

REPORT  
of  
COMMITTEE ON EXAMINATION

This is to certify that we the undersigned, as a Committee of the Graduate School, have given Raymond Lee Latchem final oral examination for the degree of Master of Science in <sup>Urology</sup> We recommend that the degree of Master of Science in <sup>Urology</sup> be conferred upon the candidate.

Minneapolis, Minnesota

March 15 1922

W. F. Brauer

Chairman

REPORT  
of  
Committee on Thesis

The undersigned, acting as a Committee of the Graduate School, have read the accompanying thesis submitted by Raymond Lee Latchem for the degree of Master of Science in Urology. They approve it as a thesis meeting the requirements of the Graduate School of the University of Minnesota, and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science in Urology.

*W. F. Braasch*  
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*H. C. Munn*  
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Statement Concerning Life of Candidate for Master's Degree (to be read by Chairman at the final oral examination; copy to be filed in the Dean's office)

1. Name of Candidate (In full):

Raymond Lee Latchem.

2. Place and date of birth:

Crete, Nebraska, Sept. 16, 1885.

3. Preliminary education, secondary and collegiate:

Washington, Iowa, High School, 4 years  
Morgan Park Academy, 2 years  
University of Chicago, 1905-1909  
Rush Medical College, 1907-1911

4. Degrees obtained with dates and names of institutions:

S.B., U. of Chicago, 1909  
M.D., Rush, 1911

5. Language examinations passed:

None required.

6. Minor line of work with date of final written examination:

Pathology; no written examination required.

7. Major line of work, with date of final written examination:

Urology; examination March 13, 1922.

8. Thesis subject with date of final approval:

The ureter after nephrectomy: an experimental study; with a report of ~~three clinical cases of pyoureter.~~

9. Degree applied for:

Master of Science in Urology.

Statement of the Work of Dr. Raymond Lee Latchem

Course No.	Title	Teacher	Beginning	Months	Grade
M167-8	Gen.Med. & Surg. Diag.	Bonta	Feb. 1-19	3	B+
M169-70	"	Berkman	May 1-19	1	B
M175-6	Urologic Diagnosis	Braasch	June 1-19	4	B+
M252f	Dermatology	Stokes	Oct. 1-19	3	B
M177w	Urologic Diagnosis	Braasch	Jan. 1-20	3	C-
M178s	Urologic Diagnosis	"	Apr. 1-20	3	C
M178su	Urology - cystoscopy	"	July 1-20	3	B-
M161f	"	"	Oct. 1-20	3	B-
M153w	Operative surgery	Hunt	Jan. 1-21	3	A
M153s	"	"	Apr. 1-21	3	A
M153su	"	Sistrunk	July 1-21	3	B
M153f	" (1st Asst)	Hunt	Oct. 1-21	3	A
M157w	Surgical Pathology	MacCarty	Jan. 1-22	3	B
	Experimental Pathology	Mann	Jan. 1-21	part time	B

Graduate School, University of Minnesota

March 13, 1922.

This is to certify that Raymond Lee Latchem, a candidate for the degree of Master of Science in Urology, has passed the final written examination for the major in the Department of Urology.

x W. F. Brasch

For the Major Department.

Graduate School, University of Minnesota

March 13, 1922.

This is to certify that Raymond Lee Latchem, a candidate for the degree of Master of Science in Urology, has completed the requirements for the minor in the Departments of Experimental Surgery and Pathology and Surgical Pathology.

Frank C. Mann

For the minor departments.

THESIS

THE URETER AFTER NEPHRECTOMY - AN EXPERIMENTAL STUDY -

With a Report of Three Clinical Cases of Pyoureter.

RAYMOND LEE LATCHEM, S.B., M.D.

Submitted to the graduate faculty of the University  
of Minnesota in partial fulfillment of the require-  
ments for the degree of Master of Science in Urology.

January 1922.

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This study was undertaken in order to investigate the ultimate fate of the ureter after nephrectomy, experiments being planned to simulate, as closely as possible, the conditions found in clinical cases when a nephrectomy is performed, and either a normal ureter, a hydroureter, or a pyoureter (infected hydroureter) is left undisturbed. A few experiments were performed leaving the normal ureter in situ to endeavor to find the natural trend of events in the healthy organ after nephrectomy, as well as to have a basis of comparison for the diseased ureters. It was felt that the experiments with hydroureters, infected and uninfected, might have some clinical importance as such ureters are constantly being left in the body after nephrectomy. For example, a ureteral calculus often produces a hydroureter and hydronephrosis but probably rarely causes complete blocking of the ureteral contents and would allow drainage of the ureter after nephrectomy. Complete blockage of the escape of ureteral contents occurs following ligation of the ureter with silk during operations such as resection of the bladder and colon for cancer and accidentally with catgut in pelvic operations. A certain percentage of such tied-off kidneys become acute surgical kidneys, especially if they were the site of infection before the ligation, and must be removed. The ureter in such cases is always slightly enlarged and full of fluid which will never have an opportunity to escape naturally.

In order to produce the hydroureters it was necessary to obstruct the outflow of urine from one kidney and produce a hydronephrosis, so considerable data was secured which simply confirmed the work of others in regard to this process. The effect of complete obstruction of the ureter on the kidney has been studied several times and full and well agreeing accounts of such work have been published by Barney, Keith and Pulford, Reed, Johnson, Caulk, and

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lastly by Harrington, so this paper will not enter into that field except to record one or two interesting cases.

Experimental work on the ureter, except for the work of Caulk and his associates, has been mainly confined to ligations, in order to study the effect on the kidney, and to transplantation experiments. Caulk's work was undertaken primarily to try to establish the length of time that a kidney could be completely obstructed and still resume function; to determine the length of time necessary for absorption of plain catgut causing the obstruction, and the length of time that elapsed before the lumen of the ureter reopened. This work showed that the catgut was absorbed in about three weeks and the lumen of the ureter was open sufficiently in from six to eight weeks to drain the urine without obstruction, during which time the kidney, unless nephrostomized, would be past the point of hope of return of function. Johnson had previously demonstrated that the function of the kidney could return to normal when obstruction had not been maintained for longer than two weeks, and that the longer the period of obstruction the slower was the rate of recovery.

Dogs were used in all of the experiments because of the similarity of the anatomy, particularly of the physiology and blood supply, to that of man. Each surgical procedure was carried out with the strictest observance of aseptic technic, identical with that used on man. The area necessary for operation was prepared by shaving, through cleansing with benzine and alcohol, and by two coats of iodine (10%). The animals were anesthetized with ether. The technic of the various surgical procedures is discussed briefly under each group of experiments, the peritoneum and fascia being closed with catgut, and the skin closed with linen and a protective dressing sealed with collodion. At all times the animals were kept under the most favorable conditions for health and comfort.



The material studied has been classified into three groups as follows:

Group 1 - Nephrectomy - leaving a normal ureter.

Group 2 - Nephrectomy - leaving either a hydroureter or pyoureter, with

A - a patent lumen,

B - a completely obstructed lumen.

Group 3 - Control Group - producing a hydroureter or pyoureter without nephrectomy, but with

A - Ureteral obstruction removed,

B - Ureteral obstruction not removed.

Group 1.

Nephrectomy - leaving a normal ureter.

In this group three dogs (see table 1) were used, a left nephrectomy being performed in each case, and the animals were allowed to live as long as possible. At autopsy the ureter, which had been deprived of its normal function of conveying urine, was in each case found patent and in two instances noticeably smaller than its mate. Microscopical study of sections taken from the same level from both ureters was made. In these sections it was impossible to detect any difference in the mucosa of each right and left ureter or in the fibrous coat. However, in comparing the muscular layers it was definite that there was a diminution of the amount of muscular tissue in the functionless ureters (see plates 1 and 2). From these observations it would appear that in a normal ureter after nephrectomy there is no attempt made toward obliteration of the lumen, but that there is atrophy of the muscular coat.

Table 1.

(see group 1.)

## Normal ureter after nephrectomy.

Experiment No. (1919)	Nephrectomy	Duration of experiment days.	Autopsy
671	10-7	480	Right kidney enlarged almost one third more than normal, right ureter normal. Left ureter apparently normal, allowed passage of ureteral catheter as well as the right ureter. Autopsy No. 54, 1921.
674	10-7	275	Right kidney and ureter normal. Left ureter thinner walled than the right and did not have the feel of normal tissue as compared with the right. Lumen patent. Aut. No.331,1920.
677	10-9	405	Right kidney somewhat enlarged, right ureter normal. Left ureter smaller than the right with patent lumen. Aut. No.593, 1920.

## Group 2.

Nephrectomy - leaving either a hydroureter or a pyoureter with (A) a patent lumen and (B) a completely obstructed lumen.

Twelve dogs were used in this group. In each instance one ureter was ligated at a point one inch above the bladder with catgut (chronic No.2) so applied as to facilitate later removal. (It was found if a small section of a small urethral catheter was split and placed around the ureter with the ligature tightened over it, that later removal was much easier than when the ligature was directly applied to the ureter.) About two weeks later the ligature around the ureter was carefully removed, the condition of the ureter noted, and the kidney on that side removed. The object of this series of experiments was to produce in each case a pathological ureter such as would be present in a

hydronephrosis or pyonephrosis produced by obstruction low in the ureter and, if possible, a ureter that would drain following removal of the obstruction. In doing the nephrectomy, the upper ureter was ligated twice with silk and severed between the ligatures, so that the content of the ureter would not be lost. In four of these experiments pure cultures of staphylococci were introduced into the distended ureter.

At the autopsies it was found in six (see table 2) cases that the ureteral obstruction had either been relieved at the time of removal of the ligature or that the lumen had opened subsequently, as the ureters were empty and it was possible to demonstrate a lumen past the point of ligation. In only one of these, however, was the ureter apparently normal in size throughout and without any constriction at the point of ligation. In the other five there was a varying degree of obstruction with reduction in the size of the lumen which allowed the passage of fluid but denied, in some cases, the passage of a ureteral catheter. It would seem that these cases could be compared to surgical cases where a hydronephrotic kidney secondary to a stone in the ureter was removed, leaving a hydroureter with a calculus in its lower portion which did not cause complete obstruction.

In the five cases the size of the ureter above the point of ligation was from two to three times that of its mate and hypertrophy of the ureter as a whole could be made out grossly, while below the point of ligation the ureters were normal. On microscopic examination the increase in size of the ureteral wall was found to be due to actual increase in the amount of muscular tissue, the increase being chiefly confined to the circular layer but also demonstrable in the longitudinal layers. That there was an actual increase in muscle tissue could be appreciated by comparing the thickness of the muscle layer in the diseased ureter with that of its mate and taking into consideration

the increased size of the one over the other. For example, in experiment 695, the thickness of the muscle wall of the left ureter is greater than that of the right and the diameter of the left ureter is several times that of the right one (see plates 3 and 4). The greatest amount of hypertrophy or increase in muscular tissue, relatively as compared with its rate, was observed in the animals which came to autopsy after the shorter periods and was less pronounced in those that lived longer, as in the experiments 713 and 782. This would indicate that after the obstruction which was providing the stimulus to muscular hypertrophy was removed that the muscular coat gradually atrophies. In experiment 782, where no obstruction to the lumen could be demonstrated, this had evidently occurred and the two ureters were apparently the same size, though still showing by microscope a slight increase of muscle tissue in the ureter that has been obstructed.

Except for the ironing out of the mucosal folds to a varying degree in each instance, the mucous membrane appeared normal. There was no demonstrable change in the fibrous coat and also none in the submucosa, except in one case (experiment 713) where there was lymphocytic infiltration and slight connective tissue formation. In no case was there any peri-ureteral inflammation either active or old as would be indicated by adhesions. The culture of staphylococci introduced into the ureteral contents in the one case had evidently drained out with the fluid and did not give rise to any inflammation.

These findings would seem to indicate that a hypertrophic hydroureter with incomplete obstruction to its lumen will, after nephrectomy, empty itself and gradually become atrophic in the muscular layer, will preserve a normal mucous membrane, and will not give rise to any irritation outside of its walls.

Table 2.

Hydroureter, with drainage of contents, at various periods of time  
after nephrectomy.

Experiment No. (1919)	Ureter ligated	Ligature removed and nephrectomy.	Condition of ureter and kidney.	Duration of experiment days.	Autopsy.
695	10-14	10-30	Tortuous hydroureter above ligature, normal below. Hydro-nephrosis.	60	Aut. No. 617. Right kidney and ureter below ligation normal. Left ureter, above ligation point, enlarged and cord-like. Lumen open to fluid.
713	10-21	11-6	Tortuous hydroureter above ligature, normal below. Hydro-nephrosis.	315	Aut. No. 445. Slight hypertrophy of the left kidney. Left ureter normal. Right ureter was slightly larger above ligation point than below. Lumen patent.
694	10-14	10-30	As above	65	Aut. No. 627. Right kidney and ureter normal. Left ureter felt cord-like and was slightly larger above point of ligation than below.
782	10-18	12-2	Very large tortuous hydroureter. Large hydronephrosis.	239	Aut. No. 339. Right kidney and ureter normal. Left ureter apparently normal. Lumen patent and free of any obstruction.
700	10-16	11-6	Large hydroureter and hydronephrosis.	167	Aut. No. 145. Right kidney, acute nephritis, right ureter normal. Left ureter enlarged above ligation point, normal below. Lumen obstructed but patent.
714	10-21	11-4	As above. Culture of staphylococcus introduced into distended ureter.	87	Aut. No. 19(1920). Right kidney and ureter normal. Left ureter almost twice size of right but lumen patent.

The operated ureters of the remaining six cases of this group (see table 3) all showed complete obstruction at the point of ligation, by which it was impossible to pass a catheter or force fluid, and it would seem, would approximate the surgical cases of complete obstruction to a hydroureter or pyoureter after nephrectomy. Each of these ureters were distended, three with clear fluid and three with pus. Those containing pus were surrounded by adhesions which made it difficult to remove them from their beds, and in one case the pus had ruptured through and caused an abscess. These ureters were enlarged from three to five times the size of their mates above the point of constriction and normal below that point.

On microscopic examination the mucosa of each was found flattened even to complete obliteration of the mucosal folds but otherwise normal. The submucosa was normal in the uninfected cases but showed lymphocytic and leukocytic infiltration, which in one instance extended into the muscular layer, in the infected cases. The muscular layer was markedly increased in all, and more increase of the longitudinal muscles was present than in the previous ureters examined. (see plates 5 and 6). This increase in longitudinal muscle was noticed especially in the ureters of the animals that lived the longest (Experiments 598 and 699) though the circular coat still predominated, which may indicate that hypertrophy occurs first in the circular and later in the longitudinal layers. Also in all of these cases the muscular hypertrophy was more pronounced than in the group where the ureter had drained, which would indicate that the muscle increased somewhat after nephrectomy and did not atrophy as long as the ureter contained fluid.

Table 3.

Hydroureter and pyoureter, with complete obstruction to drainage of contents at various periods of time after nephrectomy.

Experiment No.	Ureter ligated.	Ligature removed and nephrectomy.	Condition of ureter and kidney.	Duration of experiment days.	Autopsy.
598	10-16	11-20	Large tortuous hydroureter. Large hydronephrosis.	375	Aut. No. 549(1920) Right kidney a third larger than normal, ureter normal. Large dilated left ureter tortuous and full of pus. Complete obstruction at point of ligation. Normal ureter below. Ureter surrounded by dense adhesions.
732	10-28	11-12	Hydro-ureter and hydronephrosis. Culture of staphylococci introduced into ureter.	28	Aut. No.567. Right kidney and ureter normal. Left ureter distended with pus. Abscess around lower ureter.
717	10-23	11-11	Large hydro-ureter and hydronephrosis	46	Aut. No. 717. Right kidney and ureter normal. Left ureter twice size of right, full of clear fluid and with complete stenosis of lumen.
734	10-28	11-12	Tortuous hydroureter and hydronephrosis.	35	Aut. No.569. Right kidney and ureter normal. Left kidney distended with clear fluid as at previous operation. Complete stenosis of lumen.
733	10-28	11-12	Large hydroureter.	106	Aut. No.70(1920).Right kidney and ureter normal. Left ureter about four times normal size and distended with clear fluid. Complete stenosis.
699	10-16	11-4	Large hydroureter and hydronephrosis. Culture of staphylococci into ureter.	357	Aut. No. 512(1920).Right kidney showed chronic nephritis, right ureter normal. Left ureter large and felt hard and contained some turbid fluid. Surrounded by firm adhesions. Complete obstruction.

The most striking feature at autopsy of these cases was the distension of the ureter with the contained fluid. The three uninfected hydroureters were apparently in the same condition that they were when they were ligated and dropped back after nephrectomy. The three infected hydroureters, two of which had been deliberately infected at the time of the nephrectomy, showed definite inflammatory reaction with infiltration of leukocytes into the submucosa and outer fibrous coat (see plate 6), and the formation of connective tissue adhesions around the ureter. In one instance the infection had broken through with resultant formation of a periureteral abscess.

From these results it would seem that after nephrectomy in the cases of hydroureter and pyoureter with complete obstruction to evacuation of contents, that absorption of such contents would be very slow and limited if occurring at all, and with the additional danger in the infected cases of extension through the ureter. In this group, also, the mucous membrane remained intact but the muscular coat remained hypertrophic.

#### Group 3. Control group.

Producing a hydroureter or pyoureter without later nephrectomy but with (A) the ureteral obstruction removed and (B) the ureteral obstruction not removed.

This group consisted of nine animals in which the ureter was ligated but a nephrectomy was not performed later. The obstruction to the ureter was successfully removed in two cases, not attempted in four, and failed of removal in three. The purpose of this group of experiments was to establish controls on the results obtained in group 2.

In the two instances where a hydroureter and hydronephrosis was produced and, fourteen days later, the obstruction to the ureter removed but a



nephrectomy not performed, the animals lived for a long time (see table 4) and the results were sufficiently interesting to record. The time of obstruction was the same in each instance and, presumably, the amount of damage to the kidney equal. After the removal of the obstruction the kidney in each instance evidently resumed function and the degree of recovery was evidently effected by the condition of the ureter, as in one case there was partial obstruction of the lumen and in the other an unobstructed channel. As the result of the partial obstruction in experiment 693 (table 4) the ureter was hypertrophic and the kidney slightly hydronephrotic with some atrophy of the kidney substance. Microscopic examination of the effected kidney showed normal glomeruli and tubules but also areas of inter-tubular connective tissue formation, while the hypertrophic ureter showed the muscular coat developed at least one third more than in its mate. In experiment 712 (see plate 7) where the ureteral lumen was unobstructed, it was difficult to tell, grossly or by microscope, the substance of one kidney from the other, but the lumen of the left ureter was slightly larger than that of the right though the muscle coats were equally developed. These results were interesting in that they confirmed previous reports of the return of kidney function, providing the damage done to the kidney by the obstruction of the outflow of urine was not irreparable. From the condition of the ureters it would seem that the muscular hypertrophy produced by obstruction tends to disappear after the obstruction is removed.

Table 4.

Hydroureter, with free drainage and without nephrectomy.

Experiment No. (1919)	Ureter ligated.	Ligature removed.	Condition of operated ureter and kidney.	Duration of experiment days.	Autopsy.
693	10-14	10-28	Large hydroureter. Hydronephrosis.	325	Aut. No. 444 (1920) Right kidney slightly enlarged, ureter normal. Left kidney smaller than normal with a small amount of hydronephrosis. Left ureter thickened and enlarged at point of ligation, slightly enlarged above this area and normal below. Lumen at point of ligation very small but patent.
712	10-21	11-4	Ureter dilated and tortuous. Hydronephrosis.	340	Aut. No. 490 (1920) Right kidney and ureter normal. Left kidney but slightly smaller than the right and on cut section, aside from a slight enlargement of the pelvis, presented no gross difference from the right. The left ureter was very slightly larger than the right except at the point of ligation where it was definitely thicker. It was impossible to pass a ureteral catheter either up or down the ureter past this point but fluid passed through without difficulty. Judging from gross appearance the kidneys had equal function.

The remaining seven experiments in this group without later nephrectomy consisted of one in which the ureter was ligated at a point two inches below the kidney pelvis, two in which one ureter was crushed and ligated at a point just above the bladder, and four in which the attempt to remove the ligature, previously placed on the ureter, failed (see table 5).

The hypertrophy of which the muscular wall of the ureter is capable is well illustrated by the experiments of this group (see plate 8) as in all but the one case that lived but seventeen days the ureter was dilated and tortuous and greater increase of the muscle layer was found than in previously examined ureters. Here also in the animals that lived the longest was a greater amount of increase in the longitudinal muscle bands though the circular layer always predominated. In no case, however, was this hypertrophy equal to the hypertrophy of the ureter usually observed in cases of ureteral obstruction with a functioning kidney. The results in experiment 678, where the ureter was ligated at a point two inches below the kidney pelvis, were very interesting in that the ureter was normal below the point of ligation and did not show any atrophic tendency but was greatly hypertrophic above the point of ligation (see plates 9, 10, 11 and 12). The mucous membrane, except for the obliteration of the mucosal folds by the distension of the ureter, was normal in every case, including those that were infected.

In addition to the experiments tabulated there were four additional cases in each of which one ureter was ligated. One of these died on the eighth day from sepsis from a badly infected wound, two on the twenty-seventh and thirtieth days respectively from distemper and pneumonia, and one on the fourteenth day from the anesthetic, while preparations were being made to remove the ligature around the ureter. All of these showed the usual hydronephrosis and hydroureter.

Table 5.

Hydroureter and pyoureter with complete obstruction to drainage of contents and without nephrectomy.

Experiment No. (1919)	Ureter ligated.	Ligature not removed or failed to remove.	Condition of operated ureter and kidney.	Duration of experiment days.	Autopsy.
672	10-7	0	Ureter was crushed and ligated.	72	Aut. No. 626. Right kidney and ureter normal. Left kidney a large hydronephrotic sac. Left ureter tortuous and dilated above ligation, normal below.
701	10-16	0	Ureter crushed and ligated.	17	Aut. No. 494. Right kidney and ureter normal. Left kidney was a large hydronephrosis which had ruptured into the peri-renal fascia where there was a large collection of urine. Left ureter dilated above point of ligation, normal below.
678	10-9	0	Ureter ligated two inches below pelvis of kidney. No attempt at removal.	480	Aut. No. 34(1920) Right kidney slightly enlarged with normal ureter. Left kidney and its pelvis formed a large sac measuring 8x12x16 cm. and filled with clear fluid. Left ureter from sac to point of ligation was very tortuous and measured five inches. Left ureter normal below the point of ligation.
761	11-16	12-2	Unable to remove the ligature. Hydronephrosis and hydroureter. Re-ligated ureter.	93	Aut. No. 82(1920) Right kidney and ureter normal. Left kidney was a shell slightly smaller than right kidney and filled with pus. Left ureter was 1 cm. in diameter and filled with pus. There was an abscess around the lower portion of the ureter.
718	10-23	11-11	Ureter three times normal size. Hydronephrosis. Unable to remove ligature, so re-ligated and dropped back.	360	Aut. No. 525(1920) Right kidney and ureter normal. Left kidney was one-half the size of the right, with a thin cortex of kidney tissue and full of cloudy fluid. Both kidney and ureter were matted in adhesions. Left ureter enlarged and tortuous to point of ligation, normal below. Impossible to demonstrate any lumen at point of ligation. Condition was evidently one of infected hydronephrosis with perinephritic infection and partial absorption of the kidney contents.

Table 5. (continued)

Experiment No. (1919)	Ureter ligated.	Ligature not removed or failed to remove.	Condition of operated ureter and kidney.	Duration of experiment days.	Autopsy.
780	11-18	12-2	Hydroureter and hydronephrosis. Unable to remove ligature so religated and returned.	310	Aut. No. 489 (1920) Right kidney and ureter normal. Left kidney was a very large uninfected hydronephrotic sac with a large dilated ureter.
679	10-8	10-23	Large tortuous hydroureter and large hydronephrosis. Unable to remove ligature.	180	Aut. No. 155 (1920) Right kidney and ureter normal. Left kidney a large infected hydronephrotic sac with a large ureter also full of pus. Marked peri-nephritic infection.

. . . .

REPORT OF CLINICAL CASES OF PYOURETER.

That a diseased ureter can cause later complications after nephrectomy has been recognized by urologists though reports of cases seem to be difficult to obtain. Fowler reported a case of pyoureter after nephrectomy due to calculus in the ureter, and referred to Israel as having reported four cases of "empyema of the ureter" as a complication occurring following a total of nine hundred nephrectomies. Fowler's case was particularly interesting in that he observed the intermittent expulsion of thick pus from the ureteral meatus, thus establishing the fact that the ureter is capable of peristaltic contraction after nephrectomy. To these reported cases can be added three more from the records of the last three years of the Mayo Clinic, in each of which the ureter required removal after nephrectomy. The main

points of interest in these cases are as follows:

Case 1 - Mrs. H.L. No. 312821, age 37, registered April 10, 1920.

The patient gave the history of successful removal of a stone from the left kidney in 1915, with relief of symptoms until one year later, when recurring attacks of kidney colic began and have persisted to date. X-ray of the left kidney area showed several shadows, and cystoscopic examination revealed a large infected hydronephrosis with a functionless kidney. Nephrectomy was performed April 26, 1920, which was followed by an uneventful convalescence. On April 5, 1921, the patient returned complaining that for the last two months there had been a swelling and soreness in the region of her operation. X-ray of the left kidney area showed a shadow, 2x3 cm., opposite the third lumbar vertebra, and that a lead catheter, introduced at cystoscopic examination impinged against this shadow. There was no secretion from the left meatus. A diagnosis of stone in the left ureter, with ureteritis and abscess formation, was made and operation advised. At operation, April 11, 1921, the ureter was found distended with pus above a point completely blocked with a calculus, and there was marked peri-ureteral inflammation. Three inches of the ureter, to a point below the obstruction, was removed. The patient was discharged April 30th with a healed wound.

Case 2 - Mr. B.A.R. No. 165955, age 61, registered first in July 1916, at which time a large left pyonephrotic sac, containing about 4 litres of pus, was removed piece meal. After one month the wound was healed and dry. The patient returned in June 1920 with the statement that his health had been excellent until within the last six months when he began to have daily fever and noticed a swelling in the left flank. At the second operation, June 29, 1920, a large abscess in the left kidney area was drained but no kidney tissue found. Following this operation the patient went home with a discharging pus sinus. He returned in March, 1921, with the sinus still draining pus and com-

plaining of pain in the left side. X-ray of the kidney area, with barium injected into the sinus, showed a large pocket and outlined the left ureter almost to the bladder. On cystoscopic examination an impassible obstruction was met just within the meatus. No secretion or drainage from the left meatus was seen and the bladder was normal. At operation, March 22, 1921, the left ureter was found enlarged and distended with pus, and with a large abscess pocket at the upper end which contained a stone. The ureter was successfully removed to a point just above the bladder wall.

Case 3 - No. 295363, Miss H. J., age 29, registered October 3, 1919. This patient gave the history of a right pyonephrosis which was removed elsewhere in April 1917. Six months later she began to have at intervals of from two to three weeks attacks of severe pain in the right kidney area, which were apt to be followed by the passage of cloudy urine. In April 1919 she developed a high fever and a constant severe pain in the right flank which was relieved by the incision into and drainage of an abscess in the kidney area. Since this operation there has remained a sinus which drains pus. X-ray of the kidney and bladder areas showed a shadow in the lower right ureteral area. On cystoscopic examination the bladder was normal, and no secretion or drainage from the right meatus seen. On passage of a ureteral catheter obstruction was met just above the meatus which was passed with difficulty and with the characteristic grating that is given by a calculus. Thick pus was withdrawn from the ureteral catheter after the obstruction had been passed. A urterogram showed a dilated ureter with the original shadow included. The diagnosis of a stone in the lower right ureter with pyoureter was made and operation advised. At operation, Nov. 12, 1919, a large infected ureter distended with pus and with an abscess at the upper end was found. The entire ureter, including the portion just above the bladder wall which contained a stone measuring  $1 \times 1 \times \frac{1}{2}$  cm. was removed. This patient was discharged in three weeks with a dry healed wound.

Pyoureter requiring surgical intervention after nephrectomy is rare and is usually due to stone in the ureter which prevents escape of the ureteral contents. The fact that the ureteral lumen is seldom so completely blocked by a calculus that the ureteral contents can not gradually escape would account for the small number of cases reported. However, when the lower ureter is ligated with silk, as in bladder resections, and a later nephrectomy is required, the possibility of a pyoureter developing should be considered. This fact had been recognized by Hunt of the Mayo Clinic, who on one occasion, at time of removal of an acute septic kidney which developed following ligation of the lower ureter with silk, provided for drainage of the ureter by insertion of a catheter into the ureter, bringing it out through the wound.

#### DISCUSSION

The experimental results obtained in the hydroureters and pyoureters depended entirely upon whether the ureteral contents were evacuated or not. When drainage occurred the distended ureter became smaller, through collapse of the lumen and atrophy of the muscle coat, and peri-ureteral inflammation did not occur. When obstruction to drainage was present, the muscular hypertrophy remained and absorption of the ureteral contents seemed very limited if occurring at all. Infection of the ureteral contents if not present at the time of nephrectomy occurred later in some instances, and always spread through the ureteral wall to cause peri-ureteritis. Peri-ureteritis was present in every pyoureter in some degree varying from inflammatory adhesions to abscess formation. This would indicate that drainage of the ureteral contents should be provided for at time of nephrectomy if there is known or doubtful complete obstruction to such drainage into the bladder.

Atrophy of the muscular wall of the normal ureter after nephrectomy was a finding which was to be expected as it simply represents the atrophy of disuse



from the lack of any stimulus to ureteral contraction. Likewise the gradual atrophy of the hypertrophic muscle, which had developed in the attempt to overcome the obstruction to the outflow of the ureteral contents, would seem a natural occurrence after the obstruction had been removed and the ureteral contents drained.

The greater muscular hypertrophy found at long periods after nephrectomy in the walls of the ureters with complete obstruction to the evacuation of their contents would indicate that muscular hypertrophy increased after nephrectomy in such cases. This would seem to be logical providing the blood and possibly the nerve supply of the ureter was not interfered with, as the stimulus to ureteral peristalsis would be present as long as the ureter was distended with the fluid contents. Such must have been present in the case which Fowler reported where he observed over three years after nephrectomy the intermittent forcing of tooth paste pus into the bladder. This case differed from the experimental cases in that there was some escape of the ureteral contents with each peristaltic wave, and brings up the question whether peristalsis persists when the lumen is distended and when there is no escape of contents with the contraction. Whether nephrectomy was performed or not would not effect the persistence of peristaltic contractions of the ureter after the point had been reached when the kidney ceased secreting urine, as the ureter is not dependant on the kidney for stimulus to contraction except as it supplies the urine. The degree of muscular hypertrophy obtained in the complete obstruction experiments of group 2 and 3 would seem to indicate that peristalsis continues as long as there is stimulus supplied by ureteral contents, though this hypertrophy was not equal to that usually seen in experimental work, such as the transplantation of ureters, where there is partial obstruction to the lumen of the ureter. These findings would seem to warrant the conclusion that the hypertrophic hydroureter or pyoureter, with complete obstruction to evacuation of

contents, will remain hypertrophic and atrophy will not occur in its muscular wall. This conclusion was substantiated by study of the walls of the ureter of the three clinical cases reported as in each of these there was marked muscular hypertrophy (see plates 13 and 14).

The persistence of the mucous membrane in all of the experiments from the atrophic normal ureter to the large distended pyoureter was noteworthy. Except for the ironing out by distension of the normal mucosal folds the membrane was intact in every case, though, in the infected cases, it had permitted the migration of the infecting agent through to the submucosa and muscular wall. This finding of normal appearing mucous membrane was also made in the ureters of the clinical cases reported (see plates 13 and 14).

#### CONCLUSIONS.

From these experiments and observations the following conclusions may be drawn:

1. In the normal ureter after nephrectomy there is no attempt made toward obliteration of the lumen by disappearance or atrophy of the mucous membrane, but there is a noticeable atrophy of the muscular coat.
2. Hydronephrosis developed in every case following production of complete obstruction of the ureter, the condition progressing unless the obstruction was removed to complete destruction of the kidney substance.
3. The ureter, after complete obstruction, becomes a hydroureter by distention of the ureteral lumen by the retained urine. A hypertrophy of the muscular layers, chiefly of the circular though also of the longitudinal layers occurs.
4. In the hypertrophic hydroureter or pyoureter with drainage of its contents after nephrectomy, the mucous membrane remains intact and the muscular coat gradually atrophies.
5. In the hypertrophic hydroureter or pyoureter with complete obstruction to drainage of the ureteral contents after nephrectomy, the mucous membrane

remains intact and the muscular coats remain hypertrophic.

6. Absorption of the contents of a distended ureter is very limited if it occurs at all.
7. If infection of the contents of the ureter is present it may spread through the wall and give rise to peri-ureteral infection and abscess formation.

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Plate 1. Experiment 671. Normal right ureter. X14.

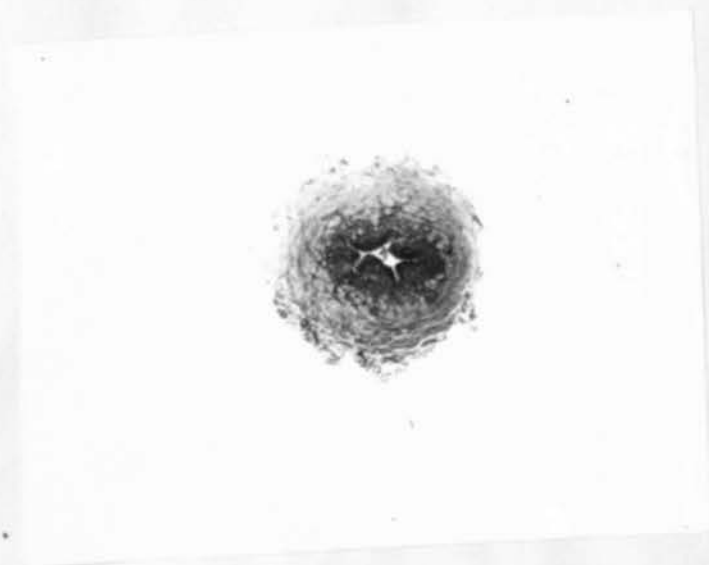


Plate 2. Experiment 671. Left ureter, showing muscular atrophy and normal mucous membrane. X14.



Plate 3. Experiment 695. Normal right ureter. X14.

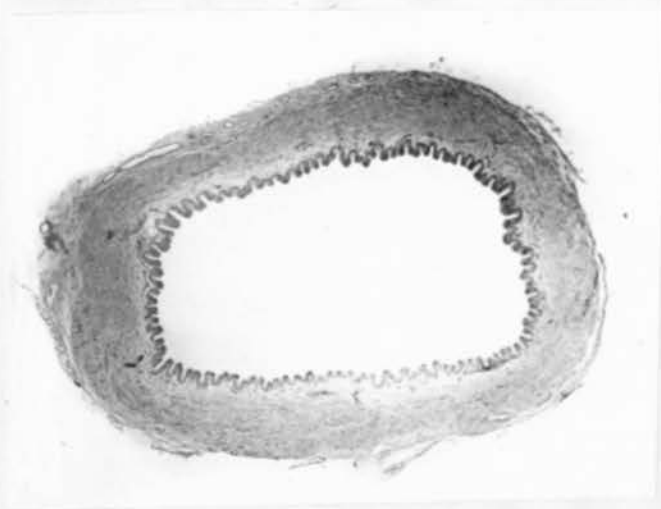


Plate 4. Experiment 695. Left ureter, showing normal mucosa and hypertrophic musculature. X14.

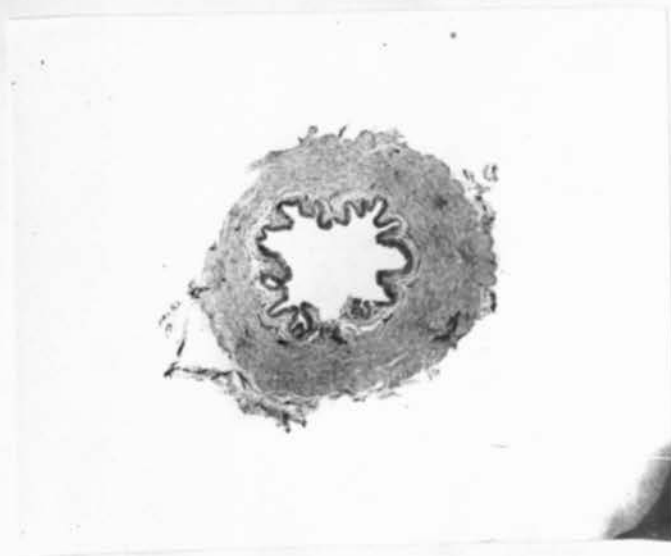


Plate 5. Experiment 598. Normal right ureter. X14

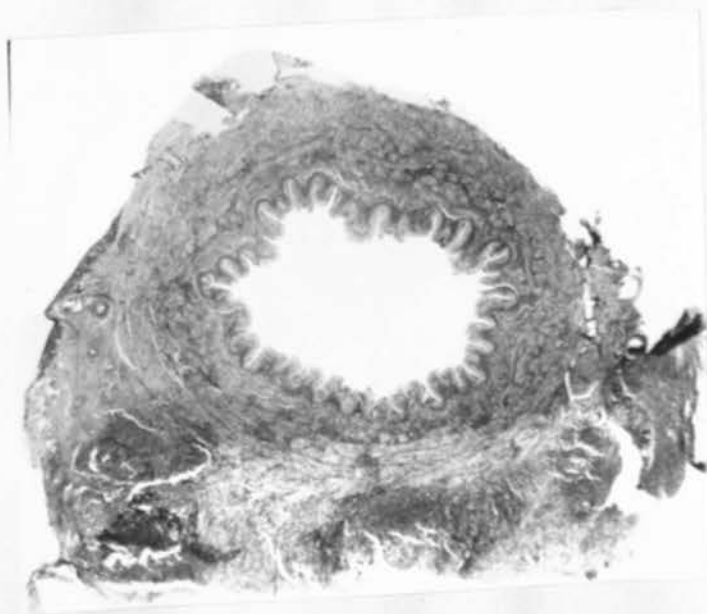


Plate 6. Experiment 598. Left ureter showing muscular hypertrophy, normal mucosa, and peri-ureteritis. X14.

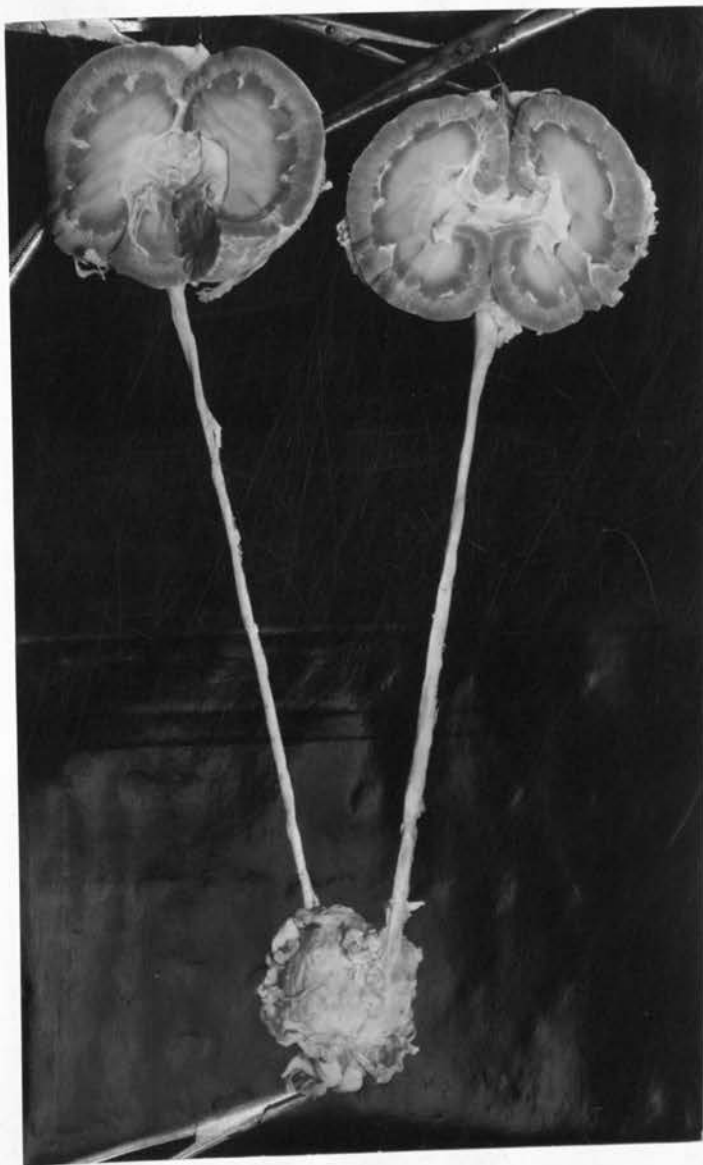


Plate 7. Experiment 712. Kidneys, ureters and bladder.



Plate 8. Experiment 679. Section of wall of left ureter, showing muscular hypertrophy. X14.

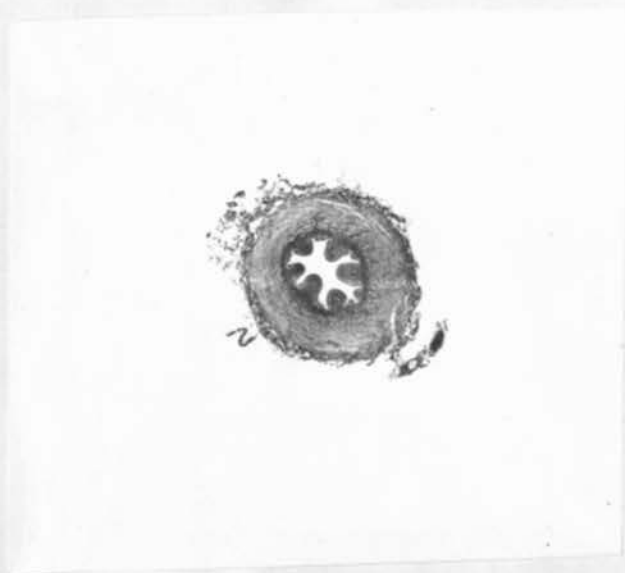


Plate 9. Experiment 678. Normal right ureter. X14.



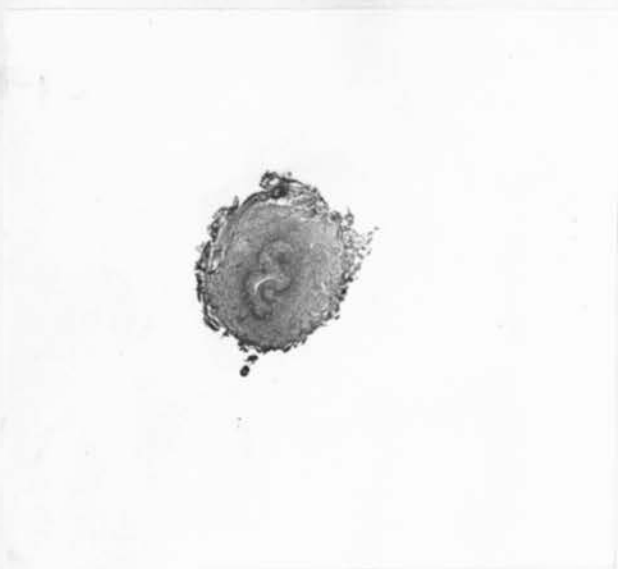


Plate 10. Experiment 678. Left ureter below point of complete obstruction, showing normal mucosa and musculature. X14.



Plate 11. Experiment 678. Left ureter above point of complete obstruction, showing normal mucosa and marked hypertrophy of the muscle layers. X14.

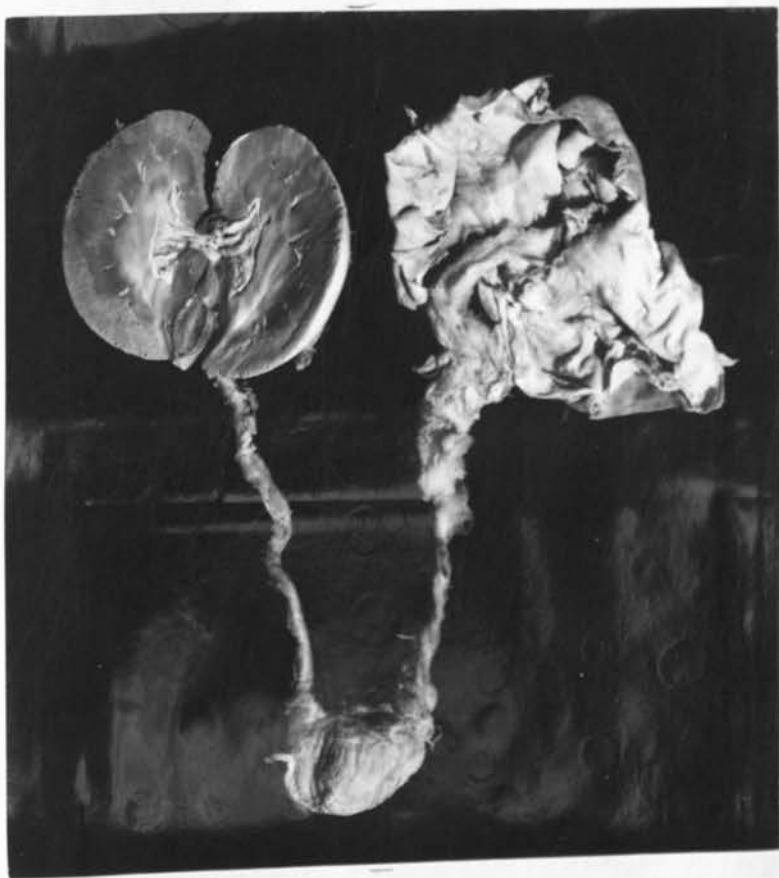


Plate 12. Experiment 678. Right kidney, left  
hydronephrotic sac, both ureters  
and bladder.

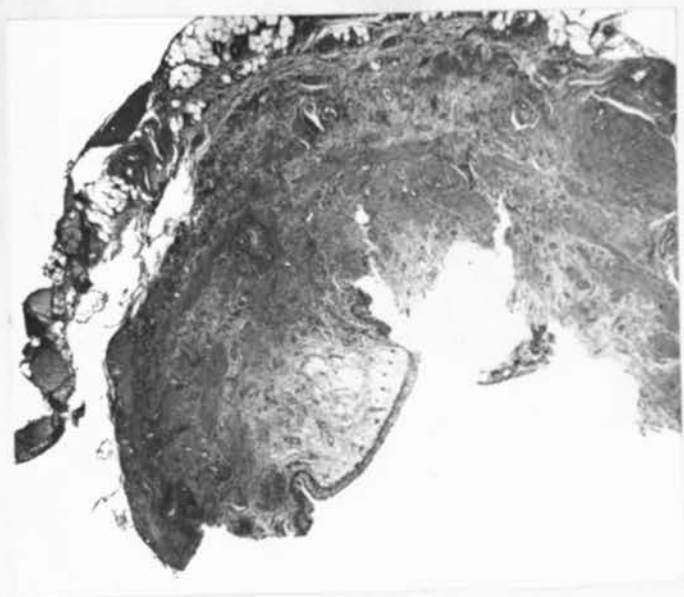


Plate 13. Clinical Case 2. (No. 165955) Section of ureter showing ureteritis, peri-ureteritis, and muscular hypertrophy, mucosa intact. X14.



Plate 14. Clinical Case 3. (No. 295363). Section of ureter showing muscular hypertrophy, peri-ureteritis, and intact mucosa. X14.