, 1896, I performed a vaginal hysterectomy for double pyosalpinx, using double clamps to control the vessels and a gauze drain. Patient complained of pain in the right loin and down the course of the ureter after recovery from the ether. Urine was in fair amount and normal. Clamps removed in forty-eight hours. The patient was somewhat but not entirely relieved. Gauze removed on the fourth day. The patient still complained of pain as above. On the sixth day urine began to come through

the vagina, and with it the pain was entirely relieved. A good recovery was now made, but a urinary fistula remained, and on examination by injecting sterilized milk and by the cystoscope I found that the urine came from the right ureter through the vagina.

I operated to turn the ureteral opening into the bladder by the vaginal route, July 27, 1897.

A narrow strip was denuded on the posterior wall of the vagina and around the side as close to the scar left by the vaginal hysterectomy and ureteral fistula as possible. A curved incision was then made, beginning at one end of the denudation on the right side and ending at the denudation on the left side. The convexity was toward the ureteral opening, the cut was curved through the vaginal wall and into the bladder. This made a flap turning toward the ureter. The concave edge of the incision was covered by a running stitch of No. 1 catgut, bringing the bladder mucosa to the vaginal mucosa.

The convex edge of the incision was stitched by interrupted silver wire stitch to the denudation and to the sides and posterior wall of the vagina—eight stitches in all. The bladder was distended with boric acid solution. No leakage occurred. Gauze drain placed in the vagina. Catheterization every four hours and washing the bladder with boric acid solution constituted the after-treatment.

On the fourth day there was pain from spasmodic contraction of the bladder. Some clots were expelled through the urethra, and quite a brisk hemorrhage occurred.

This was due to the giving way of the catgut stitch that was buried in the bladder and from rough washing of the bladder.

A gentle current of hot boric acid solution, kept up for four hours, controlled the hemorrhage, and the patient then made an uninterrupted recovery, with perfect control of the urine. I saw her but once after she left the hospital. She then claimed to be perfectly comfortable. The vagina was very little shortened. She could retain urine all night. Had been at work for two months. She failed to keep her promise to return and undergo a cystoscopic examination.

ANASTOMOSIS BY INVAGINATION.

Operator.	Date.	History.	Method.	Result.	Remarks.
MacMonagle, B.	Sept. 24, 1894	Left ureter tied and cut during the removal of an ovarian abscess and fibroid uterus.	Invagination of the upper into the lower end of ureter with two catgut traction sutures.	Recovery.	
MacMonagle, B.	Dec. 2, 1894	Hysterectomy for large, adherent, multiple fibromata; left ureter tied; right ureter ligated and cut off.	Abdomen reopened 24 hours after original operation; ligature about left ureter released; proximal end of right ureter invaginated into lower end.	Death from shock.	
Robson, A. W.		Two inches of ureter cut off in removing a myoma of the uterus, weighing 25 lbs. which had dissected up the pelvic peritoneum.	Invagination of the proximal into the distal end by splitting the lower end.	Recovery.	Remains well six months later.
MacMonagle, B.	Mar. 10, 1895	Left ureter severed while performing hysterectomy for adherent fibroid uterus.	Invagination as in other cases.	Recovery.	
Winslow, Randolph	June 16, 1897	Right ureter divided in the broad ligament a few inches from the bladder, while removing a myomatous uterus.	A slit made in distal end of ureter; upper invaginated into lower end by two traction sutures of catgut.	Recovery.	

TRANSVERSE END-TO-END ANASTOMOSIS.

Operator.	Date.	History.	Method.	Result.	Remarks.
Schopf, Franz	June 2, 1886	Right ureter cut in separating dense adhesions to uterus, pelvic wall, and broad ligament of a large cyst.	Ends of ureter freed and freshened; approximated with 8 silk ligatures.	7 wks. after operation died of tuberculosis.	Union of ureter good, surrounded by dense mass of cloacal tissue.
Pawlik, K.	Mar. 23, 1889	Large adherent ovarian cyst and a papillomatous tumor low in cul-de-sac; ureter cut in removing latter growth.	Ends of ureter sewed with two layers of silk sutures over an elastic ureteral catheter which passed out at urethra; peritoneum closed over operative area.	Died 14 hrs. after operation of peritonitis.	Autopsy showed ureter patulous; sutures prevented leakage even under high pressure with a syringe.
Tauffer, Wm.		Ureter cut in removing right ligamentary cyst.	Ends united over a catheter, 6 to 8 sutures; catheter removed before tying last 3 sutures.	Recovery.	
Tauffer, Wm.		Left extraperitoneal tumor; ureter cut during removal.	Same technic.	Recovery.	
Fritsch, Henrich		Ureter cut while removing a tumor.	Ends brought together with a fine intestinal suture.	Recovery.	

Operator.	Date.	History.	Method.	Result.	Remarks.
Hochenegg, Jul.	Feb 9, 1890	Sacroperitoneal extirpation of cancer of corpus uteri; resection of ureter and bladder.	End-to-end suture of ureter.	Death on 20th day, hemorrhage.	Autopsy showed ureter and bladder sutures intact; origin of hemorrhage not ascertained.
Cushing, E. W.		Ureter cut in removal of a large, soft myoma.	Cut ends united with two fine silk and one catgut suture.	Recovery; patient well 2 years after operation.	

END-TO-SIDE ANASTOMOSIS (VAN HOOK).

Operator.	Date.	History.	Method.	Result.	Remarks.
Kelly, H. A.	May 1, 1892	Ligated and cut ureter during a hysteromyomectomy; mistook hydro-ureter for a vein.	End to side anastomosis.	Recovery.	No leakage.
Emmet, Bache	Nov. 22, 1894	Left ureter severed in removing large edematous fibroid attached over fifth lumbar vertebra, previously attached to uterus.	The upper end larger than lower; 8 catgut traction sutures to draw down and constrict lumen.	Recovery.	
Doherty		Ureter wounded during a laparotomy.	Van Hook's method.	Recovery.	

OBLIQUE END-TO-END ANASTOMOSIS.

Operator.	Date.	History.	Method.	Result.	Remarks.
Bovée, J. Wesley	Apr. 30, 1896	Right ureter severed during removal of right tubo-ovarian abscess and left pyosalpinx.	Ureteral ends cut obliquely and dilated; united end-to-end by alternating square with two interrupted sutures, and covering all with peritoneum.	Recovery.	

IMPLANTATION INTO THE BLADDER (INTRAPERITONEAL).

Operator.	Date.	History.	Method.	Result.	Remarks.
Novaro	1893	Vaginal hysterectomy for cancer of the uterus extending into broad ligaments; uretero-vaginal fistula resulting.	Laparotomy 2 mos. after; ureter dissected out and switched into bladder above normal entrance; Paoli-Busachi method.	Recovery.	Temporary leakage for a few days.
Penrose, Chas. B.	1893	Laparotomy for carcinoma of cervix involving left broad ligament; left ureter infiltrated; excised one inch.	Distal end of ureter ligated; proximal end slit and drawn into incised bladder by two silk traction sutures (Van Hook's method for anastomosis).	Recovery.	Abdomen closed without drainage.
Krug	1894	Ureter cut, removing a large intraligamentous fibroid of the uterus.	Technic similar to Penrose, except catgut traction sutures.	Recovery.	
Kelly, H. A.	Oct., 1894	Vaginal hysterectomy, left uretero-vaginal fistula.	Laparotomy 7 weeks after, ureter cut short; bladder separated from ram of pubis; ureter slit and drawn into bladder incision with forceps and stitched.	Recovery.	Drainage; no leakage.
Krause	Oct. 5, 1894	Vag. hysterectomy; uretero-vaginal fistula formed.	Suprapubic operation; proximal end of ureter drawn into bladder incision; four interrupted sutures placed.	Recovery.	
Boldt, H. J.	Oct. 10, 1895	Vag. hysterectomy for pyosalpinx and chronic pelvic adhesions; uretero-vaginal fistula resulting.	Laparotomy 4 mos. after; ureter united to bladder with 3 silk sutures over a ureteral catheter.	Recovery.	No drainage.
MacMonagle, B.	Oct. 12, 1895	Right uretero-vaginal fistula following vag. hysterectomy.	Distal end ligated, proximal end slit and planted into the bladder. (Van Hook's method.)	Recovery.	
Ferguson	Oct., 1895	Uretero-abdominal fistula resulting from laparotomy for removal of two adherent ovarian cysts.	Operation 3 months later; ureter entered a small cavity at bottom of fistulous tract; bladder incised and upper lip placed over and stitched to ureter.	Recovery.	Leakage for four or five days.
Baldy, J. M.	Dec., 1895	Ureter cut while removing a right intralig. cyst and left pyosalpinx; dense general adhesions.	Distal end of ureter could not be found; proximal end implanted into bladder, following Van Hook's method of anastomosis.	Recovery.	Bladder stitched to pelvic wall with catgut to relieve tension on ureter.
Fullerton, A.	Mar. 10, 1897	Division of double ureter, having anomalous course, during an operation for double pyosalpinx and ovarian abscess with dense adhesions.	Both proximal orifices introduced into a common opening in a bladder; distal ends ligated.	Recovery.	

IMPLANTATION INTO THE BLADDER (EXTRAPERITONEAL).

Operator.	Date.	History.	Method.	Result.	Remarks.
Baumm	1892	Double ureter, one ending at the mouth of urethra.	Suprapubic operation; proximal end of accessory ureter inserted in bottom of bladder.	Recovery.	
Witzel		Uretero-vaginal fistula; repeated vaginal operations failed.	Suprapubic operation; ureter divided at broad ligament; lower end closed, upper end drawn beneath peritoneum in a new direction; incisions in pelvic peritoneum and in median line closed; operation finished extraperitoneally.	Recovery.	Bladder was detached from pubis and fastened to the pelvis with catgut.
Vett		Ureter cut while removing adherent adnexa.	Ureter brought into abdomen incision, fastened between parietal peritoneum and fascia; bladder opened on anterior surface extraperitoneally; ureter sewed into incision.	Recovery.	
Kelly, H. A.	Jan. 26, 1898	Uretero-vaginal fistula in right vaginal vault.	Fritsch's method; incision inside right ant. sup. spine ending near spine of pubis; peritoneum dissected from pelvic wall; bladder loosened on right side; ureter split and attached to bladder.	Died, pyelonephrosis.	Ureter healed in the bladder.

IMPLANTATION INTO THE BOWEL.

Operator.	Date.	History.	Method.	Result.	Remarks.
Küster (Reported 1891.)		Complete cystotomy for cancer of prostate.	Ureters implanted in the rectum.	Died, purulent peritonitis.	Sutures between bowel and ureters had not held.
Chaput	Sept. 13, 1892	Uretero-vaginal fistula following vaginal hysterectomy.	Left ureter implanted into the colon.	Recovery.	End of 1 year left kidney not enlarged; amount of urine excreted fairly abundant.
Chaput	Nov. 25, 1892	Tuberculosis of bladder, vesico-abdominal fistula (peristent).	Left ureter sutured into colon; 8 mos. later, Nov. 1893, rt. ureter implanted in cecum.	Death.	Recovered well from first operation; suppression of urine after the second.
Fowler	1896	Exstrophy of bladder.	Both ureters sutured on a flap formed of bowel mucosa; valve-like action obtained.	Recovery.	14 months later patient has no renal disturbance.

The first consideration in regard to surgical injuries to the ureter can always be made before the operation. The exact condition of the urine must be obtained. With aseptic urine less importance may be attached to the local chemical action. With urine showing the slightest contamination every care and treatment must be followed to correct it before operating. In urotropine we have an excellent agent for correcting vicious urine.

When extensive operations are about to be undertaken the passage of bougies into the ureters cannot be too highly commended as a means of preventing injuries. Most of the injuries during abdominal section have been due to a displacement of the ureters by a tumor or tumors arising from deep in the pelvis, pushing the broad ligament apart and displacing the ureter, and in carcinoma involving the broad ligaments. Therefore, when we find tumors situated and growing as above, or have cases of carcinoma extending into the broad ligaments, it behooves us on opening the abdomen to take special care to locate the ureters and carry them well out of the field of operation before tying and cutting.

All vessels should, as far as possible, be isolated and tied, mass ligatures being avoided. Before working deep in the pelvis the bladder should be thoroughly separated from the uterus, toward and down to the vagina, and held well up by a retractor, the ureter being carried with it and made comparatively safe.

The ureters can often be located by the fingers or by seeing the peristaltic wave. If in doubt whether or not the ureters have been ligated, it seems wise, as suggested by Kelly, to make a small, longitudinal slit in the wall of the ureter, and, passing a probe up or down, make sure; the slit being taken care of as described later. If one fails to locate the ureter deep in the pelvis it can almost always be found where it crosses the iliac vessels by nicking the peritoneum. When found gentle traction will indicate its location for a considerable distance.

By the above means injuries can very often be avoided when doing extensive operations by abdominal section. Since adopting them I have had no accident to the ureters. When injuries do occur they may be of various kinds and degrees: 1. Longitudinal slits or tears. 2. Nicking out a piece from one side. 3. Partial transverse division. 4. Complete transverse division. 5. Resection of a portion of its length. 6. Tying. 7. Separation of the fibrous coat of the ureter.

Longitudinal wounds should be carefully stitched, taking in the serous and muscular coats, but not including the mucosa. Over this it is very important to carefully stitch the peritoneum. If this cannot be done a graft of omentum or even bowel will add to the safety of the union.

When a piece has been nicked from one side the method proposed by Fenger for stricture of the ureter will be suitable if there has not been too much loss of tissue. In the latter case it would be better to make the division complete and then make an anastomosis or bladder implantation according to the location of the injury. This is justifiable and advisable, on account of the splendid results that have followed anastomosis and bladder implantation. There is less liability to stenosis, and it can be as quickly done as stitching without complete division.

The repair of complete transverse wounds of the ureter has been looked upon as very likely to fail, on account of the failures in experimental work on animals.

The results on man clearly show that failure is the exception. Transverse end-to-end anastomosis has to its credit seven cases, with recovery, in so far as the ureter was concerned. It is true Schopf's case died of tuberculosis, Pawlik's case died of peritonitis, and Hochenegg's died on the twentieth day of hemorrhage. Still, it would be far fetched to argue that the method of repair was in any way responsible for the result in those cases. The remaining four cases made good recoveries.

Oblique end-to-end anastomosis with rectangular stitches,

as practised by Bovée, gave a good result in the only case reported. End-to-side anastomosis, according to Van Hook's method, has succeeded in the three cases of which I could find a report.

Invagination of the proximal into the distal end has been uniformly successful—only one death (my own case), where the injuries were not discovered until twenty-four hours after the first operation. The abdomen was opened again as the only resource. Under these very unfavorable circumstances the passages through the ureters were established, as was proved by the drawing of six ounces of urine from the bladder, from the time of the second operation until death, the bladder having been dry from the end of the first operation until the second was done. It seems clear that the death in this case was due to the second opening of the abdomen, and could not in any way be laid to the anastomosis of the ureter. On the other hand, it cannot be held that the anastomosis was a success.

All the other cases were successful. The invagination was easily made in my cases by the method already described. In the cases of Robson and Winslow a slit was made in the distal end, to allow the proximal end more easy entrance. Gentle dilatation could be practised in case the proximal end did not enter easily. Bovée has shown that about an inch can be gained in this way ; certainly very sufficient for practical purposes.

Our choice of method in the repair of resection of a portion of the length of the ureter will depend upon the location of the injury and the amount of the ureter resected. In the end-to-side anastomosis there is a good prospect of success if the amount of tissue used in tying off the distal end and invaginating the proximal end into the slit below does not cause too much tension in the already shortened tube. Anastomosis by invagination, or the oblique end-to-end anastomosis, saves some valuable tissue, and gives equally good prospect of success.

The outer fibrous sheath of the ureter carries its chief

blood-supply, and is closely connected with the peritoneum by fibrous bands. In stripping up the peritoneum over the ureter this sheath is easily injured, and necrosis of the ureteral wall may result. The repair of this injury, as well as the tearing off of any of the peritoneum over the ureter, should receive especial attention. Before closing the abdomen the ureter should be well covered by the surrounding peritoneum, and if this is not possible, the omentum or a portion of the bowel made to fill in the exposed area.

Intraperitoneal implantation into the bladder has been reported nine times, and with one of my own, make in all ten successful cases. This is certainly the operation of choice where the injury is below the pelvic brim, and can be made to meet the bladder without too much tension. If too much tension is required to make the ureter and bladder meet, Kelly's suggestion and practice of separating the bladder from the rami of the pubis and stitching it higher in the pelvis, as practised by Baldy, is a most excellent plan of overcoming the difficulty.

Implantation into the bowel could only be considered when it is found impossible to make a union of the ends of the ureter or an implantation into the bladder. That this procedure exposes the patient to serious complications can hardly be doubted, however great improvement in technic has been made by Fowler, who reports one successful case. Martin, of Chicago, has lately reported some experimental work on dogs, and we may eventually get a method by which this procedure can be made comparatively safe.

Theoretically, it would appear to be wiser to try implantation into the other ureter. Implantation on the skin can be used to gain time, and a secondary procedure taken later.

Tying the ureter with a chance of atrophy of the kidney seems to me a most unsurgical procedure.

Nephrectomy has been often and successfully practised, but in the light of the splendid results of repair after anastomosis or implantation must certainly be a last resource.

CONCLUSIONS. 1. Surgical injuries to the ureters during extensive operations on the pelvic and abdominal viscera are comparatively frequent, and are found to occur most often during vaginal hysterectomies.

2. These injuries can often be prevented by especial care both before and during the operation.

3. In uretero-vaginal fistula great care must be taken to have the urine aseptic before undertaking an operation for repair.

4. In uretero-vaginal fistula repair through the vagina should be first tried. Failing in this, extraperitoneal implantation into the bladder is to be preferred.

5. When injuries occur during abdominal operations immediate repair by anastomosis or implantation should be undertaken. If the condition of the patient is low, implantation on the skin should be done, with a view to future operation.

6. When anastomosis or bladder implantation cannot be accomplished, implantation in the other ureter or bowel are preferable to implantation on the skin.

7. Tying the end of the ureter, with a view to atrophy of the kidney, is not advisable.

8. Nephrectomy should only be practised as a last resort.

9. The results of the different methods of ureteral anastomosis and bladder implantation have been about equally successful.