

## THE RESULTS OF LIGATION OF ONE URETER.\*

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THOSE engaged in abdominal and pelvic surgery during the period of its development will recall the fear of an accidental ureter ligation, and those familiar with the earlier textbooks on gynecology are familiar with the dangers so graphically described as following this accident. It was firmly believed for a long time that such accidental ligation of one ureter was followed within a short time by the death of the patient, and we will recall such statements expressed in medical societies as: "To ligate a ureter is necessarily fatal;" "Doubtless many cases go to the grave as a result of a ligated ureter"; and, "Were the causes of all our deaths actually known, ligation of a ureter would frequently be found to have produced many of them." These were the accepted opinions until eight or ten years ago, when the pendulum swung the other way and it was for a time thought that the accident occurring unilaterally was followed by no bad effects whatsoever. Some six or seven years ago Dr. Robert T. Morris stated that ligation of one ureter was followed by absolutely no ill consequences, that the kidney ceased to functionate, and underwent atrophy.

The statement emanates from one of the large surgical clinics in this country that in seven different cases one ureter had been intentionally ligated for the purpose of getting rid of the kidney, the patients each suffering from accidental

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injury of a ureter and consequent fistula. This statement bears out the generally accepted opinions to-day as to a single ureter ligation, and it seems that we have been convinced that the result of this surgical accident is far from being a fatal one, and that practically the only effect is the physiological loss of the kidney on the affected side.

Personally we have never so far as we know ligated a ureter during the course of an operation, so we can only speak from the experience gained as a result of our experimental work. Nor has the one of us engaged in pathological work ever seen this accident at the autopsy table, notwithstanding our work for some years past has given us ample opportunity for a large number of post-mortem examinations.

During the past summer in connection with some other work we were doing in the Pathological Laboratory of the University of Louisville, we began a series of experiments to determine, if possible, what did actually take place as a result of the ligation of one ureter. The observations made were in many respects quite interesting and by no means uniform in regard either to the end result or the condition at any given time subsequent to our ligations. While our work is not completed, it is sufficient to enable us to arrive at some definite conclusions and has gone far enough to enable us to present some few facts at least.

The experimental work along this line heretofore has been largely from the metabolic side and has been carried out almost entirely upon guinea pigs and rabbits. Our work has been from the clinical and pathological stand-point. In a study of the effects of ligation of one ureter upon the kidney and upon the animal, it has been shown by Amos, Bainbridge, and Beddard that the renal tubules continue to secrete urine and that Heidenhain's view as to the functions of the kidney is in all probability the correct one; their experiments decidedly indicate that the secretory activity of the tubules is rapidly impaired by ligation of the ureter, whereas the glomeruli are more gradually involved. Even two months after ligation the kidney can still secrete some water and some nitrogenous material.

The rapid flow of urine occurring immediately after opening the ureter is doubtless analogous to that observed clinically under similar conditions. It can hardly be the result of increased secretory activity on the part of the kidney, since this organ subsequently yields much less urine than the normal kidney of the same animal. It may be suggested, as a conjecture, that the sudden alteration of pressure on the damaged glomerular epithelium allows purely physical factors to act unchecked and that the first rush of urine is formed by simple filtration through the glomeruli.

Bainbridge concludes:

(1). Ligation of one ureter is followed by hydronephrosis of the kidney.

(2). There is a temporary loss of weight followed by complete recovery, no ill effects are noticeable two months after the ligation.

(3). The initial pressure of the urine is low and bears no relation to the blood-pressure.

(4). The secretory power of the kidney, as evidenced by its capacity to secrete water and nitrogenous constituents, steadily diminishes after ligation of the ureter, but is not lost at the end of two months.

(5). No absorption (that is, any evidence of it) was obtained when KI was put under a pressure of 50–80 mm. Hg into the renal pelvis.

Orth found following ligation there occurred dilatation of the tubules, flattening of the epithelium, and changes in Henle's loop. Immediately following ligation the pressure of urine upon the veins of the pelvis of the kidney brings about a state of hyperæmia and hemorrhage, particularly under the capsule and in the connective tissue. After two or three days anæmia succeeds hyperæmia and ultimately atrophy develops. The pressure of the stagnant urine in the ligated ureter and pelvis of the kidney causes an œdema of the organ extending to the capsule and surrounding connective tissue. This œdema is due to the reabsorption of the watery elements of the urine by the lymphatics, and of course disappears when secretion ceases.

Lepine and Poeteret found by experiment that the secretion of urine ceases as soon as the counter-pressure in the pelvis of the kidney amounts to 50 mm. of mercury.

Cohnheim showed that a 50 mmHg pressure is necessary to arrest the flow of urine. When an obstruction takes place gradually, the walls of the ureter lose their tone, so that the largest hydronephrotic sacs are those brought on insidiously or experimentally, which give the stagnant urine time to exercise mechanical dilatation of the walls, while with a sudden closure there is a distention of the kidney and ureter which very soon disappears. The stout elastic capsule of the kidney and the resorptive function of the lymphatics are forces which contribute largely toward the reduction in size in these latter cases of sudden complete obstruction.

Straus found in his experiments, using 20 guinea pigs, that four or five months after ligation there was a high grade hydronephrosis with atrophy of kidney and disappearance of pyramids. Histological examination showed atrophy collapse of tubules, shrinkage of epithelium, cystic widening of the Malpighian corpuscle, and thickening of capsule and blood-vessels. There was compensatory hypertrophy to nearly double the size in the other kidney. Five of his experimental animals died of peritonitis.

We find a report of only one clinical case in the English literature, this being a translation from the German of Landau's case. Landau cites three operators, Bastianelli, Futh, and Phenomenow, who had carried out the procedure which he reports, namely, ligation of the ureter for the relief of accidental urinary fistula. He says in his report:

"It is now seven months after the operation, and the patient has made a good recovery in spite of the fact that for three days she vomited and had a violent headache, and that the urine was lessened to half the amount for two weeks. Up to this time there have been no symptoms of hydronephrosis. The cystoscopic examination shows the right kidney to be functionless, the orifice of the right ureter appearing on the bladder wall as a small dimple."

Our experiments were carried out on dogs. The technic consisted of ligating the ureter with Pagenstecher yarn close

**FIG. 1.**

**Experiment 3.** Marked hydro-ureter; abscess of kidney; staphylococcus infection. Kidney shown to right from unligated side.

**FIG. 2.**

**Experiment 8.** Enormous hydro-ureter. Miliary abscess of kidney, particularly the cortex. Kidney shown to right from unligated side.

FIG. 3

Experiment 32. Enormous pyelonephrosis. Kidney 3 inches in diameter. 5 inches in long axis.

FIG. 4.

Experiment 33. Hydro-ureter, atrophic kidney. Compensatory hypertrophy shown in kidney to right, which is from the unligated side.

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to the bladder. The posterior layer of peritoneum is left intact if the ligation is done low down. Some of the earlier dogs were tied high up, but this necessitated a search and division of the posterior parietal peritoneum and was abandoned after four or five applications. In tying low down no handling of intestines is required, and usually three to five minutes suffice to complete the entire operation. Dogs Nos. 2, 4, 5, 21, and 30 died as a result of operation. The others were destroyed in from two hours to two months after application of the ligature, and not only were the symptoms studied during their life, but the post-mortem condition was noted, and in many, bacteriologic examinations were made of the urine in the pelvis of the kidney and in the bladder. Those dogs showing abscesses in the kidney were also studied in part from the bacteriologic stand-point, showing a staphylococcus present as a constant finding. This organism was the only one found in the urine in those instances in which a bacterium was present.

The specimens from dogs Nos. 3, 8, 32, and 33, as seen in the accompanying illustrations, show the different changes we have observed. Each specimen is shown with the normal kidney, namely, the kidney from the unligated side of the same dog.

In Experiment 22, we tried to simulate the happenings of an accidental ligation and division of a ureter during the course of an operation, using, however, non-absorbable ligature for purposes of identification and to enable us to surely relieve the constriction after one week. The results in this case are extremely interesting. Only a few of the animals appeared sick or at all affected, which is in keeping with what usually happens. However, it must be noted that in Experiments 3, 5, 8, 18, 31, and 32, abscess formation was noted in the kidneys. This is probably in keeping with the work of Brewer as shown in his Chairmanship address before the Surgical Section of the American Medical Association. It is clearly demonstrated by him we believe, and generally accepted, that kidney infections occur through the blood channels, the organ as a result of injury becoming a *locus minoris resistentiæ*,

permitting bacterial lodgement and development. Ligation of or sudden obstruction of a ureter which is complete, even though existing for a few hours only, may do the same thing. When the obstruction exists as long as two or three days it may result in abscess formation, while if the absolute obstruction be continued, it may eventuate in a large pus kidney. Such a pyonephrosis is noted in Experiments 31 and 32, the latter being shown in Fig. 4. Experiment 31 presented an exactly similar condition of the kidney and also had present when destroyed a suppurating femur which had begun as a swelling about two weeks earlier, the swelling rupturing with purulent discharge a week later, *i.e.*, a week before destruction. This dog had an extensive osteomyelitis, doubtless of embolic origin from the suppurating kidney. Animals 28 and 33 are still living and will be studied at a later date.

We think the œdema in the perinephritic tissue is also worthy of note, and believe with Orth that the secreted urine is probably reabsorbed in this way, that is, through the lymph channels.

Constant were the dilatations of the peripheral veins—showing a very probable anastomosis of the renal vein with the adrenals and the intercostals. This is noted in some of the protocols.

Shortly after ligation there is a distinct hydro-ureter with hydronephrosis. This is usually present at the end of two hours. The kidney is very much enlarged, weight (opened) greatly increased. At first there is a distinct venous congestion, and on section of kidney considerable amount of blood escapes. Later this bluish tinge of the kidney disappears and is replaced by a marked dilatation of peritoneal veins, which represents the anastomosis between vessels of the kidney and the adrenal, also of the renal with probably an intercostal vein. At the end of 24 hours a marked perinephritic œdema is visible. After two or three days this disappears. The cortical tissue of the kidney after the initial venous congestion is thickened and distinctly paler.

It would seem from our experiments that in from 10 to 15



per cent. of the ligations such gross and extensive changes in the kidney have taken place as would have required in man further surgical operation to relieve, but the animals have gone on and lived without apparent discomfort. An atrophy occurs without such gross and extensive surgical change in the kidney in from 80 to 90 per cent. of those cases in which the ureter has been ligated. It is definitely proven that ligation of the ureter is an accident that is not to be absolutely disregarded, and it is a bad procedure to ligate a ureter to get rid of the kidney (Nierenausschaltung).

The detailed protocols of the series of experiments are omitted in this publication but will appear in full in the *Transactions of the Southern Surgical and Gynecological Society* for 1911.

#### CONCLUSIONS.

1. Ligation of one ureter is followed by a primary hydro-ureter and hydronephrosis, which results in ultimate destruction of kidney function as a result of pressure atrophy of the secreting tubules.
2. Not infrequently infection and suppuration of the kidney may follow ligation of its ureter, due to lessened resistance in the kidney as a result of circulatory changes.
3. The microscope shows very strikingly that the greatest effect histologically is exerted upon the tubular structures and that the glomeruli are only slightly involved as a result of the fibrous deposits accompanying atrophy. (This will be the subject of further study.)
4. Pyelo- and pyonephrosis may occur from hæmatogenous infection in such kidneys, leading to their complete destruction functionally and anatomically.
5. Experimental animals may present no apparent symptoms though suffering from marked hydro- or pyelonephrosis. This may possibly be true in man as regards subjective symptoms.
6. Embolic septic processes may ensue following hæmatogenous kidney infections though the latter present no apparent symptoms.

7. The ligation of the ureter for the purpose of eliminating the kidney or its function (Nierenausschaltung) in the presence of ureteral fistula or the accidental ligation of a ureter is not without danger, and under such conditions if restoration of the lumen of the ureter is impractical or impossible, nephrectomy should be the procedure of choice.

8. Ureteral fistulæ are sometimes spontaneously cured by cicatrization and occlusion of the ureter and secondary atrophy of the kidney.

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