THE UNIVERSITY OF MINNESOTA

GRADUATE SCHOOL

Report

of

Committee on Examination

This is to certify that we the undersigned, as a committee of the Graduate School, have given James Albert Hughes Magoun final oral examination for the degree of

Master of Science in Surgery

We recommend that the degree of

Master of Science in Surgery

be conferred upon the candidate.

W. F. Braasch acting - Chairman

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Date May 16-1922

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REPORT

OF

COMMITTEE ON THESIS

The undersigned, acting as a Committee of the Graduate School, have read the accompanying thesis submitted by James Albert Hughes Magoun, Jr., for the degree of Master of Science in Surgery. 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 Surgery.

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THESIS

ABSORPTION FROM THE URINARY TRACT

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Submitted to the faculty of the Graduate School of the University of Minnesota in partial fulfillment of the requirements for the degree of Master of Science in Surgery.

March, 1922.

With the advance in our knowledge concerning the pathology, diagnostic methods, and treatment of the diseases of the urinary tract, the absorptive powers of its various portions have assumed a greater significance. The introduction of drugs into the urethra, bladder, ureters, or kidney pelvis, whether as opaque media, for roentgenology procedures, or as therapeutics agents, are noxious in proportion to their capability of causing local irritation in proportion to their toxicity, and to their absorbability. Again, through absorption, certain parts of this system, once infected, may be the source from which secondary or metastatic infection may occur. It was, therefore, notwithstanding that considerable experimentation has been performed on various phases of this problem, considered fitting to devote further study to absorption from this system.

In this research experiments have been conducted to determine whether certain dyes and bacteria can be absorbed from the kidney pelvis, ureter, bladder or urethra, and whether in some instances the conditions under which the bacteria pass are at all analagous to the pathological status found clinically.

Dogs were used in all the experiments. The animals were etherized at a constant ether tension. Their condition was kept as near normal as possible by the judicious use of heat, etc. In some of the experiments the blood pressures were recorded. All operative manipulations were carried out with the minimum of trauma and hemorrhage. The dyes used included phenolsulphonephthalein, indigo-carmine, and methylene blue. They were recovered in the urine, collected from one or both ureters depending upon the nature of the experiment. The urine was collected in white porcelain dishes. A drop or two of sodium hydroxide, 25 per cent, was placed in each dish when phenolsulphonephthalein was employed. Bacillus prodigiosus was the bacteria chosen, since

it is easily identified, since it probably never occurs spontaneously in the sites from which cultures were taken, and since it is rarely the cause of bacterial contamination in the laboratory. The bacillus was grown in dextrose broth or washed from agar slants, with sterile salt solution. The suspensions of either dyes or bacteria were injected by the gravity method or with a syringe, care being used to exert only the minimum amount of pressure. In using the gravity method a straight glass tube about 2.5 mm. in diameter was connected by a T-tube to a cannula inserted into the ureter or to a catheter inserted into the bladder, and to a graduated burette. The straight glass tube was graduated in cubic millimeters. A stop-cock was inserted on each side of the T-tube. The fluid containing the dyes or bacteria was placed in the burette and allowed to flow into the graduated tube to any desired height. Great care was taken to exclude air from the entire system and not to contaminate adjacent tissues. The time that the dye was introduced was carefully recorded and the urine was tested repeatedly for the dye. When bacteria were used the following procedure was also carried out. The dogs were killed with ether at the end of from two to three hours, and cultures taken from the heart's blood, the lungs, liver, spleen, inferior vena cava opposite the renal vein, right kidney cortex and medulla, and left kidney cortex and medulla. The cultures were made by planting from 2 to 5 cc. of blood and from 0.2 to 0.5 cc. of the tissue juice of the various organs into tall tubes of glucose broth. The material from the tissues was obtained by aspirating the macerated particles and juice into sterile pipets. The inoculated tubes were allowed to stand at room temperature for from forty-eight to ninety-six hours. The positive cultures were then plated on plain agar. In many of the experiments the fluid to be injected was warmed to 35°C. before injection.

In order to avoid confusion, it would seem best to consider the absorption from the various components of the urinary system separately.

I. Absorption from the pelvis of the kidney.

A. Literature.

In 1872 Treskin concluded that urea having been excreted by the kidneys, may enter the blood or lymphatics from the urinary passages. Albarran, in 1889, was among the first to investigate experimentally the infections of the blood stream through the kidney. He produced infection in the blood stream by introducing Bacillus pyogenes into the ureter. His work was without previous bacteriologic control of the blood, however, and in many cases peritonitis occurred. He traced the organism from the bladder to foci of infection in the kidney. "From these foci the organisms go into the connective tissue and then penetrate into the blood vessels, enter the circulation, and lead to far off emboli." P. Bazy says "on injecting a cocain solution (1/1) into the ureter of a rabbit it will ascend to the kidney and death ensue". Lewin and Goldschmidt assert definitely that absorption occurs from the kidney. Nikolaus Waschetko considers that in the anatomic integrity of the kidney the kidney epithelium as well as the epithelium of the excretory ducts from the kidney is without doubt permeable. Lepine and Boulard in a resume of their work, believe that a partial resorption of sugar occurs in the tubules of the normal kidney.

Burns and Swartz do not believe that absorption takes place from the pelvis of the kidney under normal conditions. If an acute pyelitis occurs, however, absorption, and the clinical phenomena of chills and fever result. These authors consider such clinical manifestations as due to the absorption of urine and bacterial toxin either from the blood vessels or lymphatics of the renal pelvic mucosa directly, or from the urine and bacterial toxins retained in the uriniferous tubules. They do not suggest, however, that these clinical symptoms may be due to the passage of the bacteria through the kidney into the blood stream, thus causing a bacteremia. In their later work, after the injection, by the gravity or syringe method, of indigocarmin and india ink

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particles into the previously ligated ureter, they found these substances in the opposite kidney, in the liver, lungs, and spleen. They then conclude: "It is reasonable to suppose that if particles of ink can travel in this manner, bacteria and other foreign substances can do likewise."

Macht states that certain drugs or poisons may be absorbed through the kidney pelvis. Weld has shown with what ease certain drugs may be absorbed from the renal pelvis, and the untoward action of some of them. Weld also demonstrated that phenolsulphonephthalein and brillian t green (?) were quickly and readily absorbed when injected in small amounts, (1/1½ cc) into the kidney pelvis. Kidd has recently stated that the renal pelvis is a highly sensitive absorbing surface, not only for bacterial poisons, but for chemical poisons such as cocain.

B. Experimental work.

Four series of experiments were performed on the kidney, one in which phenolsulphonephthalein was injected, and three in which the Bacillus prodigiosus was employed.

Series I. In one experiment a low right rectus incision was made. The right ureter was isolated and ligated at its junction with the bladder. A small ureteral catheter was then placed in its upper portion and ligated there. The wound was closed. The dog was then turned on his right side and a left lumbar incision made. The left ureter was exposed at its junction with the kidney pelvis. A small ureteral catheter was introduced into the pelvis and held there by a purse-string suture. Through this 1½ cc. of phenolsulphonephthalein was injected. The catheter was then withdrawn and the purse-string suture tied. Care was taken to avoid soiling and no appreciable pressure was used while injecting. The urine collected from the right ureter gave the characteristic reaction for phenolsulphonephthalein in twenty minutes and continued to be excreted over a period of two hours. This experiment was

not repeated because the results were very conclusive and had been previously confirmed by Weld.

To determine whether bacteria may be absorbed, three series of experiments were performed:

Series 2. In the second series, through a lumbar incision a cannula was inserted into the left ureter from 2 to 4 cm. from the pelvis of the kidney. A twenty-four hour broth culture of Bacillus prodigiosus was then permitted to flow into the pelvis at from 10 to 30 cm. pressure. From two to three hours afterward the dogs were killed with ether and cultures made as outlined above. Results are shown in Table II. In twelve experiments even with this low pressure, Bacillus prodigiosus was recovered from the blood stream or other organs in three instances. It was found in the left kidney in all but two of the experiments.

Series 3. The procedure in the third series was the same as in the second, with the exception that the pressure at which the organisms were passed into the ureter was increased to from 60 to 78 cm. Results are shown in Table III. At this pressure, which was slightly less than the secretory pressure of the kidney, the organisms were recovered from the blood stream or other organs in six of seven experiments, and they were recovered from the left kidney in all.

Series 4. In the fourth series in addition to the procedure followed in series 2 and 3, a cannula was inserted into the right ureter 4 cm. above the bladder; to the cannula was attached a straight glass tube. The cannula inserted into the left ureter was also 4 cm. above the bladder. A forty-forty-eight hour broth culture of Bacillus prodigiosus and washings from forty-eight hour agar slants were placed in the buret and allowed to flow into the left ureter, while the pressure was kept under 21 cm. The tubing connected with the cannula in the left ureter was then clamped. The femoral vein was

isolated, and from 100 to 150 cc. of a 5 per cent sodium sulphate solution were injected slowly. The secretory pressure of the right kidney was measured in the graduated tube connected with the right ureter. After from two to three hours the routine procedure as previously described was carried out. The organisms were introduced under a very low pressure and the intrapelvic pressure was subsequently increased by stimulation of the kidney. The results are shown in Table IV. In four of these five experiments, Bacillus prodigiosus was recovered in other organs than the kidney.

Conclusions: It may be concluded, therefore, that certain dyes and bacteria are readily absorbed from the pelvis of the kidney.

II. Absorption from the ureter.

A. Literature.

The literature on this phase of the problem is quite limited. Bazy considers that the ureter has little absorbing power. Lewin and Goldschmidt and Cohnheim think that absorption occurs from the ureters. Weld in two experiments in which one and one-half cc. of phenolsulphonephthalein were injected into the ureter found that there was no absorption of the dye. Macht on the other hand has shown that certain drugs may easily be absorbed from the ureter.

B. Experimental work.

Two series of experiments were performed. In the first a right lumbar incision was made, exposing the ureter at its junction with the kidney pelvis. A ligature of fine silk was then placed about the ureter at this point, taking care to avoid injury to its blood supply. The wound was closed. The animal was then turned on its back and a low right rectus incision made into the peritoneal cavity. The left ureter was isolated at its junction with the bladder and a small ureteral catheter ligated in its upper portion. The lower right ureter was next found and a ligature placed about it (avoiding the blood supply). The ureter was opened, a small ureteral catheter introduced for 1 to

2 cm. into its upper portion and the ligature tightened about it but not tied. Varying amounts of phenolsulphonephthalein or indigocarmine were then injected through this catheter. The catheter was removed and the ligature tied tightly. The operative area was well packed off to avoid soiling. The wound was closed. The urine from the left ureter was collected in the usual manner. The results are shown in Table V. Absorption occurred in six of the seven experiments.

In the second series bacteria were used, and a similar technique was employed, with the exception that the left ureter was not disturbed. Cultures were taken as usual. The results are shown in Table VI. In only one of the five experiments were the organisms recovered, i.e. in spleen and vena cava.

Conclusions: We may conclude, therefore, that certain dyes are readily absorbed from the ureter and that certain bacteria may be.

III. Absorption from the bladder.

A. Literature.

For many years there has been a controversy among physiologists as to the absorbing power of the normal bladder. One group of experimenters considers that the normal bladder does not absorb, while another group states definitely that it does. The majority of these investigators agree that the acutely inflamed bladder absorbs to some extent. Macht has recently shown that the bladder absorbs certain drugs poorly. R. Shoji concludes that the epithelial layer of the bladder in the living animal is permeable to water and sodium chloride under physiological conditions.

For an extensive review of the literature on absorption from the bladder, the reader is referred to an article by Mann and Magoun which will appear shortly.

B. Experimental work.

All experiments were performed upon dogs. The animals were

maintained under constant ether anesthesia throughout the period of experimentation. Water was administered by stomach tube three to four hours previous to the beginning of the experiment in order to insure a flow of urine. The bladder and ureters were exposed through a low median incision. Constancy in regard to the amount of dye in the bladder was secured by either one of two methods: In one series of experiments the solution in the bladder was kept under a constant pressure. In this series, No. 1, both ureters were ligated and sectioned at their point of entrance into the bladder. This was for the purpose of collecting urine. A hard catheter was inserted into the urethra (all dogs in this series were females), and held firmly in position by a ligature placed on the bladder side of the urethral sphincter. A glass T-tube as described above was attached to this catheter. The dye was allowed to flow from the burette until the pressure in the bladder as shown by the level in the straight glass tube reached a definite point. In the other series, No. 2, the urethra was ligated so that the dye could not reach the urethral mucosa. One ureter was ligated and sectioned at its point of entrance into the bladder. The other ureter was ligated about 2. cm. from its point of entrance into the bladder and a ureteral catheter passed in for almost 1½ cm. The dye was injected with a syringe through this catheter into the bladder. The catheter was held by a purse string suture which was tightened after its removal. An amount of dye was injected into the bladder equal to about 20 per cent of its capacity.

In each series of experiments a ureteral catheter was inserted into each ureter pointing toward the kidney in order to collect the urine. The results of these two series are shown in Tables VII and VIII. The dyes were absorbed to a slight degree from both the normal and the acutely inflamed bladder.

Series 3. Female dogs were used in all the experiments. Light ether anesthesia was maintained. A steel catheter was placed into the

bladder and the urine expressed. A small low midline incision was made and a double ligature passed around the catheter at the juncture of the bladder and the urethra; each ureter was then firmly ligated. At variable pressures a dextrose-broth culture of Bacillus prodigiosus of approximately forty-eight hours was allowed to flow into the bladder. Cultures were taken as usual.

The experiments may be divided into three parts. In the first series of eleven experiments the bladder was normal and the solution was injected under low pressures. In the second, of two experiments, the bladder wall was normal but a pressure of from 30 to 40 cm. of water was employed. In the third, of four experiments, an acute cystitis had been produced a few hours earlier by the injection of tincture of cantharides. The results of the experiments are summarized in Table IX. In experiments VI and VIII respectively high intravesical pressure was used. Acute cystitis was produced in experiments 7, 9, 11 and 13. In all the other experiments the bladder mucosa was normal and the pressure was low.

These experiments show that there is little absorption from the bladder.

IV. Absorption from the Urethra.

A. Literature.

Claude Bernard in 1857 found that intoxication ensued when he injected curare into the urethra of dogs. Alling noted that the healthy urethra is capable of absorbing medicinal substances injected into it. Pousson and Segalas assert that absorption takes place from the prostatic urethra. Maas and Pinner believe there is absorption from the normal urethra, but if the urethra is diseased, absorption may be greater or less than in the normal. Cohnheim, Phelip, Walsh and Bazy admit absorption from the urethra. Macht has shown that certain drugs are easily absorbed from the urethra and Kidd considers the urethra to possess a great absorbing power.

B. Experimental work.

Series 1. Male dogs under a constant ether anesthesia were employed in these experiments. A low right rectus incision was made, the bladder was drawn up and a double ligature placed about the urethra at its junction with the bladder. A small ureteral catheter was ligated in the upper portion of each ureter. The abdominal wound was closed. A purse-string suture was then placed about the external urethra and a No. 10 French soft rubber catheter was introduced into the urethra for about 1½ cm. and the purse-string suture tightened on this. Then from 2 to 4 cc.of the dye was injected slowly into the urethra through the catheter exerting a minimum amount of pressure. The catheter was withdrawn and the purse-string suture tied. Care was taken to avoid soiling about the prepuce. The urine from both ureters was collected as usual. The results of this series are given in Table X. In five experiments the phenolsulphonephthalein or indigocarmine appeared in the urine from one or both kidneys in four cases. The discrepancy in the appearance time of the dye in the four positive experiments is probably due to the delayed secretion of urine in two of them.

Series 2. When bacteria were injected into the urethra, a similar technique was employed with the exception that the catheters were not placed in the ureters and that cultures were taken after two to three hours as in the preceding experiments. The results are given in Table XI. In only one of five experiments were the bacteria recovered, and in this case they were found in the bladder urine.

We may conclude that both dyes and bacteria may be absorbed by the normal urethra.

Discussion

We see from a review of the above experiments that the absorptive powers of the various portions of the urinary tract differ. The

kidney absorbs dyes and bacteria to a marked extent. The ureter and urethra absorb the dyes readily but the bacteria less so. The bladder on the other hand shows a very small degree of absorbability for the dyes and none for the bacteria.

From a clinical standpoint, absorption from the urinary tract is of importance in several ways. In the introduction of drugs into the urethra, ureter or renal pelvis for whatever cause, the possibility that their absorption may occur and lead to dire results should always be borne in mind.

What influence can this absorbability have on the various dyes which are commonly used as indicators of renal function ? It has been suggested that if the bladder is capable of absorbing to any great extent, the retention of the urine (containing the excreted dye) in the bladder over a period of two hours might lead to reabsorption of this urine and an unreliable phenolsulphonephthalein estimation. As it has been distinctly shown that the bladder has little absorbing power, this can probably never occur. On the contrary, any lesion or deformity which would lead to a retention of the dye-containing urine in the ureter or pelvis of the kidney, might result in the absorption of this urine and an apparent low phenolsulphonephthalein output. As an example of this, the following case is cited.

Case 359632, Mr. E. M., aged 21, came to the clinic February 23, 1921, complaining of a painless hematuria. At the onset of his illness, September 1920, hematuria was slight and intermittent; recently it had been more severe and constant. For eight years he had had a slight dull backache referred to the lumbar area.

Roentgenograms revealed multiple shadows in the left kidney. On cystoscopic examination the catheter encountered an obstruction in the left ureter 2 cm. above the meatus. There was no return of phenolsulphonephthalein from the left kidney. Operation revealed a large hydronephrotic sac, with a

capacity of about 10 to 12 oz., containing multiple round stones. Approximately one-half of the normal amount of kidney tissue remained; the ureter was not dilated.

In this case there was an indefinite form of obstruction at the ureteral pelvic junction. A large amount of renal tissue remained. The diminished output of the phenolsulphonephthalein in the presence of so large an amount of renal tissue, may be explained in several ways: 1. by dilution of the dye by fluid in the renal pelvis; 2. by reflex inhibition of secretion caused by the presence of the stones, and 3. last but not least in importance, the reabsorption of the dye from the kidney pelvis.

It has been suggested that in cases of pyelitis, the clinical phenomenon of chills and fever may be due to the absorption of urine and bacterial toxins. In the last few years the fact that the bacteria themselves may be absorbed from the urinary tract into the blood stream and result in a bacteremia, has received more attention. Braasch has noted that a reaction following cystoscopy occurs much more frequently in male patients than in female. He attributes this to the absorption of bacteria through the prostatic urethra. Crabtree in nine cases of prostatic hypertrophy admitted to the hospital with sterile urine and then placed on an inlying catheter, took blood cultures during or soon after the chills which these patients developed. Organisms belonging to the colon group were recovered in seven of the nine cases. He considers that infection took place by way of the prostate from infection of the prostatic urethra from the inlying catheter. In conclusion Crabtree says, "One cannot deny that a pyelonephritis might be the source of a blood infection in the cases in which I have recovered the colon bacillus from the blood. Yet in the one case in which sufficient data was obtained to allow concludions, blood infection was apparently primary".

Panton and Tidy recovered the colon bacillus from the blood of two patients who were apparently suffering from pyelonephritis. Kidd in discussing these cases, says, "Bacteria cannot be found in the blood except during the rigor in these cases of pyelitis. * * * * Further work is needed on this subject. I feel certain that it will be proved that a rigor means in every case a temporary and cursory invasion of the blood stream with some microorganism". Braasch has found that when a ureteral catheter is passed into the kidney pelvis, one occasionally notes that the patient develops chills and fever. He thinks that it is presumable to suppose in this type of case that bacteria carried to the renal pelvis by the ureteral catheter may pass back through the kidney and infect the blood stream. I have taken cultures during the chill in nine cases of pyelonephritis and one of epididymitis, complicating prostatic hypertrophy. In the nine patients with pyelonephritis, organisms were recovered from the blood in six cases. Two of these could be definitely identified as the colon bacillus and one was definitely the bacillus pyocyaneous. One was a gram negative bacillus resembling a colon bacillus. Another was a diphtheroid gram positive bacillus, and the last was a staphylococcus albus. The last two organisms were considered to be contaminations. There were four negative cultures including the one from the case of epididymitis.

In the experimental portion of this paper, no attempt has been made to study absorption under pathological conditions, and whether it would be greater or less is problematical. Again the path by which absorption takes place has not been dealth with. In general one may assume that the absorption occurs through the blood and lymphatics with the former exerting the greater influence.

CONCLUSIONS

1. Certain dyes and bacteria can be absorbed from the normal kidney, ureters and urethra.

2. A small amount of dye can be absorbed from the normal and acutely inflamed bladder.

3. Bacteria could not be recovered in the blood stream or various organs after injection into either the normal or acutely inflamed bladder.

4. In considering the relative absorbability, the kidney would seem to have the greatest absorptive power, with the urethra second and the ureter third.

5. It would appear that both experimentally and clinically, bacteria may pass from the kidney pelvis into the blood.

6. In certain clinical cases, the kidney, once infected, may act as a focus for a secondary bacteremia.

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Table I, Series 1.

ABSORPTION FROM THE KIDNEY

Experiment	Condition of kidney	Dye used	Amount of dye injected, cc.	Appearance of dye	Apparent amount of dye
107	rt. normal kidney	phenolsulphonephthalein, no dilution.	1	in 20 min. from left ureter	large

Table II, Series 2.

ABSORPTION FROM THE KIDNEY

Experiment	Pressure above kidney pelvis, Cm. of water.	Positive cultures of Bacillus prodigiosus
550-19	20 to 30	1. Renal vein 2. Left kidney cortex 3. Left kidney medulla
560-19	20 to 30	1. Left kidney medulla
562-19	20 to 30	1. Left kidney cortex 2. Left kidney medulla
565-19	10 to 30	1. Heart blood 2. Liver 3. Renal vein, A and B
592-19	20 to 30	All cultures negative
618-19	20 to 30	1. Left kidney cortex
620-19	20 to 30	1. Left kidney cortex
630-19	20 to 30	1. Left kidney cortex 2. Right kidney cortex
649-19	20 to 30	1. Left kidney cortex
654-19	20 to 30	1. Left kidney cortex
657-19	20 to 30	1. Left kidney cortex
666-19	20 to 30	All cultures negative

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Table III, Series 3

ABSORPTION FROM THE KIDNEY

Experiment	Pressure above kidney pelvis cm. of water.	Positive cultures of Bacillus prodigiosus
531-19	78	1. Left kidney cortex 2. Left kidney medulla
534-19	70	1. Heart blood 2. Right kidney 3. Liver 4. Renal vein?
704-19	60	1. Lung 2. Renal vein, A and B 3. Heart blood, A and C 4. Right kidney cortex 5. Left kidney cortex 6. Right kidney medulla 7. Liver, A and B 8. Spleen
800-19	60	1. Renal vein 2. Left kidney cortex
801-19	60	1. Liver, A and B 2. Renal vein, A, B and C 3. Heart blood, A, B and C 4. Spleen 5. Right kidney cortex
802-19	60	1. Liver, A and B 2. Spleen
803-19	78	1. Heart blood, A, B and C 2. Renal vein, 1 and 2 3. Liver, 1 and 2 4. Left kidney cortex

Table IV, Series 4

ABSORPTION FROM THE KIDNEY

Experiment	Pressure in left ureter, cm. of water	Pressure in right ureter, cm. of water	Positive cultures of Bacillus prodigiosus
739-19	20	65	1. Lung 2. Heart blood, A, B and C 3. Renal vein, A and B 4. Liver 5. Right kidney cortex 6. Left kidney cortex
756-19	20	64	1. Renal vein 2. Liver 3. Left kidney cortex
760-19	20	78	1. Liver 2. Left kidney cortex
804-19	20	50	1. Heart blood 2. Left kidney cortex
805-19	20	65	All cultures negative

TABLE V, Series 1

ABSORPTION FROM THE URETER

Experiment	Condition of ureter injected	Dye used	Amount of dye injected cc.	Appearance of dye	Apparent amount of dye	Comments
62	Normal left ureter	Phenolsulphonephthalein no dilution	1	In ten minutes from right ureter	Large	In this experiment the ureteral catheter was placed into ureter from the inside of bladder and the ureteral orifice closed by double purse-string suture after removal of catheter; there was some soiling in bladder.
69	Normal left ureter	Phenolsulphonephthalein no dilution	0.5	In nine minutes from right ureter	Large	One ureter was slightly distended at postmortem.
78	Normal left ureter	Phenolsulphonephthalein no dilution	0.25	Negative	Negative	The blood vessels were injured at the upper portion of ureter; slight leakage
87	Normal right ureter	Phenolsulphonephthalein, no dilution	0.25	In nine minutes from left ureter	Large	
107	Normal right ureter	Indigocarmine, no dilution	0.25	In thirty minutes from left ureter	Fair	Questionable interference with blood supply of ureter
125	Normal right ureter	Phenolsulphonephthalein, no dilution	0.25	In two minutes from left ureter	Large	
171	Normal right ureter	Phenolsulphonephthalein, no dilution	0.25	In thirty minutes from left ureter	Large	

Table VI, Series 2

ABSORPTION FROM THE URETER

Experiment	Amount of fluid culture injected, c.c.	Condition of ureter	Culture for Bacillus prodigiosus
144	0.375	Normal right ureter	Negative
149	0.25	Normal right ureter	Negative
150	0.5	Normal right ureter	Negative
161	0.33	Normal right ureter	Positive in 1. spleen 2. vena cava
233	0.33	Normal right ureter	Negative

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Table VII, Series 1

ABSORPTION FROM THE BLADDER

Experiment	Pressure in bladder of water, cm.	Condition of bladder	Dye used	Appearance of dye	Apparent amount of dye
234	7	Acute	Phenolsulphonephthalein, 5 cc, besides 25 cc. culture B. prodigiosus	Twenty-six minutes after injection	Small
236	7	Acute	Phenolsulphonephthalein, 5 cc. besides culture B. prodigiosus	None	
268	8	Normal	Phenolsulphonephthalein, 5 cc. besides culture B. prodigiosus	Trace from right ureter in eight minutes; from both ureters in fifteen minutes.	Fair
275	7	Normal	Phenolsulphonephthalein, 5 cc. besides culture B. prodigiosus	From right ureter in fifty minutes; from left in sixty-five minutes	Trace
276	7	Normal	Phenolsulphonephthalein, 5 cc. besides culture of B prodigiosus	From left ureter in fifty-five minutes; none from right	Small
339	7	Normal	Phenolsulphonephthalein, indigocarmine-- 10 cc.	Indigocarmine from both ureters in fifteen minutes; trace after one hour and thirty minutes. NaOH added and phenolsulphonephthalein present in urine from both ureters	Phenolsulphonephthalein large; Indigocarmine large .
351	10	Normal	Indigocarmine 10 cc. besides culture B prodigiosus	From both ureters in twenty-three minutes	Large
361	7	Normal	Phenolsulphonephthalein diluted 1-6 with water 5 cc.	From both ureters in sixteen minutes	Small
363	7	Normal	Phenolsulphonephthalein diluted 1-6 with water	From both ureters in sixteen minutes	Trace
403	12	Normal	Phenolsulphonephthalein diluted 1-6 with water (13 cc.)	From both ureters in fifteen minutes	Small amount quantitative estimation about 1 per cent

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Table VII, Series 1, (continued)

ABSORPTION FROM THE BLADDER

Experiment	Pressure in bladder of water cm.	Condition of bladder	Dye used	Appearance of dye	Apparent amount of dye
403 (continued)					phenolsulphonephthalein excreted from both ureters in two hours.
412	12	Normal	Phenolsulphonephthalein diluted 1-6 with water. (18 cc)	From right ureter in twenty-five minutes. None from left. Left kidney found absent at necropsy.	Quantitative estimation about 2 per cent phenolsulphonephthalein excreted from right ureter in two hours
421	12	Normal	Indigocarmine 5 cc.	From both ureters in thirty minutes	Small
672-20	15	Normal	Methylene-blue diluted 1-4 with water - 10 cc.	From both ureters after two hours	Trace
673*	12	Normal	Methylene-blue diluted 1-2 with water - 27 cc.	From both ureters in twenty-eight minutes.	large

*Bladder filled with high pressure, then pressure lowered.

Table VIII, Series 2

ABSORPTION FROM THE BLADDER

Experiment	Condition of bladder	Dye used	Amount of dye injected cc.	Appearance of dye	Apparent amount of dye	Comments
18	Normal	Phenolsulphonephthalein - diluted 1-4 with water.	20	From both ureters in twenty-five minutes	Fair	
85	Normal	Phenolsulphonephthalein - diluted 1-3 with water.	40	"	Trace	
100	Acute	Phenolsulphonephthalein - diluted 1-3 with water	30	From right ureter in thirty minutes; from left in sixty minutes	Large	
875 (1921)	Normal	Phenolsulphonephthalein - diluted 1-24 with water.	30	None	None	Injection of the dye into peritoneal cavity. No return. Poor secretion of urine.
925 (1921)	Normal	Phenolsulphonephthalein - diluted 1-4 with water	45	None	None	Poor secretion of urine. 1 cc of phenolsulphonephthalein given intravenously; no return.

Table IX, Series 3

ABSORPTION FROM THE BLADDER

Experiment	Pressure in bladder cm. of water	Condition of bladder	Cultures for Bacillus prodigiosus
1	2	Normal	Negative
2	2	Normal	Positive in bladder wall only
3	3	Normal	Positive in bladder wall only
4	3	Normal	Negative
5	1	Normal	Negative
6	30-40	Normal	Negative; bladder wall purple-red
7	7	Acute	Negative
8	30-40	Normal	Negative
9	7	Acute	Negative
10	6	Normal	Negative
11	3	Acute	Negative
12	7	Normal	Negative
13	7	Acute	Negative
14	8	Normal	Negative
15	7	Normal	Negative
16	7	Normal	Negative
17	10	Normal	Positive in bladder wall only

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Table X, Series 1

ABSORPTION FROM THE NORMAL URETHRA

Experiment	Condition of urethra	Dye used	Amount of dye injected, cc.	Appearance of dye	Apparent amount of dye	Comments
49	Normal	Phenolsulphonephthalein-no dilution	3	In about forty-five minutes urine from both ureters	Fair	
58	Normal	Phenolsulphonephthalein-no dilution	2	In both ureters in five minutes	Large amount. Quantitative estimation 2.5 per cent in two hours	Slight pressure used when injecting
59	Normal	1. Indigocarmine--no dilution. 2. Phenolsulphonephthalein - no dilution.	1. 3 indigocarmine. 2. 2 phenolsulphonephthalein. 3. 4 phenolsulphonephthalein	Negative for one hour Negative for one-half hour From both ureters in thirty minutes	Negative Negative Large	Between Procedure 2 and 3, 2 cc. of fluid withdrawn from urethra by pressure.
61	Normal	1. Phenolsulphonephthalein - no dilution. 2. Indigocarmine - no dilution.	1. 3 2. 2	1. From both ureters in six minutes. 2. From both ureters in fourteen minutes	Large amount quantitative estimation 2. per cent in three hours. Large amount.	Fluid withdrawn from urethra by catheter and syringe between 1 and 2. Slight soiling of phenolsulphonephthalein about prepuce. No soiling with indigocarmine.
78	Normal	Indigocarmine--no dilution.	2	Negative	Negative	Phenolsulphonephthalein was placed in left ureter and there was no secretion. (Table V.)

Table XI, Series 2

ABSORPTION FROM NORMAL URETHRA

Experiment	Amount of fluid culture injected cc.	Culture for Bacillus prodigiosus
125	1.5	Negative
171	3	Positive in bladder urine
213	4	Negative
221	3	Negative
226	4	Negative
239	4	Negative

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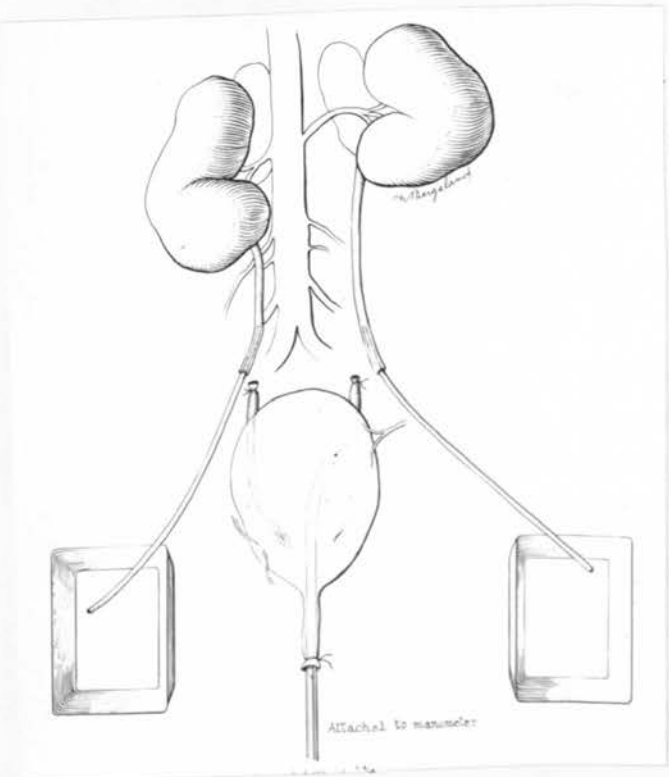

Figure 1. Method of introducing dyes into the urinary bladder under constant pressure.

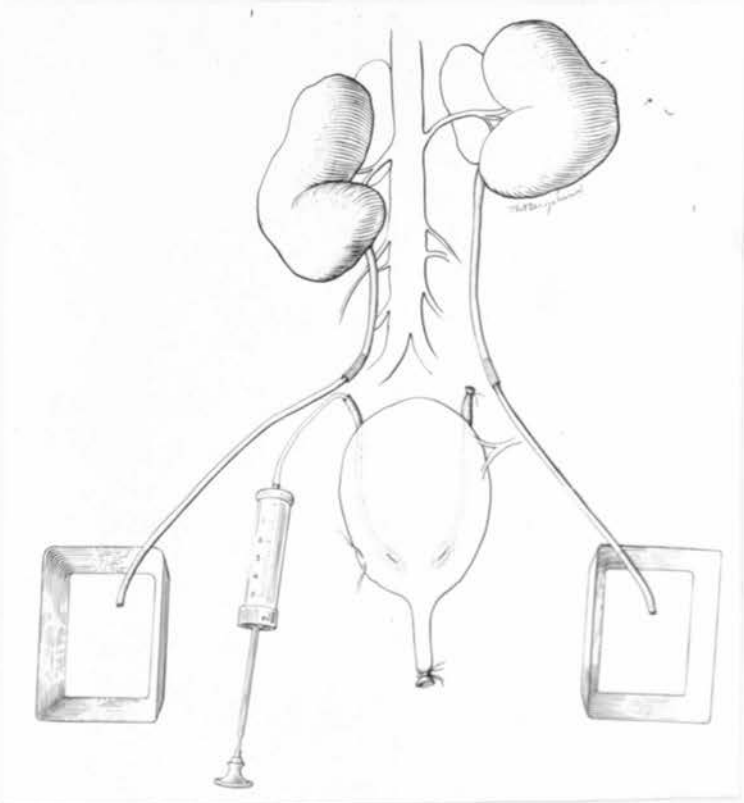

Figure 2. Method of introducing a given amount of dye into urinary bladder.

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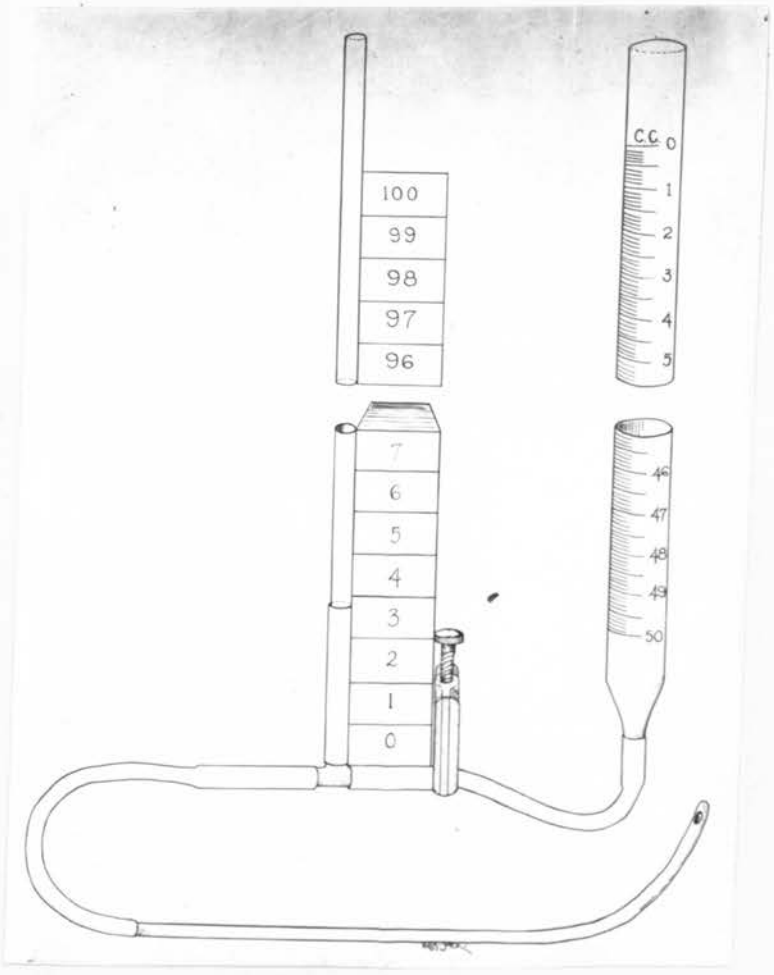

Figure 3. Manometer.