U. M.

THE UNIVERSITY OF MINNESOTA

GRADUATE SCHOOL

Report

of

Committee on Thesis

The undersigned, acting as a Committee of the Graduate School, have read the accompanying thesis submitted by **Edward H. Weld** 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.

W. F. Braasch
Chairman

C. H. Rowntree

Wm Carpenter MacCarty

May 31 1918 L. L. Mann

P. D. Carman

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 Edward H. Weld 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.

Minneapolis, Minnesota

May 31 1919

W. F. Braasch
Chairman

A. C. Beckwith

E. T. Bye

C. G. Rountree

B.O. 91

APR 15 1920

25 3574

THESIS

RENAL ABSORPTION WITH PARTICULAR REFERENCE TO PYELOGRAPHIC MEDIUMS

Edward Howland Weld

Submitted to the Graduate Faculty of the University of Minnesota in partial fulfillment of the requirements for the Degree of Master of Science in Surgery

May, 1919.

RENAL ABSORPTION WITH PARTICULAR REFERENCE TO PYELOGRAPHIC MEDIUMS

This study concerning the absorption of different substances from the kidney pelvis was originally undertaken for the purpose of determining, first, the effect of different substances used in pyelography on the kidney tissue, and second, the gradual development of a hydronephrosis as demonstrated by means of the x-ray.

The dangers of pyelography have been thoroughly discussed in the literature of the last ten years. Braasch and Mann (1916) in a study of the various substances used in pyelography, give valuable data well supported by experimental work on the effect of all substances used up to that time. Since then Cameron has brought out the use of potassium and sodium iodid as an opaque medium when used in pyelography. In a later article on the same subject Cameron and Grandy further advocated the use of this medium. In 1918 I investigated the advisability of using sodium bromid for pyelography; my findings at that time suggested the desirability of further observation of the effect of the newer pyelographic mediums on the kidney.

All the dangers incident to pyelography have resulted from, (1) the use of insoluble mediums, (2) the use of mediums which were poisonous when absorbed, and (3) the injection of the mediums under too great a pressure. That pyelographic mediums may reach the circulation is well known to all investigators. The literature is filled with reports on the use and danger of silver substances.

The means by which these substances are conveyed to the circulation have not been discovered, and to my knowledge nothing has been published concerning the absorption from the kidney pelvis.*

The problems that have developed in the course of this work are:

1. Is it possible to note the gradual development of a hydronephrosis by means of successive radiographic examination?

2. How long are pyelographic mediums retained in the kidney pelvis?

3. What are the effects of retention of pyelographic mediums?

4. Are pyelographic mediums or other substances absorbed from the kidney pelvis and, if so, in what manner?

5. Do hydronephrotic kidneys allow any absorption from their dilated pelves?

6. Will substances in the blood stream or in the intestinal tract enter the pelvis of a kidney which has a ligated ureter with or without a hydronephrotic sac?

7. By what channels does absorption from the blood streaminto the kidney pelvis or from the kidney pelvis into the blood stream take place?

The anatomy and physiology of the kidney are briefly discussed with relation to their bearing on the subject of this work.

---

* When this research work was practically completed Burns and Schwartz published an article on absorption from the renal pelves in hydronephroses due to permanent and complete occlusion of the ureter. Because they found India ink that had been injected into the pelvis in the glomeruli and tubules they state that, "the path of absorption is by way of the tubules and through the capillaries of the glomeruli". They also state that they found India ink in the glomeruli of the opposite kidney as well as in the spleen and liver. We have repeated this experiment with similar results but we do not feel that they are justified in their conclusion that the path of absorption is by way of the tubules to the glomeruli because the India ink is also found in the glomeruli of the opposite kidney; this proves that the ink was in the circulation, and if it gets into the glomeruli of one kidney by way of the circulation it may also get into the glomeruli of the injected kidney by the same route.

The kidney is not a typical secretory gland. It develops mainly from the coelom and is therefore of mesodermal origin, while ordinary glands develop from either the ectoderm or endoderm. The entire organ is a good example of a compound tubular gland. It is made up of a number of divisions or lobes which are well-marked in the fetal kidney (Fig. 1) but which later fuse to form a smooth surfaced organ. On logitudinal section, the divisions may easily be distinguished. In Figure 2 may be noted a fibrous capsule made up of two layers, an outer layer which is easily removed in a normal kidney and which becomes adherent to the fat and subcutaneous tissue at the hilum, and an inner fibromuscular layer which is intimately fused with the connective tissue of the kidney substance and which dips in between the lobules. This somewhat diagrammatic sketch by Brödel shows a dense cortical layer of tissue which equals one-third the width of the kidney substance, and an inner medullary portion which demonstrates more of the lobular division of the kidney and occupies two-thirds the thickness of the organ. The cortex extends varying distances into the medulla and these extensions separate the tubules into pyramids. The cortical extensions are known as renal columns, or columns of Bertin; they contain the blood vessels of the kidney. The pyramids contain groups of tubules which open into the calyces of the pelvis of the kidney. There are usually eight of these pyramids but the number may vary.

The kidney is composed of a large number of units, each of which is formed by a long branched tube, closed at one end, which runs three times across the substance, beginning in the cortical area and terminating in the calyces of the kidney (Fig. 3). The closed end of the tubule is supposed to be dilated in the form of a sphere into which a tuft of blood vessels grow; the whole is called a malpighian corpuscle (Fig. 4). The invaginated end of the tubule is known as the capsule; it opens into the tubule which twists and doubles at first and which is known as the proximal convoluted tubule. It then runs in a straight line toward the pelvis of the kidney (descending limb) where it doubles back (the loop of Henle) in a straight course to the neighborhood of the capsule where it

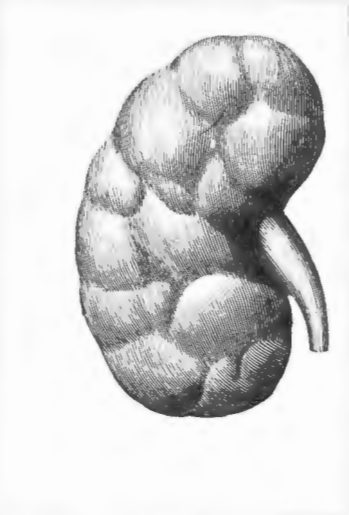
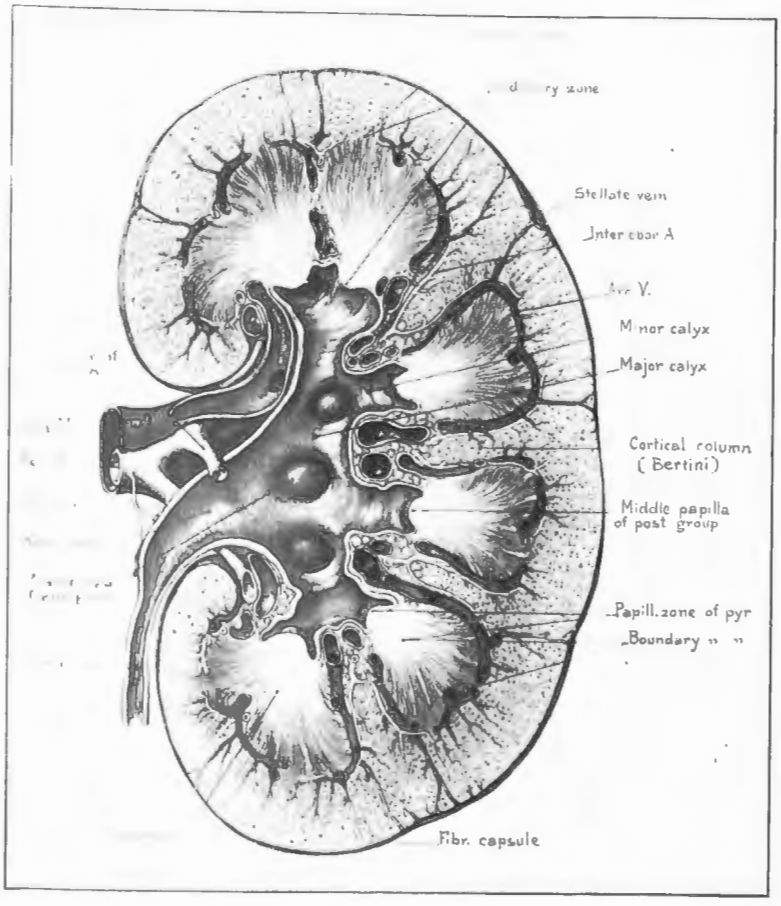
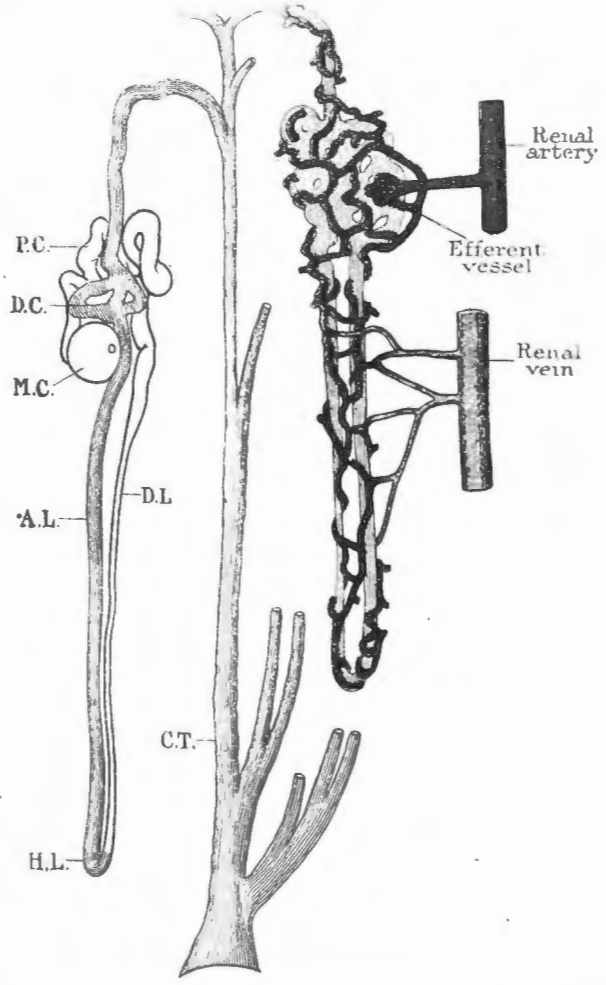


Fig. 1. Fetal kidney.
Showing lobulation.



LONGITUDINAL SECTION THROUGH HUMAN KIDNEY, SHOWING GROSS ANATOMY.

Fig. 2.



On the left the tubule is drawn after a diagram of G. C. Huber's. The tubule is outlined from the capsule to the loop of Henle and is shaded from that point to the end of the collecting tubule. On the right a diagram of the circulation is added : M.C., Malpighian corpuscle ; P.C., proximal convoluted tubule ; D.L., descending limb ; H.L., loop of Henle ; A.L., ascending limb ; D.C., distal convoluted tubule ; C.T., collecting tubule.

Fig. 3.

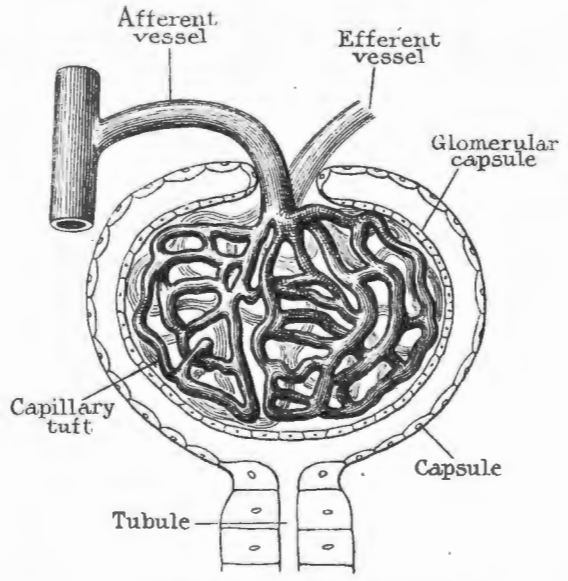
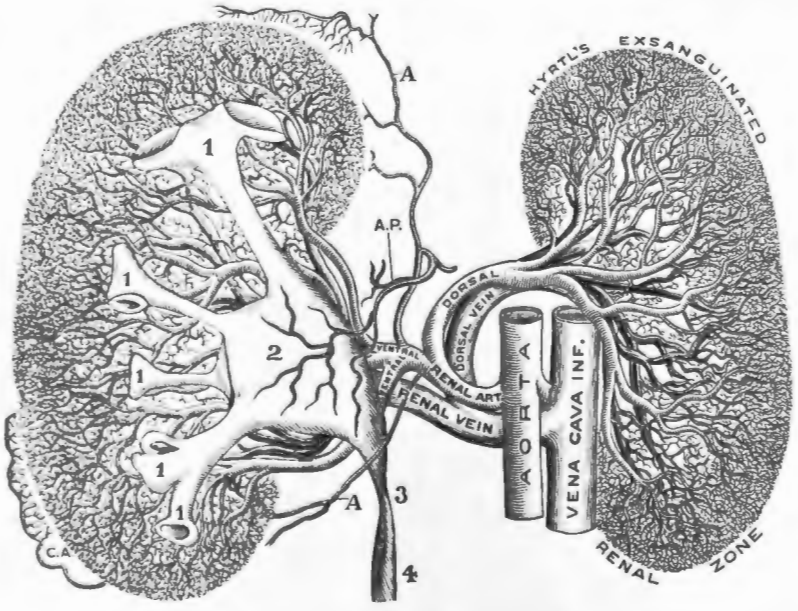


Diagram of Malpighian corpuscle.

Fig. 4.



Corrosion anatomy. The renal vascular blades opened like a book. (Byron Robinson.)

Fig. 5.

becomes tortuous again (the distal convoluted tubule) which joins with other collecting tubules to empty into the pelvis of the kidney on one of the pyramids by projection into one of the calyces known as a renal papilla.

The renal artery and vein enter the kidney at the hilum, the vein lying anteriorly and the pelvis posteriorly with the artery between them (Fig. 5). Branches are given off to the suprarenal body and to the ureter. Then the artery divides into anterior and posterior branches which radiate up between the pyramids. At the juncture of the cortex and the medulla, they turn at right angles and run parallel to the surface of the kidney, join with branches from neighboring pyramids and form an arc across the bases of the pyramids (Fig. 6). From these arches vessels pass into the cortical and medullary areas. Those to the cortex give off side branches which enter the capsule (the afferent arteries) which again break up into capillaries around the walls of the tubules, and are then collected into venules which coalesce to form the renal vein (Fig. 7).

In studying the circulation of the kidney by means of the x-ray, it appears that not enough attention has been given to the difference in the circulation between the medullary and cortical portions of the kidney. When the venous circulation is injected with an opaque medium (Fig. 8), the whole of the kidney is uniformly injected, the venous capillaries apparently being equal in number in both the cortex and the medulla. When the arteries are injected, however, about 90 per cent of the capillary circulation is in the cortex (Fig. 9). This leaves the medullary portion of the kidney with a large venous capillary system but a very small arterial system. Figure 10 shows an injection of the kidney pelvis which has extended up into the tubules of the medulla. There is abundant lymph supply and sympathetic nerve supply. Just what effect the nerve supply exerts, has not been fully determined. The work of Dederer and of Quimby in transplanting kidneys seems to indicate that the kidney can secrete normally without any nerve supply.

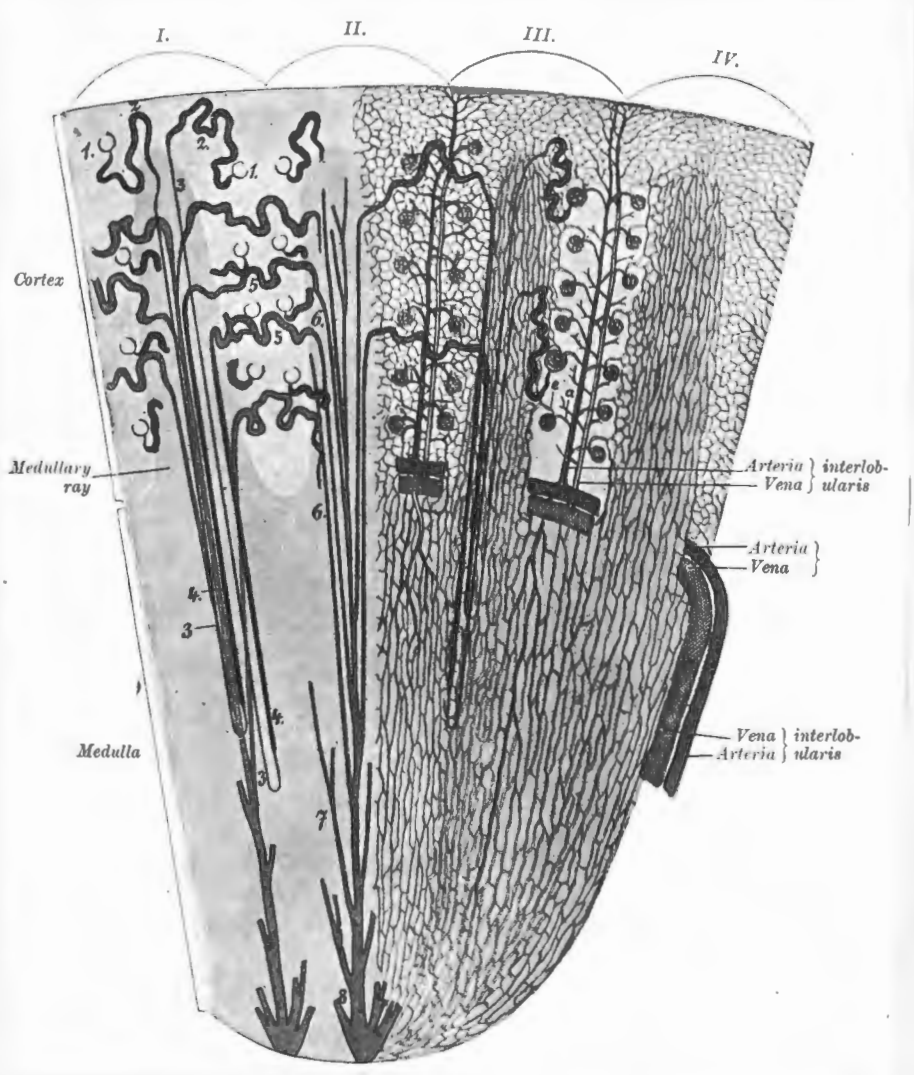


Fig. 6. Diagram of kidney circulation and tubular arrangement. From Gray's Anatomy.

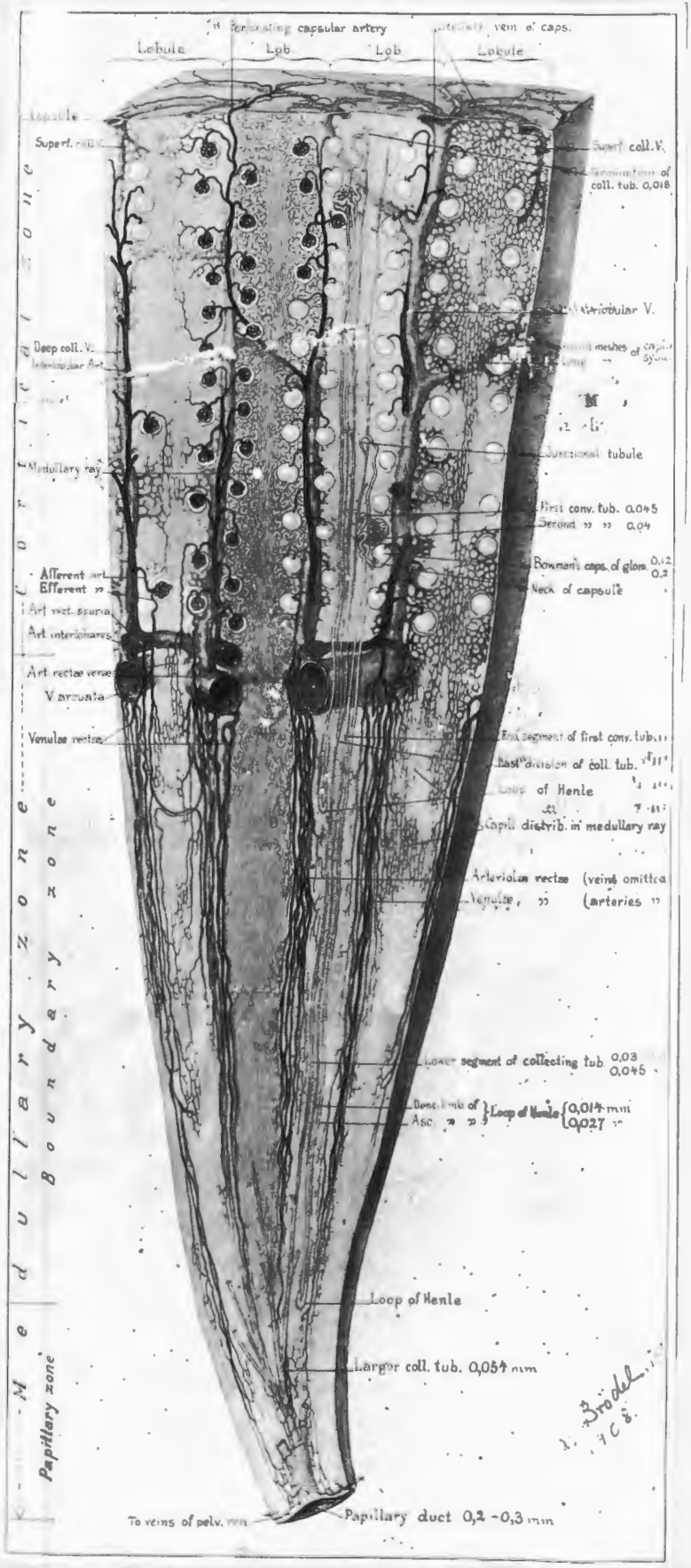
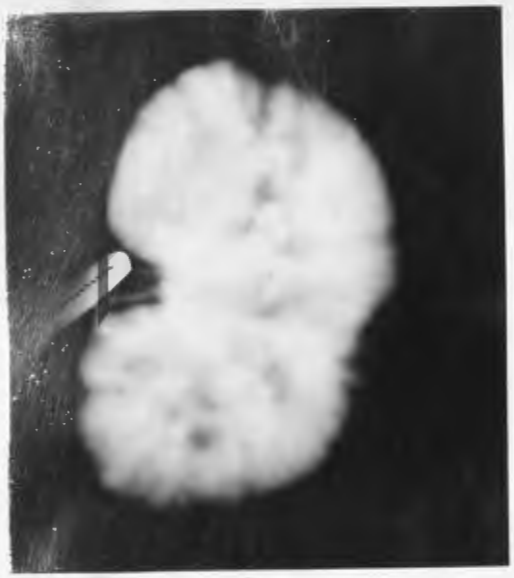
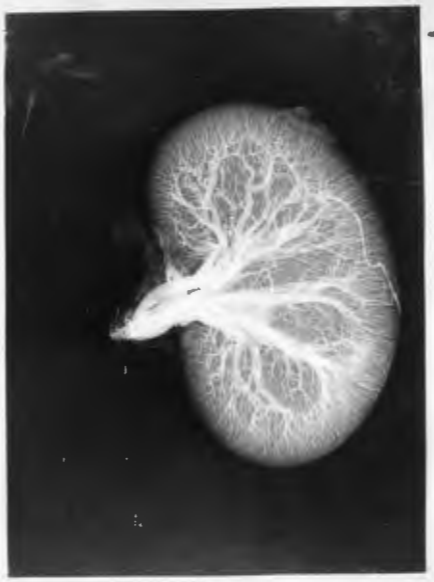


Fig. 7. Diagram of kidney circulation and tubular arrangement by Max Brödel.



A



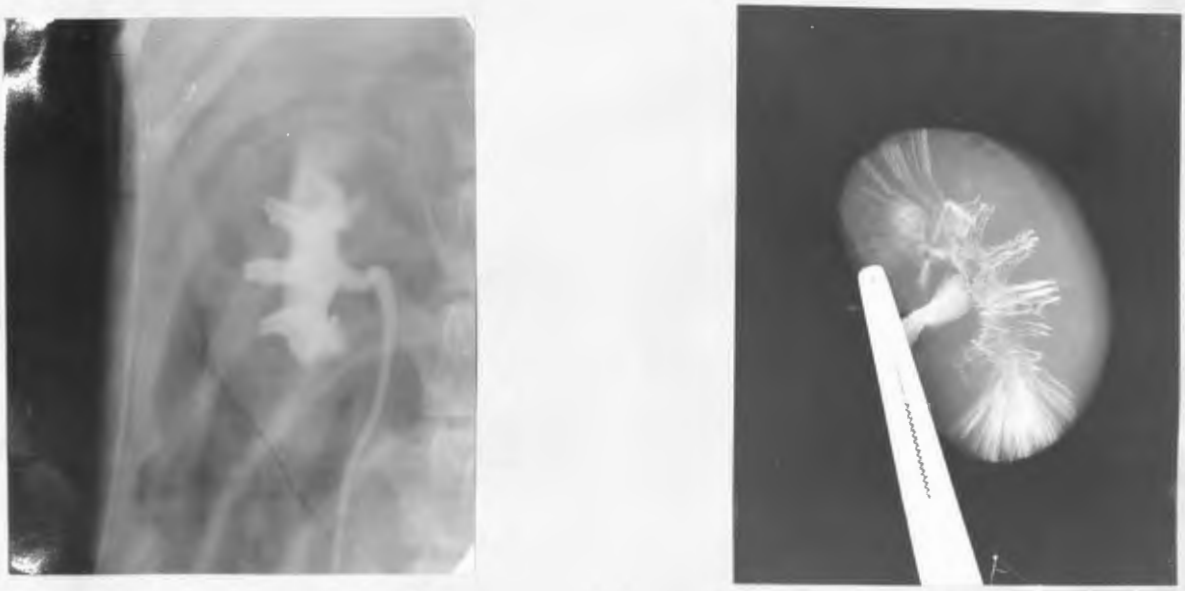
B

Fig. 8. Radiograph of an injection of the venous circulation of the kidney. A. Sodium bromid solution. B. Bismuth emmulsion with condensed milk.

A

B

Fig. 9. Radiograph of an injection of the arterial circulation of the kidney. A. Sodium bromid solution. B. Bismuth and sodium bromid.



A B

Fig. 10. Radiograph of an injection into the kidney pelvis .

A. 25 per cent sodium bromid solution.

B. Colloidal silver injected under pressure breaking through at the poles of the kidney.

From this complicated structure of arteries, veins, and tubules, various views concerning the secretion of urine which have been evolved have provoked much discussion during the last seventy-five years. One theory is known as the Bowman-Heidenhain theory. In 1842 Bowman, after observing the malpighian body, thought that water filtered through this and flushed out the urea which had been excreted in the solid form in the tubule. In 1874 Heidenhain, by experiments, supported this theory. He held that the constituents of the urine were excreted by vital activity of the epithelium of the capsule and tubules, that the glomerular capsule secreted water and those salts which accompanied water and that the convoluted tubules eliminated such solids as urea, uric acid, hippuric acid, etc. Cushny states: "This theory allows the renal cells a high degree of intelligence and mounts to little more than to state that the kidney secretes the urine by vital activity of the cells." The second theory is that of Ludwig, who two years after Bowman advanced his views, stated that the capsule is a filter which allows all the constituents of the plasma to pass, except the proteins, and that the tubules absorb some of the filtrate and return it to the blood by a process of diffusion. He explained the entire process by physical forces. On the basis of inadequate physical forces . the third or"modern theory" may be said to disprove Ludwig's views; it accepts the general scheme of filtration through the capsule of the glomeruli, supplementing it by the vital activity of the cells, especially of the tubules. Some cells of tubules may secrete and some may absorb.

Technic

Dogs (96) were used in all the experiments. The animal was anesthetized with ether and a lumbar incision was made with the usual surgical technic. The operation seemed to be facilitated if the lumbar region was elevated by means of a pad about three inches thick; this gave better exposure. The muscles were split down to the peritoneum, which was pushed forward; the ureter was located, drawn up and ligated, while care was taken not to disturb the blood

supply. The various solutions to be tested were then injected into the ureter which was again ligated about 1 to 2 cm. below the pelvis of the kidney. The ureter was divided between the two ligations. The wound was then closed and x-rays taken immediately afterward and at various intervals as long as any shadow of the kidney pelvis could be noted.

The solutions were injected with a piston syringe. As a rule, from 1.5 to 2 cc. were injected. It is known that this amount of fluid will penetrate somewhat into the tubules and that it will probably cause greater distention than if only enough to fill the kidney pelvis were used. As the same amount of all mediums was injected however, it was thought that they could be easily compared by this method even though the pressure was greater than would normally occur in doing pyelographic work. Furthermore, in ligating the ureter* we were not working under normal conditions. Nephrectomies were done on the 96 animals at intervals of from one hour to thirty days and the specimens were studied microscopically. A few of the kidneys were removed at necropsy when the dogs died of intercurrent disease. A number of the kidneys were tested physiologically for the urinary secretory pressure, and for absorption and others were used in perfusion experiments.

The gradual development of hydronephrosis observed by means of the x-ray.- In one series of dogs a 25 per cent solution of potassium iodid was injected in the kidney pelves, in a second series a 25 per cent solution of sodium bromid, and in a third series a 15 per cent solution of thorium nitrate was injected, and the ureter ligated below the point of injection. An x-ray was immediately taken, and followed by a second x-ray in twenty-four hours when it was

---

* In another series of experiments to be described later, the effect of these mediums will be studied under a constant known pressure of injection without the ligation of the ureter.

found that the shadow had entirely disappeared. Further experiments showed that a shadow was only faintly present in one hour after injection and that it was entirely gone in one and one-half hours. The shadow of thorium nitrate was slightly more distinct in one hour than that of sodium bromid or potassium iodid. Saturated solutions of sodium bromid and potassium iodid disappeared in approximately the same time. An insoluble medium such as colloidal silver solution of 25 per cent was very indistinct two hours after injection. Insoluble substances such as bismuth carbonate and barium sulphate, stayed indefinitely in the kidney pelvis however, but they had a tendency to settle in lumps so that a distinct outline of the kidney pelvis could not be well determined as the hydronephrosis developed.

In view of the fact that the pyelographic mediums are so readily absorbed, it does not seem practical to watch the gradual development of a hydronephrosis by means of the x-ray when the ureter has been ligated.

The effects of the retention of pyelographic mediums.-The substances tested were a saturated solution of sodium bromid and potassium iodid, a 25 per cent solution of sodium bromid and potassium iodid, a 15 per cent solution of thorium nitrate, a 5 per cent silver iodid emulsion, a 25 per cent colloidal silver solution, and a 25 per cent protargol solution. One and one-half to two cubic centimeters of these different mediums were injected into the kidney pelvis by the usual technic and at first the kidneys were removed in from five to thirty days after the injection. They were all hydronephrotic as was shown by gross and microscopic examination. A few of them were infected. The tissue showed mainly the effects of gradually developing hydronephrosis apparently identical to that in the tissue obtained when the ureter was ligated without the injection of any substance into the kidney pelvis. When a nephrectomy was done, one to three hours after the injection and ligation, the medullary tissue was congested and reddened. Microscopically, the medullary portion showed an acute congestion while the cortical portion was normal. This area of congestion is better shown

when methylene blue, eosin, or colloidal silver (Fig. 11) are injected into the kidney pelvis for these materials stain only the medullary portion, especially at the poles of the kidney. The unabsorbable mediums, such as colloidal silver, are apt to produce areas of cortical necrosis; silver iodid effects the tubules much more than it does the glomeruli. In a thirteen day kidney there was 90 per cent destruction of the tubule cells but only 5 per cent destruction of the glomeruli. This is possibly owing to the fact that the silver emulsion does not reach the glomeruli but stays in the tubules of the medullary portion. It is noticeable that in all the experiments very little effect was produced in the glomeruli, even when the tubules were almost totally destroyed. All substances used in pyelography, when retained, will in a certain percentage of cases produce a pyonephrosis. This will also occur occasionally when the ureter is only ligated and when no injection is made, a fact always to be taken into consideration in studying the effects of different pyelographic mediums. It is apparent that in experiments to determine the effect of pyelographic mediums on kidney tissue, too long a time elapsed after the injection of the medium into the kidney pelvis before the nephrectomy was done because the medium soon leaves the kidney, as is shown by x-ray. Any damage will be shown in an acute condition one or two hours after the injection.

The damage that is found when the kidney is taken out five or six days after the injection has been made, is probably due largely to the effect of the gradually developing hydronephrosis, unless of course an unabsorbable medium has been used. From the standpoint of effect on the kidney tissues, little if any difference will be found between the newer pyelographic mediums, sodium bromid, potassium iodid and thorium nitrate.

Experiments to determine the toxicity of the different substances have given surprising results. Inasmuch as it has not been known that pyelographic mediums could be absorbed rapidly, very little attention has been given to their toxic effects. In view of the knowledge gained from the experiments,

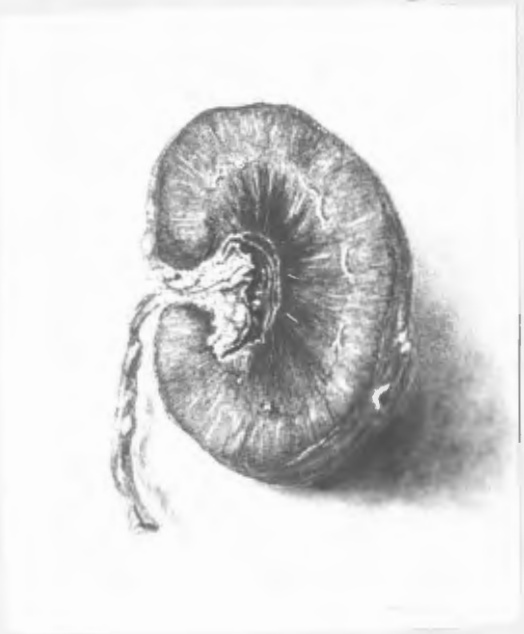


Fig. 11. Injection of kidney pelvis with methylene blue at 40 mm. mercurial pressure while the circulation was still intact. Nephrectomy ten minutes later.

however it seemed advisable to test the toxicity of the substances. For the details of these investigations see complete protocols of experiments. It was found that 2 cc. of potassium iodid injected into the vein even when it was injected very slowly, caused the immediate death of the animal (Figs. 12 and 13). It was also found that 5 cc. of a 12 per cent solution of thorium nitrate caused a toxic curve (Fig. 12) that a 10 cc. injection of thorium nitrate further emphasized its toxicity (Fig. 13) and that 22 cc. injected from a burette by gravity method caused the death of the animal (Fig. 14). The thorium used in the 5 cc. and in the 22 cc. experiment was taken from Bottle A, that in the 10 cc. experiment was taken from Bottle B. In another experiment thorium taken from Bottle C produced no ill effect even when 100 cc. were injected intravenously. In another experiment a solution taken from a freshly opened Bottle D that was purchased at the same time that Bottle C was purchased was injected into the vein of a dog and toxic effects could be noted by the time 25 cc. were injected. The injection was continued, the blood pressure gradually dropped, and the animal died in thirteen minutes after 50 cc. had been injected (Fig. 16). This animal weighed 10.4 kg. Just previous to this experiment a dog weighing 7.2 kg. had received in the same manner 55 cc. of sodium bromid intravenously in eleven minutes without causing any ill effects. In still another experiment 40 cc. of a 15 per cent solution of thorium nitrate taken from the freshly opened Bottle E caused the death of a dog which weighed 9 kg. The thorium was injected at the rate of 5 cc. per minutes; the first 20 cc. caused a gradual rise of blood pressure and then the blood pressure began to fall. The thorium from Bottle A was approximately a year old, that from Bottle B was four months old, the contents of Bottle C had just been received from the laboratory where it is manufactured.

Experiments with 5, 10, 30, and 50 cc. of a 25 per cent solution of sodium bromid injected slowly (3 cc. to 5 cc. per minute) intravenously produced no ill effect on the dog (Figs. 12, 13, and 15). Blood pressure and pulse curve seemed to be somewhat increased for a time. In view of these experiments, it is

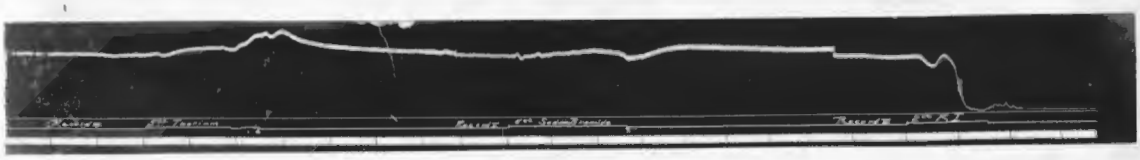


Fig. 12. Record I. shows the injection of 5 c.c. of thorium taken from Bottle A.
Record II. shows the injection of 5 c.c. of a 25 per cent solution sodium bromide.
Record III. shows the injection of 2 c.c. of a 25 per cent solution of potassium bromide.which rapidly caused the death of the dog.

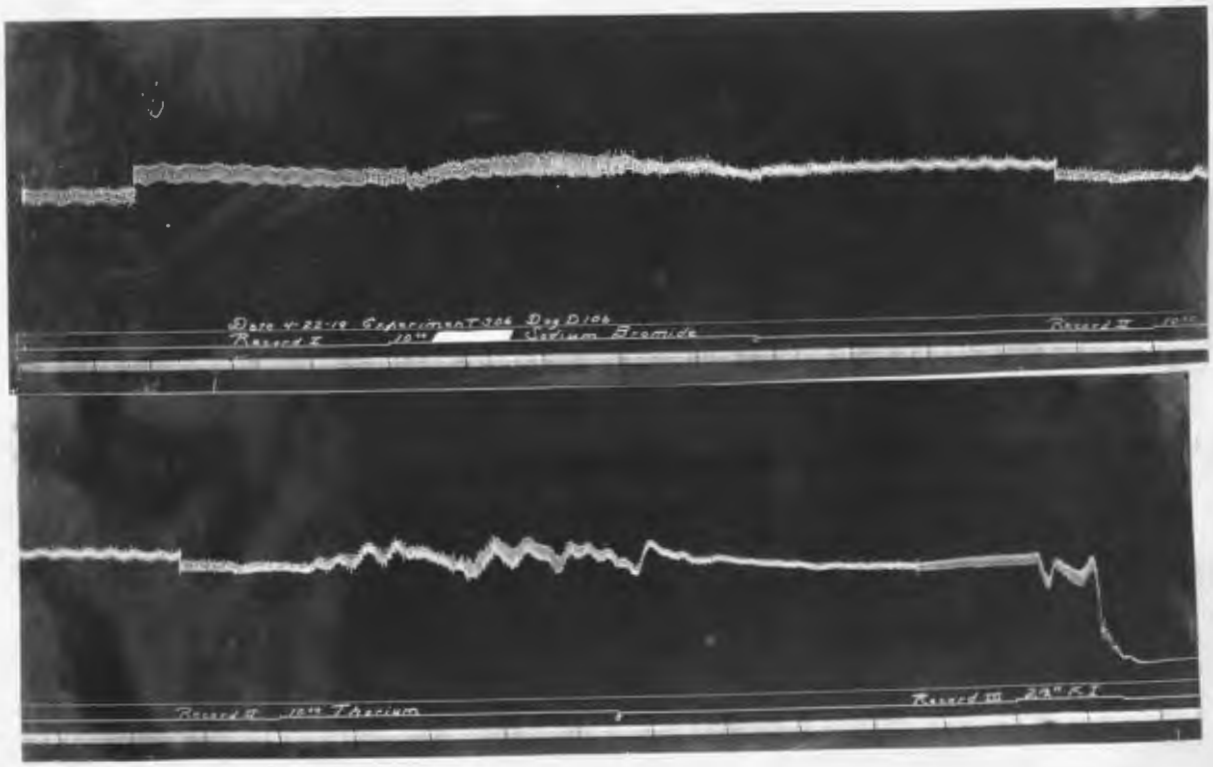


Fig. 13. Record I. Injection of 10 c.c. of 25 per cent sodium bromide.
Record II. Injection of 10 c.c. of 15 per cent thorium nitrate solution from Bottle B one year old.
Record III. Injection of 2.5 c.c. 25 per cent iodide solution which killed the dog.

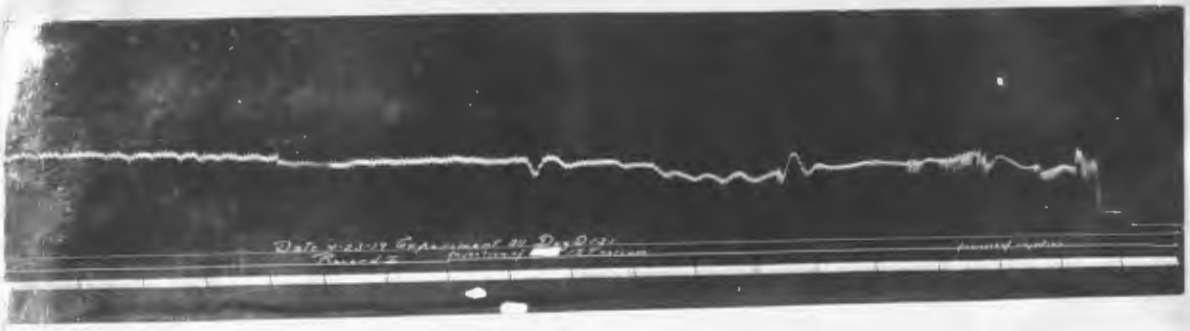


Fig. 14. Injection of 22 c.c. 15 per cent thorium nitrate solution which caused the rapid death of the dog. Solution taken from Bottle B.

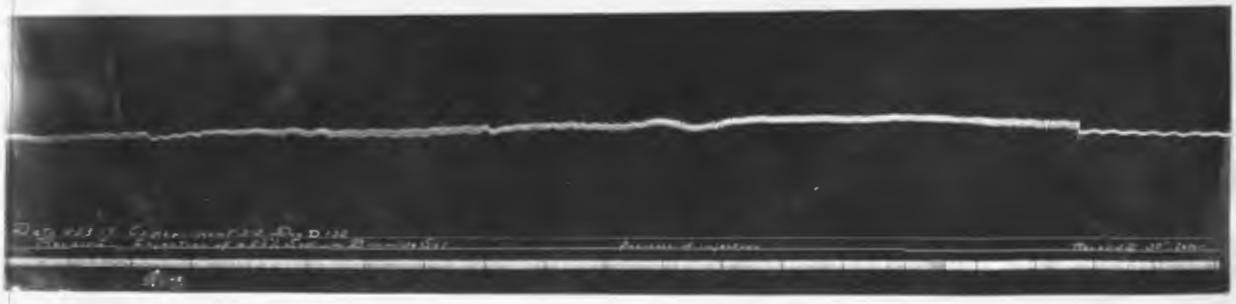


Fig. 15. Injection of 30 c.c. 25 per cent solution of sodium bromide.

Fig. 16. Injection of 50 c.c. of 15 per cent thorium nitrate solution which caused death. Solution taken from Bottle D.

questionable whether potassium iodid , because of its toxicity when absorbed should be used as a pyelographic medium. In view of the fact that thorium nitrate is toxic under certain conditions, it is also doubtful whether it should be used. Just what these conditions are has not been fully determined. I have recently reported from the clinic, a death which occurred from the use of thorium nitrate and which apparently was due to the toxic effects of this drug when absorbed. Whether the solutions were toxic when they were made by the manufacturer or whether they became toxic in the course of some chemical decomposition is not known. Careful investigation of the toxicity of thorium solutions of different ages, kept under different conditions of temperature and exposure to light and air, should be carried out in order to determine what effect such varying conditions have on the solution.

The absorption of different substances by the kidney.- In order to ascertain how soon substances will absorb, phenolsulphonephthalein, sodium bromid, potassium iodid, and brilliant green solutions were injected into the kidney pelvis and the ureter was ligated. These substances were found in the opposite ureter in from six to twelve minutes. When there was a rapid diuresis the substances came through more quickly. In one representative experiment a tube of phenolsulphonephthalein 4 mm. in diameter and 370 mm. in height was connected to the right ureter. In five minutes this pressure dropped to 290 mm. showing that there had been considerable absorption. The dye came through from the left ureter six minutes after it had entered the right ureter. At 290 mm. pressure it remained stationary for ten minutes showing that this was the secretory pressure of the kidney. From these experiments I conclude that substances are very rapidly absorbed by the kidney from the kidney pelvis. Phenolsulphonephthalein is taken into the circulation from the kidney pelvis just as rapidly as if it were given by intramuscular injection. The advantage of using non-toxic pyelographic mediums is demonstrated.

The question of absorption from the dilated pelvis in hydronephrotic kidney, and the question of the entrance of substances into the blood stream or into the intestinal tract into a kidney which has a ligated ureter with or without a hydronephrotic sac.- Phenolsulphonephthalein and potassium iodid were injected into the stump of the ureter of hydronephrotic kidneys and the ureter was ligated at the point of injection. It was shown that these substances were absorbed, and then excreted by the other kidney. The rapidity of this absorption apparently depends on the amount of medullary tissue that remains in the hydronephrotic kidney, or, the larger the hydronephrotic sac, the less the medullary tissue and the slower the absorption. It was found that when these substances were fed to dogs or injected into the jugular vein they could easily be found in a normal kidney pelvis with a ligated ureter or in a hydronephrotic sac. The amount found varied in inverse proportion to the size of the hydronephrosis that had developed.

A typical example of absorption into or from a hydronephrotic sac is given in the following experiments:

Excretion into a hydronephrotic sac. Experiment 123. Dog D19. Ligation and division of left ureter. Sixteen days later, injection of 2cc. of phenolsulphonephthalein into the jugular vein. Four hours later a nephrectomy was done. A hydronephrosis of 40 cc. capacity, contained a trace of phenolsulphonephthalein. The bladder urine gave 22 per cent phenolsulphonephthalein return.

Absorption from a hydronephrotic sac. Experiment 121. Dog. D17. Ligation and division of left ureter. Sixteen days later, injection of 1.5 cc. phenolsulphonephthalein into the left hydronephrotic kidney. Forty-two hours after the injection the dog excreted 95 cc. of urine which contained 20 per cent phenolsulphonephthalein. Seventy-two hours after injection a left nephrectomy was done. A hydronephrosis of 55 cc. capacity contained 30 per cent phenolsulphonephthalein.

These experiments seem to show that there is a circulation or transference of absorbable drugs into and out of the kidney pelvis when the ureter is ligated and that this is greater the greater the amount of normal kidney tissue that remains. It is also greater if there is active kidney secretion such as can be induced by diuretics. It has been said that the size of a hydronephrosis depends on the amount of collateral circulation that develops. I am inclined to believe that the collateral circulation that develops is secondary to the development of a hydronephrosis. It is certainly true that the larger the hydronephrotic sac, the larger the collateral circulation. It seems more likely that the difference in the size of the hydronephrotic sac in a given length of time depends more on the activity of the secretion of the kidney, than on the amount of collateral circulation developed for the greater the diuresis, the larger the secretory pressure and the greater the dilatation of the pelvis of the kidney. It was found that with a secretory urine pressure of 600 mm. the injection of 100 cc. of a 2 per cent solution sodium sulphate intravenously caused the secretory pressure to go up to 1150 mm. of urine pressure at which it remained stationary for one hour. Two experiments were performed in which one-half cubic centimeter of phenolsulphonephthalein was injected into a ureter which had been ligated at its juncture with the kidney pelvis and just before it entered the bladder. In these experiments no absorption of phenolsulphonephthalein was noted in the four days that the animals were kept under observation.

Channels through which substances in the blood stream enter the kidney pelvis or enter the blood stream from the kidney pelvis.- In order to ascertain how this absorption could take place several experiments were undertaken; Locke's solution was used as a perfusion medium. The kidneys were removed from an anesthetized dog; they were kept moist and warm while canulas were placed in the ureter, vein, and artery; they were then perfused with Locke's solution at body temperature. The artery was perfused first so as to be sure of washing the blood from the kidney. Further precaution was taken to clamp the artery before the vein

when the kidney was removed from the living animal. Dr. Mann has frequently noted and found experimentally that the kidney cannot be perfused backward, that is, from the vein to the artery. The kidney becomes tense and hard and does not allow any fluid to come from the artery when as much as 120 mm. mercury pressure is used on the vein. A very small amount however, occasionally comes from the ureter. We know that most organs such as the spleen, the thyroid, or an extremity can have a reversed circulation, that is, an anastomosis may be made between the arteries and veins and also between the vein and the artery and the part will live. In the kidney, however, no fluid will come from the vein out of the artery even when 150 mm. mercury pressure is used. It seems possible that the double capillary system which exists here may be responsible for the phenomenon, and it may be that the obstruction made in the first capillary network dilates the tubules on the second network so that they are closed. In this way a valve action exists that effectively steps the flow. When the artery was connected with the Locke's solution at 100 mm. pressure the solution dropped very rapidly from the vein, and a slight amount from the ureter. If the vein waw slightly constricted it dropped more rapidly from the ureter.

After the kidney had been washed free from blood by perfusion through the artery, the ureter was connected with Locke's solution under pressure and it was found that it would go through the vein fairly rapidly. When the pressure on the ureter was 120 mm. of mercury, the solution came from the vein at a pressure of 20 mm. of mercury. When the perfusion solution was colored with methylene blue or brilliant green, it was found that the colors rapidly made their appearance in the fluid from the vein. When a kidney that had been perfused with methylene blue solution by the ureter, was sectioned longitudinally, it was found that only the medullary portion of the kidney was stained. This was true whether the solution was injected in the live animal or after the kidney had been removed.

When the vein was injected with the potassium chromate solution and the artery with silver nitrate solution, a red precipitate of silver chromate was produced in the cortex, while the capsule, medullary portion, and pelvis were yellow. (Fig. 17). These solutions were used at the suggestion of Dr. E. C. Kendall.

When silver nitrate solution was injected into the ureter and potassium chromate was injected into the vein, a red precipitate of silver chromate was noted in the medullary portion only (Fig. 18).

From these experiments it is apparent that there is a circulation within the kidney from the artery to the vein and from the pelvis to the vein, which are independent of one another. We might conceive of the circulation in the kidney as represented in Figure 19. All the fluid enters the kidney through the artery, from which part of it goes through the capillaries of the glomeruli and is then collected into smaller arteries. From this a second set of capillaries springs which surround the tubules and is then collected into the veins. The other part of the fluid, a serous portion, leaves the arterial system at the glomeruli and probably some at the convoluted portion of the tubules. This fluid is said to gain entrance into the tubules probably by physical processes and also by vital activity of the cells. This fluid, so-called glomerulus filtrate, travels down the tubules and is in a large part reabsorbed into the venous circulation either by vital activity of the cells or by physical processes. The part that is not absorbed escapes into the pelvis of the kidney as urine. Figure 20 illustrates the results that have been deduced from analysis of the experiments; it also shows the probable course of fluid when it is injected into the ureter and escapes from the vein.

When colloidal silver is injected into the vein of a dog it rapidly causes death, as is noted in the blood pressure tracing (Fig. 21). When colloidal silver is injected into the ureter, however, no effect is noted until the pressure reaches approximately 250 mm. of mercury. When there is a sudden release of

Fig. 17. Renal vein injected with potassium chromate solution; renal artery injected with silver nitrate solution. Red silver chromate precipitated in cortical portion.

Fig.18. Renal vein injected with potossium chromate solution; ureter injected with silver nitrate colution. Red silver chromate precipitated in the medullary portion.

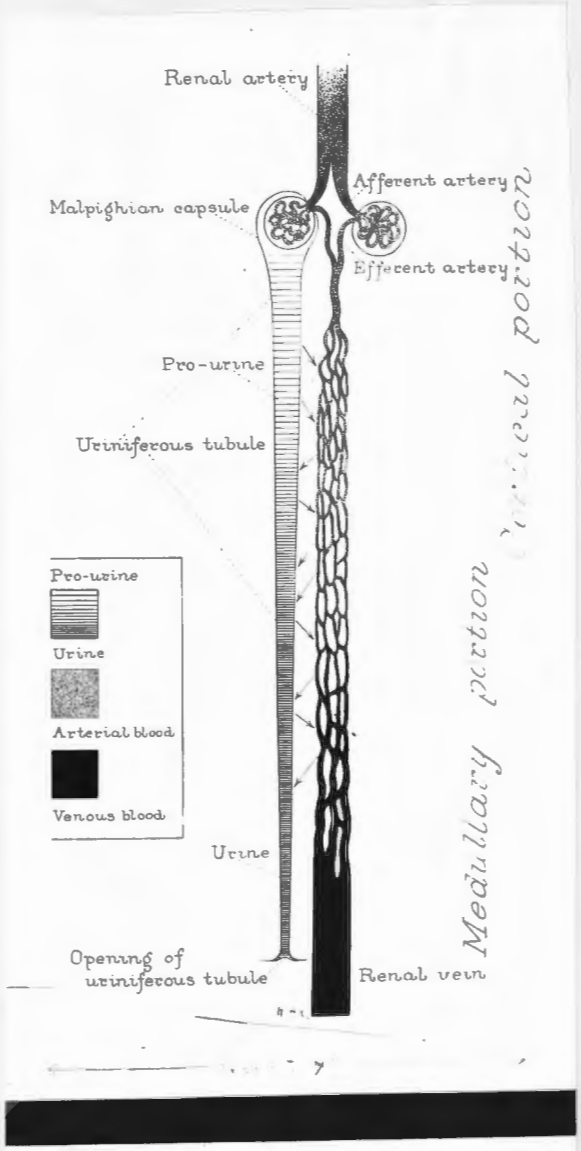


Fig. . A diagrammatic conception of the "modern view" of urinary secretion.

Fig. 19.

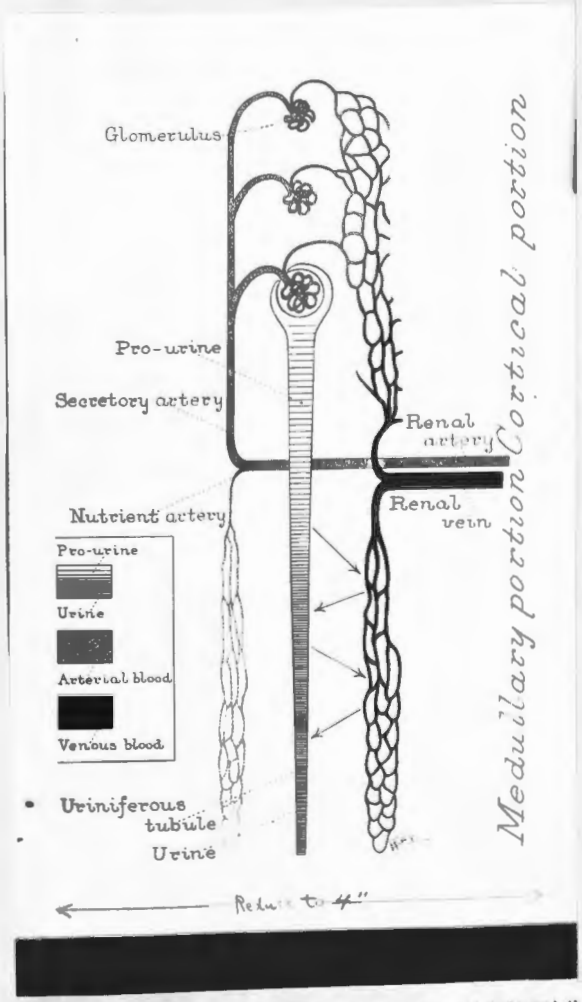


Fig. . Diagram of absorption from the uriniferous tubule and the formation of urine.

Fig. 20.

pressure, the colloidal silver rapidly leaves the syringe and the animal dies (Figs. 22 and 23). Apparently the solution breaks through the tubule walls and enters the veins. It is surprising how little force one has to exert on the syringe to make a pressure of 250 mm. of mercury. Death usually occurs four or five minutes after the injection; this undoubtedly explains many of the cases of sudden death after the use of colloidal silver, which are mentioned in the literature. It also emphasizes the necessity of using non-toxic mediums in pyelography and of avoiding too high pressure in making pyelographic injections. Figure 39 shows some of the colloidal silver in the veins of the kidney and Figure 40 some flecks noted in the right kidney nine days after the injection into the left kidney pelvis.

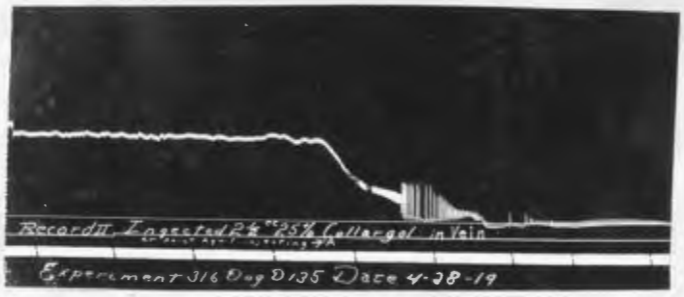


Fig. 21. Collargol injected in vein.

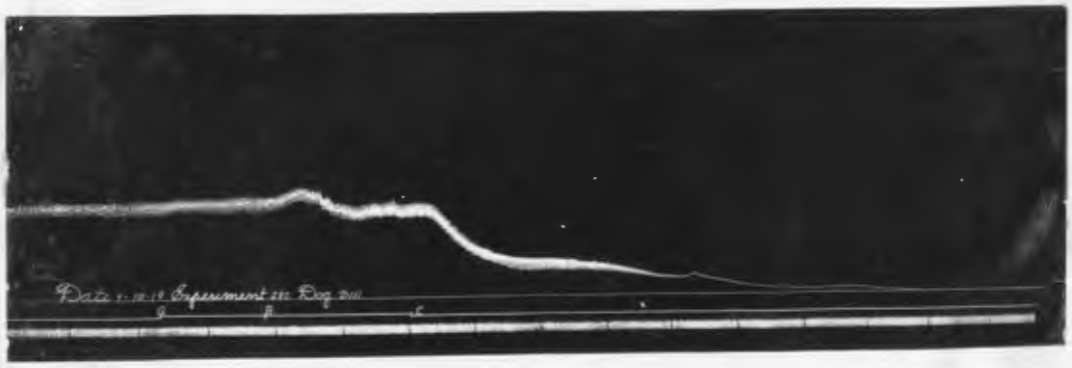


Fig. 22. Collargol injected in ureter under 250 mm. pressure.

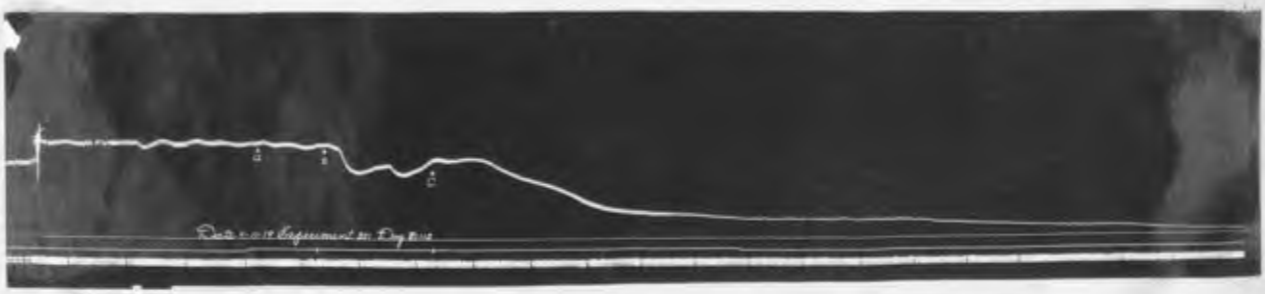


Fig. 23. Collargol injected in ureter under varying pressures, finally broke into curculation and caused death of the animal.

CONCLUSIONS

1. It is not feasible to note the gradual development of hydronephrosis by x-ray.

2. There does not seem to be much difference in the effect on the kidney tissue of sodium bromid, potassium iodid or thorium nitrate solutions used as pyelographic mediums.

3. Sodium bromid is non-toxic when it is injected directly into the vein.

4. Thorium nitrate 15 per cent solution as now put on the market varies in toxicity. Some solutions tested have been very toxic.

5. Potassium iodid solutions are very toxic when injected into the veins.

6. The effect on the kidney tissue of pyelographic medium retained in the kidney pelvis is most noted in the first hour after injection. Later the effects seem to be the same as would occur from the gradual development of a hydronephrosis from a ligated ureter. This is not true when silver salts or other insoluable mediums are used.

7. Mediums such as sodium bromid, potassium iodid and thorium nitrate are not retained in the kidney pelvis more than one and one-half hours when the ureter is ligated, but are absorbed rapidly, apparently from the medullary portion of the kidney.

8. Hydronephrotic kidneys allow absorption from their sacs in inverse proportion to the size of the sac or the amount of kidney destruction. The kidney tissue first to be destroyed is the medullary portion.

9. Substances in the blood stream or in the intestinal tract enter the pelvis of a kidney with a ligated ureter in inverse proportion to the size of the hydronephrosis that has developed.

10. Absorption from the pelvis takes place through the medullary portion of the kidney. Perfusion experiments indicate that this is a very

rapid process. The nuclei of some cells are stained when dyes are absorbed; this ~~way~~ indicates that the process is more than one of filtration.

11. Absorption from the kidney pelvis indicates that the kidney may be a focus of infection that should always be considered.

12. Unabsorbable mediums produce destruction of the kidney tissue and should therefore not be used.

13. There is danger of injecting pyelographic mediums directly into the blood stream if too great a pressure is exerted; for this reason non-toxic sterile mediums should be used.

14. Sodium bromid is the best pyelographic medium thus far known.

Experiment	Dog	Solution	Per-cent	Interval of time between 1st and 2nd op.	Macroscopic results	Dilated tubules	Glomerular destruction	Destruction of cells of tubules	Round celled infiltration	Total per-cent of destruction
488	C613	Sodium bromide	25	8 days	16 c.c. hydronephrosis	2	1-	2	1	25
489	C614	Sodium bromide	25	8 days	20 c.c. hydronephrosis	2½	1-	2	2	25
490	C615	Sodium bromide	25	8 days	14 c.c. hydronephrosis	1+	1-	2	1	20
561	C680	Sodium bromide	Saturated	6 days	15 c.c. hydronephrosis	1½	1-	2-	0	20
562	C681	Sodium bromide	Saturated	6 days	12 c.c. hydronephrosis	1½	1-	2	1	15
654	C741	Sodium bromide	Saturated	9 days	12 c.c. hydronephrosis	2	1-	2	0	20
678	C755	Sodium bromide	Saturated	7 days	12 c.c. hydronephrosis	2	1-	2	2	30
890	C876	Sodium bromide	Saturated	8 days	12 c.c. hydronephrosis	2-	1-	2	2	30
893	C879	Sodium bromide	Saturated	2 hours	Very slight irritation Medullary portion	1	0	1-	0	0?
118	D14	Sodium bromide	25	1 hour	Very slight irritation Medullary portion	1-	0	1-	0	0?
89	C985	Sodium bromide	Saturated	1 hour	Very slight irritation Medullary portion	1-	0	1	0	0?
90	C986	Sodium bromide	Saturated	2 hours	Very slight irritation Medullary portion	1	0	1	0	0?

564	C683	Potassium iodid	Saturated	13 days	16 c.c. hydronephrosis	2	1	2	1	35
563	C682	Potassium iodid	Saturated	3 days	10 c.c. hydronephrosis	2	1	1	1-	25
926	C896	Fed K.I. by mouth 10 G. daily	Saturated	10 days	Definite test for K.I. 25 c.c. for K.I.	3	2	4	1	85
65	C965	Potassium iodid	Saturated	2 hours	Slight irritation Medullary portion	1	0	1-	0	5-
91	C987	Potassium iodid	Saturated	24 hours	Slight irritation Medullary portion	2	1-	1	0	10
117	D13	Potassium iodid	25	1 hour	Slight irritation Medullary portion	1	0	1	0	7
56	C961	Potassium iodid	Saturated	1 hour	Marked irritation Medullary portion	1-	0	1	0	6?
676	C752	Thorium	15	7 days	15 c.c. hydronephrosis	2+	1	3	1	60
891	C877	Thorium	15	8 days	16 c.c. hydronephrosis	2	1	2-	2	50
85	C981	Thorium	15	2 hours	Slight irritation of medullary portion	1	1-	1	0	7
86	C982	Thorium	15	1 hour	Slight irritation of medullary portion	1+	1-	1	1-	10
722	C723	Thorium	15	28 hours	45 c.c. hydronephrosis	2+	2-	2	2	30
119	D15	Thorium	15	1 hour	Slight irritation of medullary portion	1	½	½	0	5
586	C701	Silver iodid	5	13 days	20 c.c. hydronephrosis	2	1	3½	7	85
587	C702	Silver iodid	5	21 days	25 c.c. hydronephrosis	1	1	2	1	10
588	C703	Silver iodid	5	28 days	40 c.c. infected hydro.	2 +	2 +	2	2	45
92	C988	Collargol	25	5 minutes	Pelvis and medullary portion stained.	Tubules stained. Some in vein				
87	C983	Collargol	25	5 minutes	Pelvis and medullary portion stained.	Tubules stained. Some in vein.				

88	C984	Collargol	25	5minutes	Pelvis and medullary portion stained	Tubules stained. Some in vein.					
66	C966Lt.	Collargol	25	8 days	Pelvis and medullary portion stained	2	1	2½	3	50	
66	C966Rt.	Collargol	25	8 days	Normal	1-	1	2	Collargol in tissue		
37	C953	Protargol	15	19 days	20 c.c. hydronephrosis	2	1	3	2	60	
38	C954	Protargol	15	19 days	20 c.c. hydronephrosis	2-	1	2	2	30	
589	C704	Protargol	15	28 days	120 c.c. pyonephrosis	2	1	2	2+	25	
84	C980	Methylene blue		10minutes	Coloring of medulla.	Blue in medulla and in nuclei of cells					
605	C710	Bismuth carbonate solution		24 days	20 c.c. hydronephrosis	2	1-	3	1	60	
606	C711	Barium sulphate		5 days	10 c.c. hydronephrosis	2	1-	2+	1	40	
614	C715	Bismuth carbonate solution		16 days	15 c.c. hydronephrosis	3	1	3	2	60	
920	C892	Ligated and tied ureter.		22 days	30 c.c. pyonephrosis	4	2	3	2	85	

Experiment	Dog		Dilated tubules	Glomerular destruction	Destruction of tubular cells	Round celled infiltration	Total per-cent of destruction
737	C804	1 c.c. phenolphthalein injected in hydronephrosis, 20 c.c. capacity of 8 days duration and returned in bladder in 11 minutes	2	1	2+	2	25
736	C803	1 c.c. phenolphthalein injected in rt. kidney pelvis, ligated and divided ureter. Phenolphthalein returned in bladder in 10 minutes. Urine from left kidney for 2 hours and 10 minutes gave 7 per cent phenolphthalein returned. Nephrectomy in 8 days showed hydronephrosis 15 c.c. capacity.	2	1	3	2	40
668	C750	1 c.c. phenolphthalein injectedin rt. kidney, pelvis and ureter ligated. Returned from opposite ureter in 13 minutes, 7 per cent in first half hour, 5 per cent in second half hour.					
103	C999	Injected 2 c.c. phenolphthalein subcutaneously and in 4 hours nephrectomy wasdone on a 20-day hydronephrosis, 100 c.c. capacity; found a trace of phenolphthalein.	1	2	3	3	80
104	C1000	Injected 2 c.c. of phenolphthalein in rt. hydronephrosis, 56 c.c. capacity and placed catheter in opposite ureter. No return in 1½ hours. Nephrectomy 4.8 hours later showed a trace of phenol-phthalein in bladder urine and 70 per cent phthalein still in hydronephrosis.	3	3	3½	1	90
105	D1	Injected 2 c.c. phenolphthalein in hydronephrosis, 36 c.c. capacity and in 48 hours found trace in bladder. Nephrectomy was done which showed 65 per cent phenolphthalein left in the hydronephrotic sac.	3	1	2	1	70
106	D2	Injected 2 c.c. phenolphthalein in jugular vein and in 4 hours nephrectomy was done of 20-day 60 c.c. hydronephrosis which gave no phenolphthalein return.	3	1	2	1	70
120	D16	Injected 2 c.c. phenolphthalein in jugular vein and in 4 hours nephrectomy was done of 16-day hydronephrosis of 35 c.c. capacity. This showed a trace of phenolphthalein while bladder urine gave 55 per cent returned.	2½	1	2	1	60

121	D17	Injected 2 c.c. of phenolphthalein in lt. hydronephrosis of 16 days, 55 c.c. capacity; in 3 days nephrectomy was done, fluid from which gave 30 per cent phenolphthalein retention, while urine collected from other kidney gave 20 per cent return.	2½	2	3	0	60
122	D18	Injected 1½ c.c. phenolphthalein in lt. hydronephrosis of 40 c.c. capacity, 16 days old; in 3 days nephrectomy was done and fluid showed 35 per cent phenolphthalein return. Urine from the other kidney showed 10 per cent return.	2½	2	2	0	60
123	D19	Injected 2 c.c. of phenolphthalein in jugular vein and in 4 hours urine from the bladder gave a 22 per cent phenolphthalein return. Nephrectomy of a 40 c.c. hydronephrosis gave a trace of phenol-phthalein.	1	3	2½	2	75
35	C951	Injected 1 c.c. phenolphthalein in jugular vein and in 15 minutes nephrectomy was done of a 19day hydronephrosis, 35 c.c. capacity, which gave no phenolphthalein return.	2	2	2	2	50

Protocols

Experiment 300. Dog D124, weighing 5 kg. was anesthetized with ether by the cone method following which he was intubated and the Connell method was started at 9:10 A.M. with a tension of 40. The apparatus was arranged to record carotid blood pressure. The femoral vein was exposed so that solutions could be easily injected with a small hypodermic needle.

At 9: 23 A. M. 1 cc. of a 25 per cent solution sodium bromid was injected into the left femoral vein in 75 seconds. This caused slight irregularity in the pulse curve and raised the blood pressure 3 mm. The record was stopped in five and one-half minutes and the dog was allowed forty-five minutes in which to recover.

At 10:10 A. M. injection of 1 cc. of a 25 per cent solution potassium iodid caused a toxic curve. Seventy-five seconds were taken for the injection. The injection was slightly uneven; if it had been given gradually the curve probably would have been more regular. There was a slight temporary raise of 3 mm. in the blood pressure. The record was stopped in five and one-half minutes, and the dog was allowed forty minutes in which to recover.

At 10:50 A. M. injection of 1 cc. of thorium nitrate 15 per cent solution caused a slight irregular reaction almost identical to that caused by the injection of sodium bromid. The record was run five and one-half minutes; the dog was allowed eighteen minutes in which to recover. The solution used came from Bottle A (one year old?).

At 11:08 A. M. 5 cc. of thorium nitrate were injected in two and one-half minutes; this caused a marked rise in blood pressure, about 30 mm., and then a gradual decrease for three minutes at which time the blood pressure stayed about normal. The record was run for five and one-half minutes. The solution used came from Bottle A.

The dog was allowed eighteen minutes in which to recover; 5 cc. of a 25 per cent solution sodium bromid were then injected; blood pressure rose about 5 or 6 mm. which was not nearly so high a rise as that caused by the thorium nitrate.

The dog was allowed eighteen minutes to recover and 2 cc. of a 25 per cent solution of potassium iodid were injected in to the femoral vein; this caused a rapid fall in blood pressure and the death of the dog.

Experiment 306. Dog D126, weighing 5.4 kg. was prepared as in previous experiments. The femoral vein was exposed, and at 2:18 P. M. 10 cc. of a 25 per cent solution of sodium bromid were injected at the rate of 2 cc. per minute into the right femoral vein. The pulse curve increased somewhat in amplitude. During the injection the blood pressure rose about 6 mm., after which it returned to normal. The record was stopped in twelve minutes.

After allowing the animal three-fourths of an hour to recover, at 3:03 P. M. 10 cc. thorium were injected at the rate of 2 cc. per minute. This gave a decided toxic curve as is shown in Figure 13 , and a slight rise in blood pressurs, after which the curve returned to normal. The record was run seven minutes. The solution used in this case came from Bottle B (two months old?)

At 3:40 P. M. 2.5 cc. of potassium iodid were injected at the rate of 2 cc. per minute; the animal died in two and one-half minutes. Experiments 300 and 306 seem to show that sodium bromid has a less toxic effect than thorium when it is injected intravenously, and that potassium iodid, because of its toxicity and the rapidity with which it is absorbed, would be a dangerous medium for pyelography.

Experiment 308. Dog D126, weighing 5.6 kg. was prepared in the same method, after which the animal was intubated and connected with the insufflating apparatus. The left ureter was exposed through a midline incision and connected with a canula which was in turn connected with an upright glass

[illegible]

[illegible]

Experiment 311. Dog D131, weighing 4.9 gm. was prepared as in previous experiments. The injection of 15 per cent solution of thorium was given in exactly the same amounts per minute as had been used in the previous experiment when a 25 per cent solution of sodium bromid was used, that is, 1 cc. per minute in three minutes, 5 cc. in four minutes, 8 cc. in six minutes, 10 cc. in eight minutes, and 16 cc. in nine minutes, blood pressure dropping to zero. The record shows decided toxicity. The solution used came from Bottle A (one year old?).

Experiment 312. Dog D132, weighing 4.7 kg., was prepared as in previous experiments. At 3:15 P. M. a normal record was taken; three minutes later a 25 per cent solution of sodium bromide was injected from a burette, gradually, at the rate of 1 cc. a minute for the first three minutes; during the fourth minute 2 cc. were injected. At the end of eight minutes 10 cc. had been injected. The rate was then increased as the marker on the tracing shows, and in the next five minutes 20 cc. more were injected; 30 cc. were injected in thirteen minutes when the record was stopped and the animal was allowed to remain on the table for thirty minutes; another record was then taken. The main effect of this injection was to increase the blood pressure and slightly to increase the pulse curve; respirations were not increased but appeared to be deeper. Because of the sodium bromid no toxic effect was noted.

Experiment 314. Dog D268, weighing 12 kg, was prepared as in previous experiments. The left femoral vein was exposed and connected to a burette from which 15 per cent thorium nitrate solution was injected, 6 cc. in five minutes, 10 cc. in eight minutes, 3 cc. in thirteen minutes, and 50 cc. in eight and one-half minutes. This did not appear to affect the condition of the dog in any way. Following this, 1 cc. of a saturated solution of potassium iodid was injected directly into the vein, and caused the immediate death of the animal. The solution used for this experiment came from Bottle C (one month old?).

Experiment 316. Dog D135, weighing 7.2 kg., was prepared in the usual manner. The left femoral vein was exposed, and connected with a burette from which a 25 per cent solution of sodium bromid was allowed to run by gravity at the rate of 3 cc. per minute for the first three minutes, and then at the rate of 6 cc. per minute for the next eight minutes; 55 cc. was given in eleven minutes. This produced no ill effect on the dog that could be noted by the blood pressure curve. The dog was then killed by injecting 2.5 cc. of the 15 per cent colloidal silver solution directly into the vein. This was done in order to obtain for publication a tracing of the death curve by colloidal silver. The dog died in two minutes after the colloidal silver was injected.

Experiment 317. Dog D136, weighing 10.4 kg., was anesthetized by the cone method, intubated and kept under constant ether tension with the Connell apparatus at a tension of 40. The apparatus was arranged to record the carotid blood pressure. The left femoral vein was exposed and connected with the burette from which the thorium nitrate solution was allowed to run by gravity. In the first minute, 6 cc. were injected, causing a rapid fall in blood pressure. Because of this, the animal was allowed one minute in which to recover. At the end of three minutes 9 cc., of four minutes, 12 cc., of five minutes, 14 cc., of six minutes, 17 cc., of seven minutes, 21 cc., of eight minutes, 32 cc., of nine minutes, 37 cc., of ten minutes, 41 cc., of eleven minutes, 44 cc., of twelve minutes, 47 cc., and at the end of thirteen minutes, 50 cc. of the solution, had been injected. The solution was then injected at the approximate rate of 4cc. per minute. At the end of the eighth minute the blood pressure gradually began to go down and continued to fall until the animal died after the 50 cc. dose had been injected. This thorium nitrate solution was taken from Bottle D which had been received from the manufacturer about one week before. The bottle was not opened before it was used in the experiment.

Experiment 319. Dog D138, weighing 9 kg., was prepared in the usual manner. Thorium solution was allowed to flow from a burette into the left femoral vein, 4 cc. at the end of one minute, 10 cc. of two minutes, 15 cc. of three minutes, 20 cc. of four minutes, 25 cc. of five minutes, 30 cc. of six minutes, 34 cc. of seven minutes, 38 cc. of eight minutes, and 40 cc. at the end of eight and one -half minutes, at which time the animal died. The blood pressure gradually rose until 30 cc. had been given; it then began to sink in a more rapid curve than that in which it had risen until death ensued three minutes later.

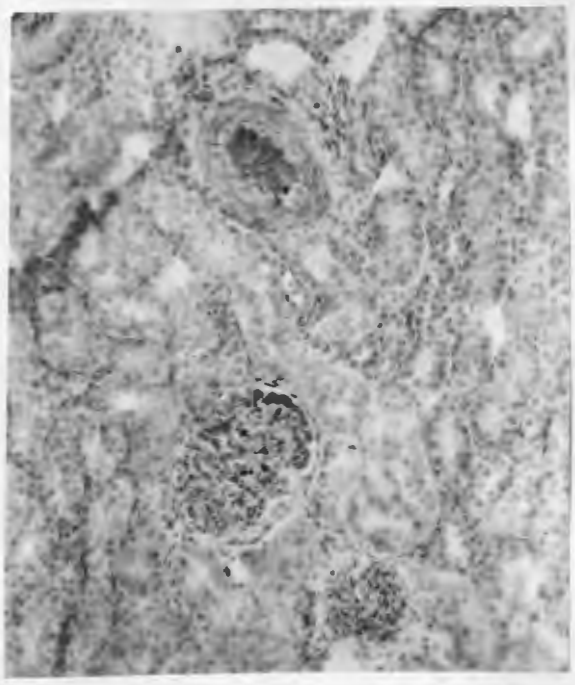


Fig. 24. Experiment 488. Photomicrograph (X100) showing areas of degenerating tubular cells 8 days after the injection of a 25 per cent solution of sodium bromid .

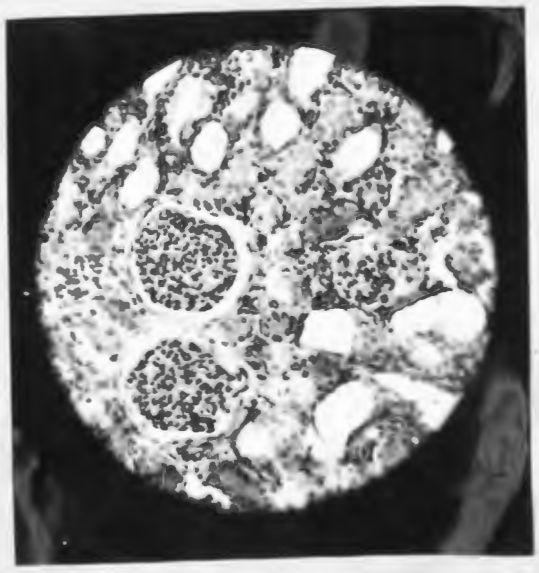


Fig. 25. Experiment 678. Photomicrograph (X100) showing dilated tubules even around the glomeruli 7 days after injection of a saturated solution of sodium bromid .

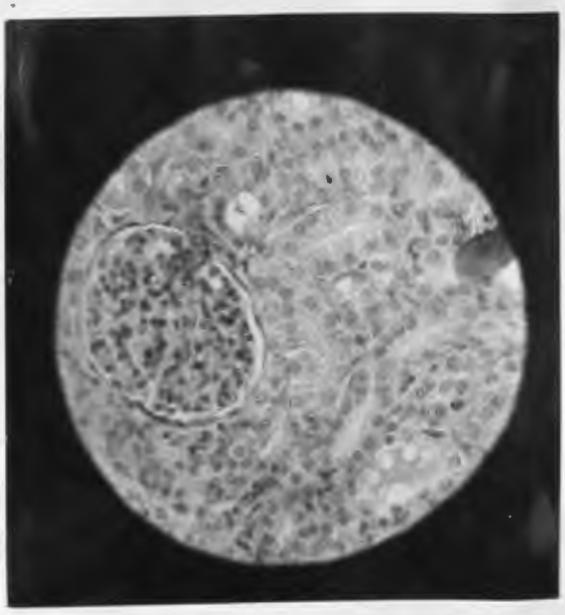


Fig. 26. Experiment 593. Photomicrograph (X200) showing dilated tubules with edema of the cells 6 days after the injection of 2 c.c. of a saturated solution of sodium bromid .

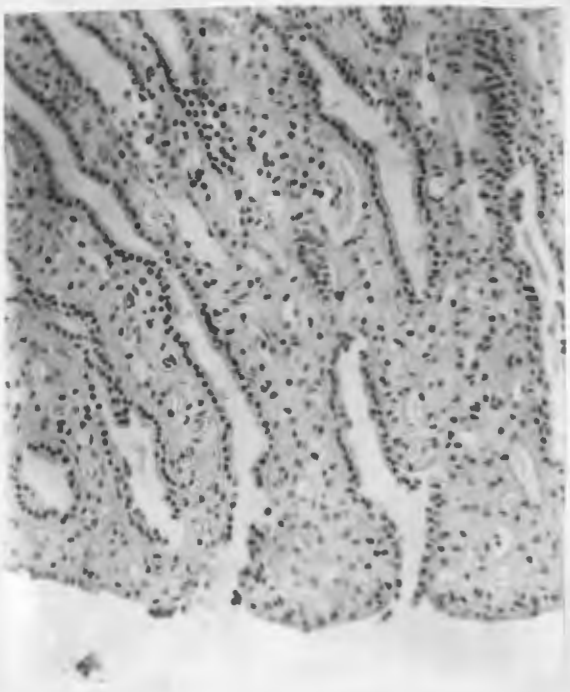


Fig. 27. Experiment 118. Photomicrograph (X100) showing opening of slightly dilated tubules in renal papillae 1 hour after the injection of a 25 per cent solution of sodium bromid.

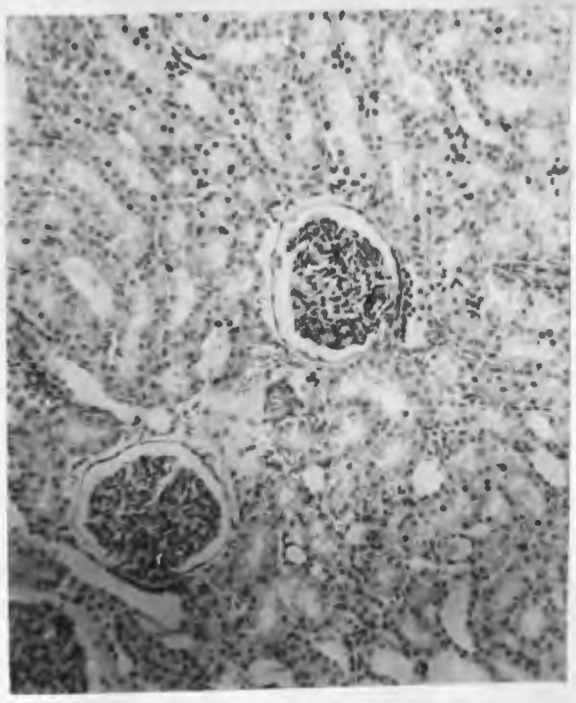


Fig. 28. Experiment 118. Photomicrograph (X100) showing dilated convoluted tubules and capsule, slight edema of cells 1 hour after the injection of a 25 per cent solution of sodium bromid.

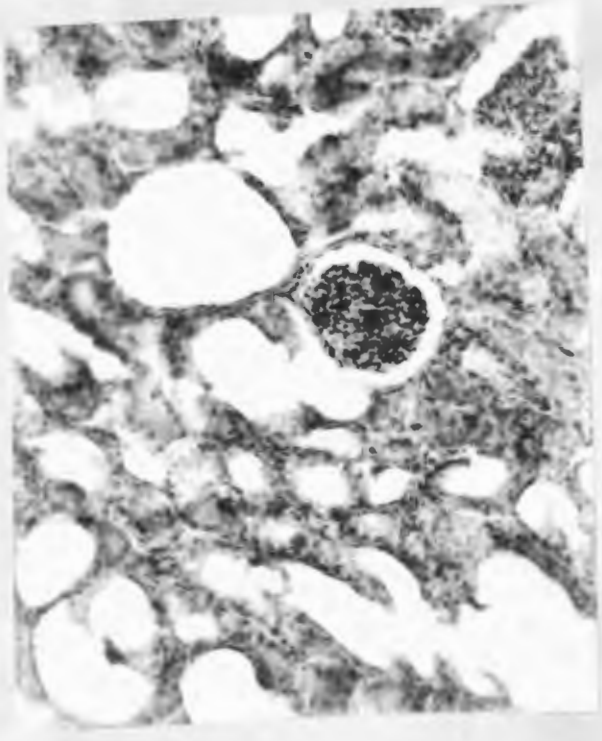


Fig. 29. Experiment 926. Photomicrograph (X100) showing a cortex of a dog which had been fed 10gm. potassium iodid for 14 days following the division and ligation of the ureter. The fluid of the hydronephrosis that developed had a positive test for iodin. The cells of the tubules of the kidney showed 85 per cent destruction.

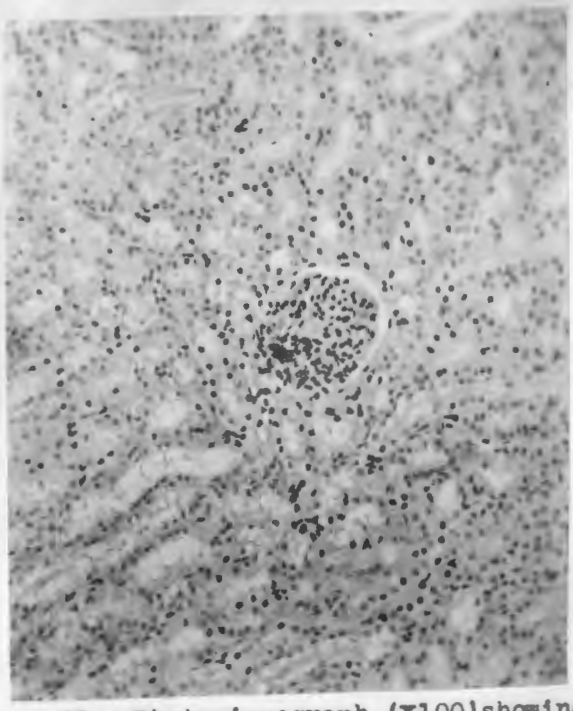


Fig. 30. Experiment 65. Photomicrograph (X100)showing cortex 2 hours after injection of the saturated solution of potassium iodid. Slightly dilated tubules. Moderate edema of the tubular cells.

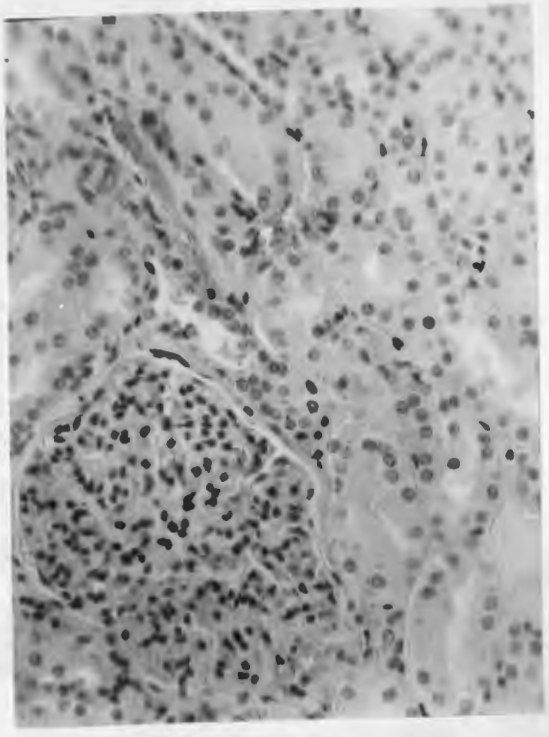


Fig. 31. Experiment 56. Photomicrograph (X200) showing edema of tubular cells 1 hour after injection of a saturated solution of potassium iodid.

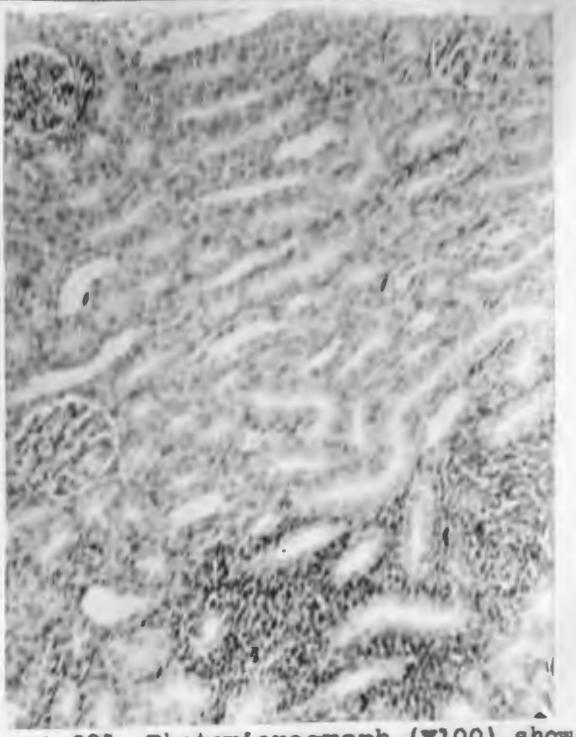


Fig. 32. Experiment 891. Photomicrograph (X100) showing a round cell infiltration destruction of the tubular cells and dilated tubules 8 days after the injection of thorium.

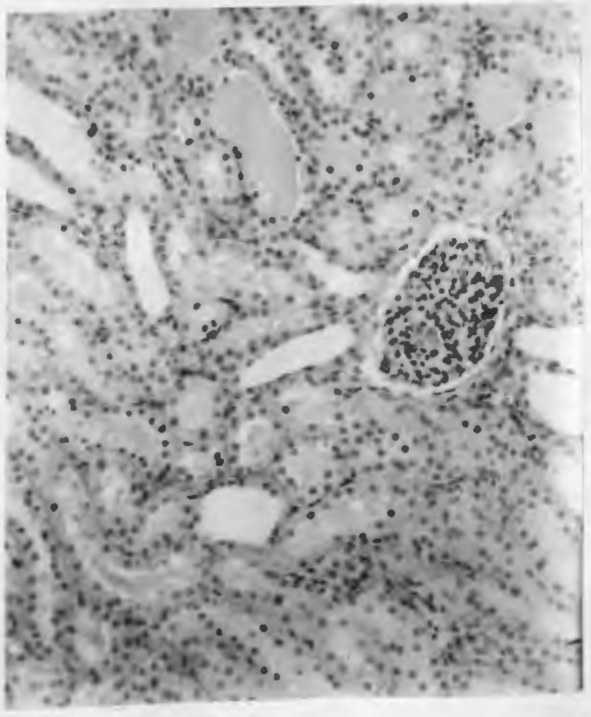


Fig. 33. Experiment 86. Photomicrograph (X100) showing dilated tubules with edema of tubular cells 1 hour after the injection of thorium.

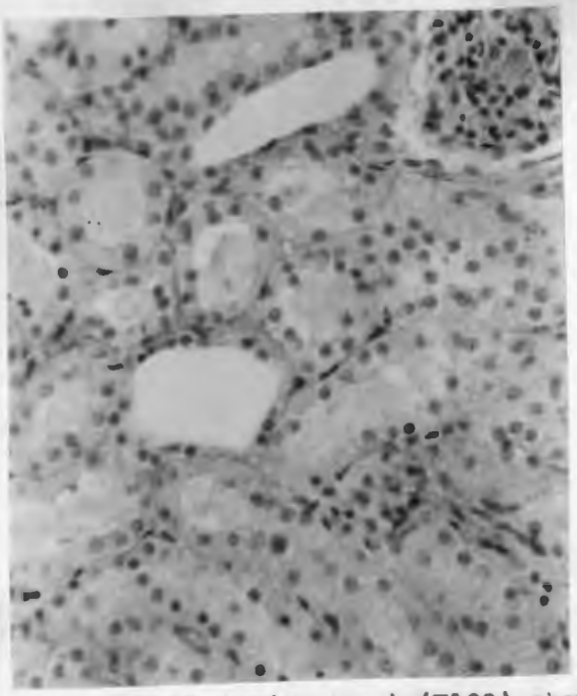


Fig. 34. Experiment 86. Photomicrograph (X100) showing same as Fig.33 at a higher magnification.

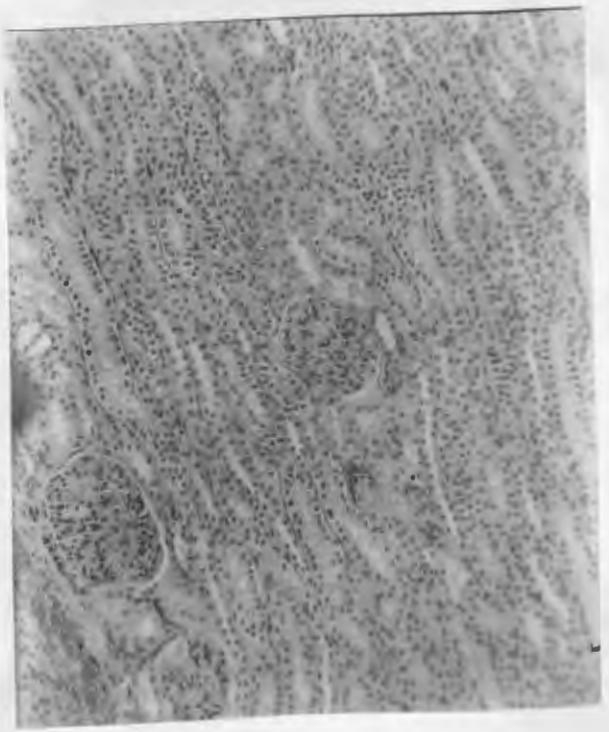


Fig. 35. Experiment 119. Photomicrograph showing convoluted tubules and glomeruli 1 hour after the injection of 1.5 c.c. thorium.

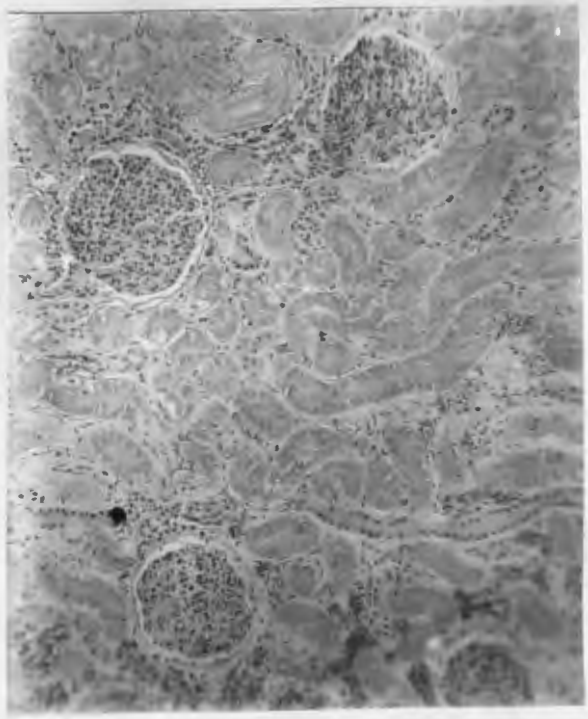


Fig. 36. Experiment 586. Photomicrograph (X100) showing almost complete destruction of tubular epithelium 13 days after the injection of 5 per cent silver iodid emulsion.

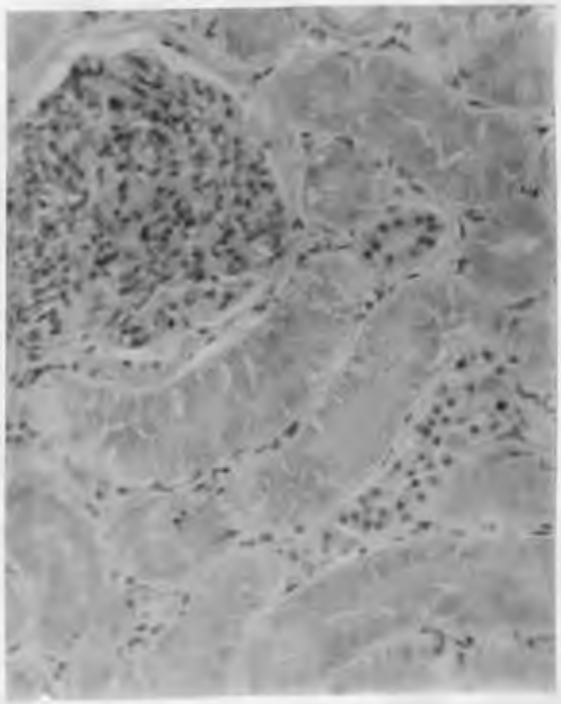


Fig. 37. Experiment 586. Photomicrograph (X200) showing the same as in Fig. 36.

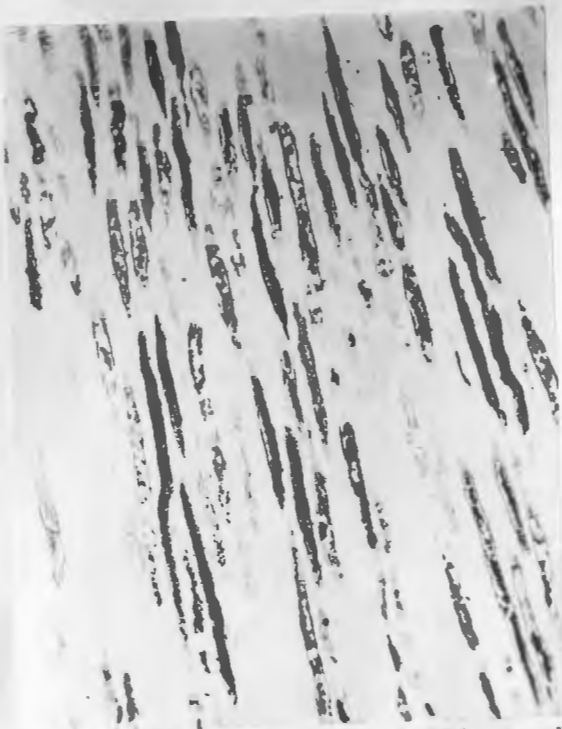


Fig. 38. Experiment 92. Photomicrograph (X50) showing collargol in the collecting tubules immediately after injection.

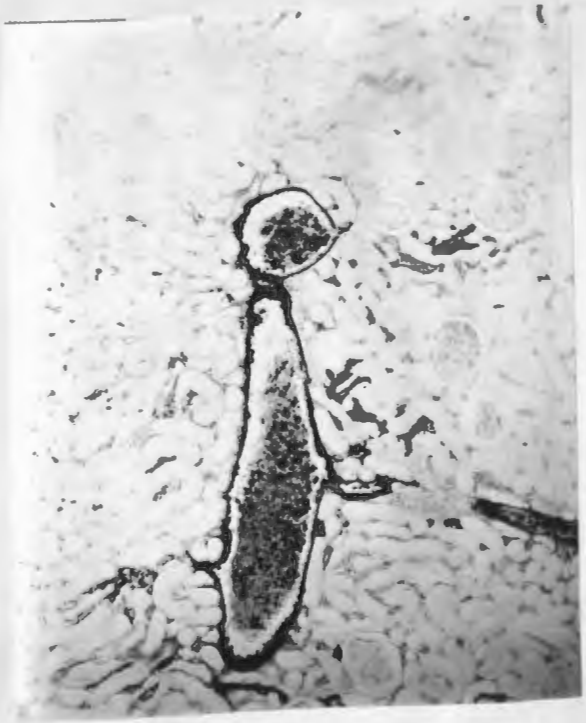


Fig. 39. Experiment 92. Photomicrograph (X50) showing collargol in the same immediately after injection.

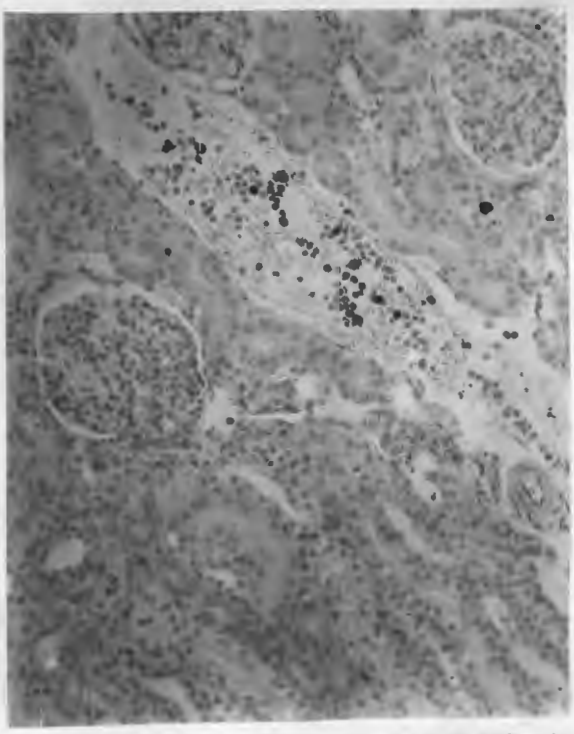


Fig.40. Experiment 66. Photomicrograph (X100) showing collargol in the right kidney 9 days after it had been injected in the left kidney pelvis.

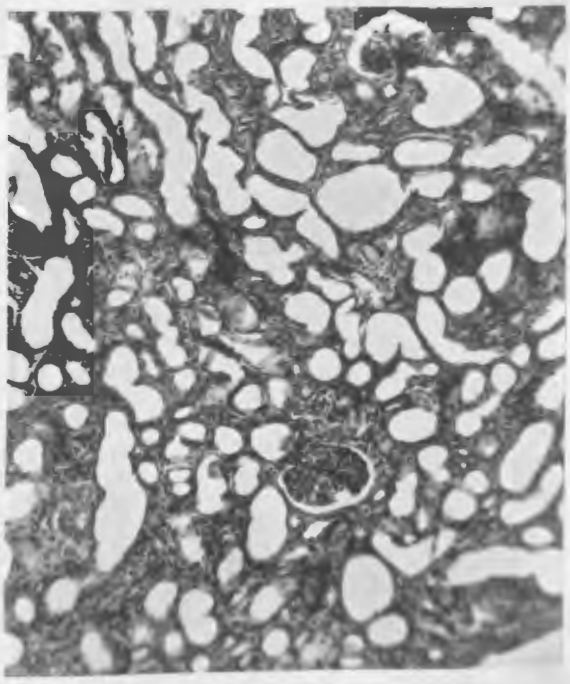


Fig. 41. Experiment 920. Photomicrograph (X100) showing a badly damaged kidney due to the development of a hydronephrosis 22 days after ligation of the ureter without the injection of any media.

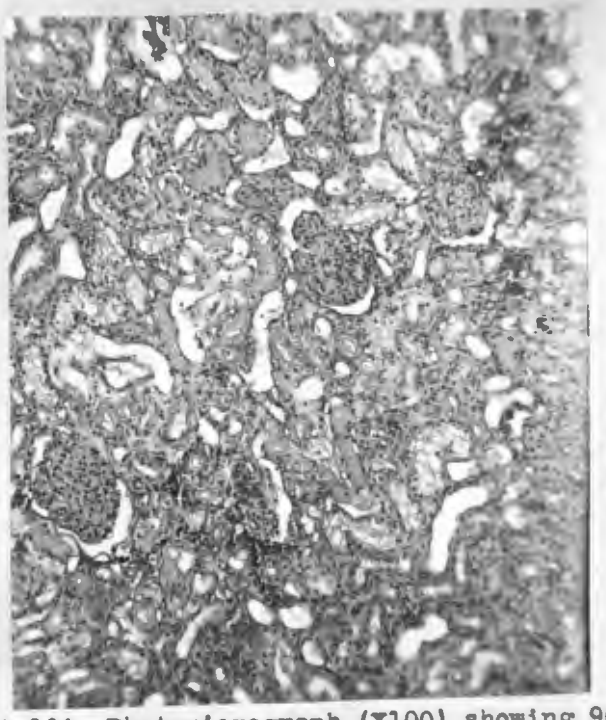


Fig. 42. Experiment 104. Photomicrograph (X100) showing 90 per cent destruction of the tubular cells. Phenolsulphonephthalein was injected into the pelvis of this kidney but did not show return in the opposite kidney in the one and one-half hours that the animal was under observation, showing that the absorption is very slow from the pelvis of the kidney where we have a very large hydronephrosis with a great amount of tissue destruction.

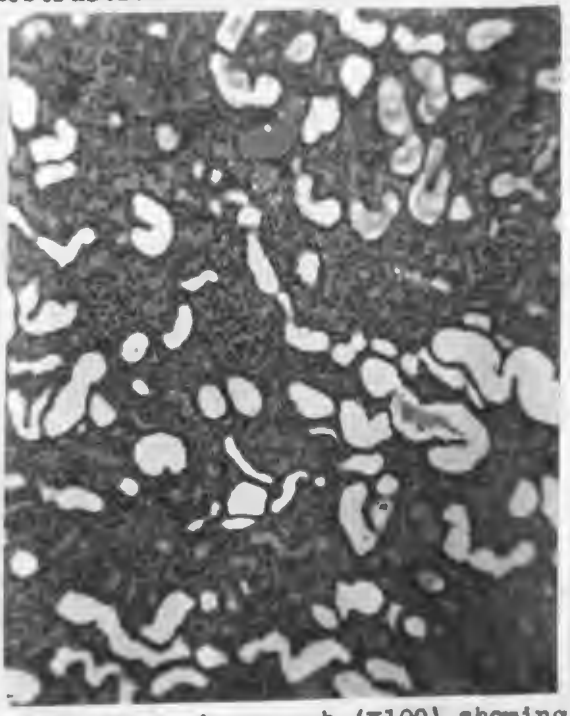


Fig. 43. Experiment 121. Photomicrograph (X100) showing dilated tubules with 60 per cent destruction of the tubular cells. Phenolsulphonephthalein was absorbed from this kidney pelvis.

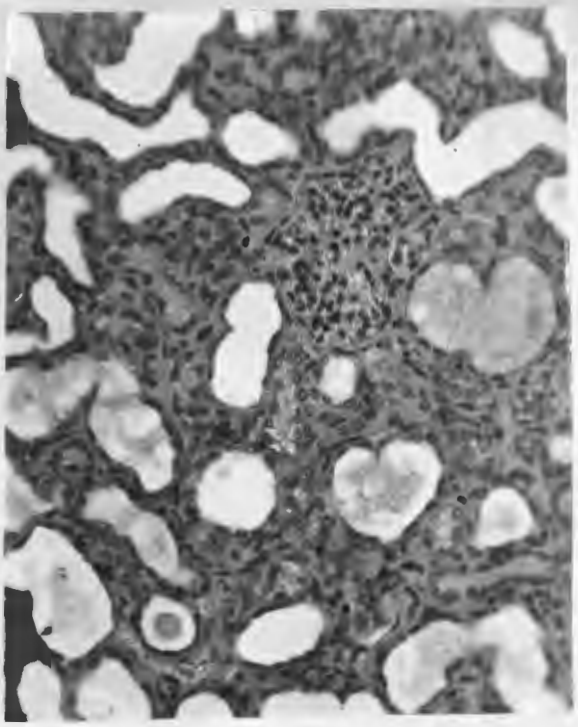


Fig. 44. Experiment 121. Photomicrograph (X200) showing dilated tubules with 60 per cent destruction of the tubular cells. Phenolsulphonephthalein was absorbed from this kidney pelvis.

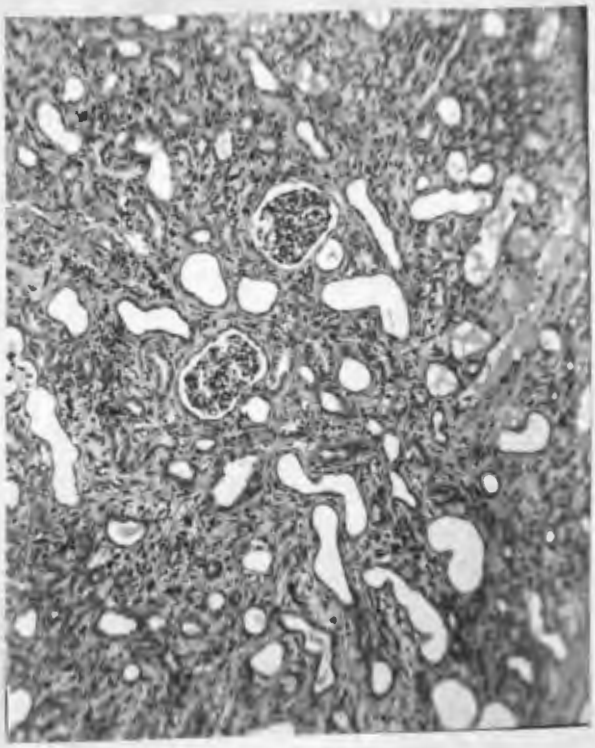


Fig. 45. Experiment 123. Photomicrograph (X100) showing the cortex of a kidney with 75 per cent destruction. Phenolsulphonephthalein was injected in the vein and found in this hydronephrotic sac 4 hours later.

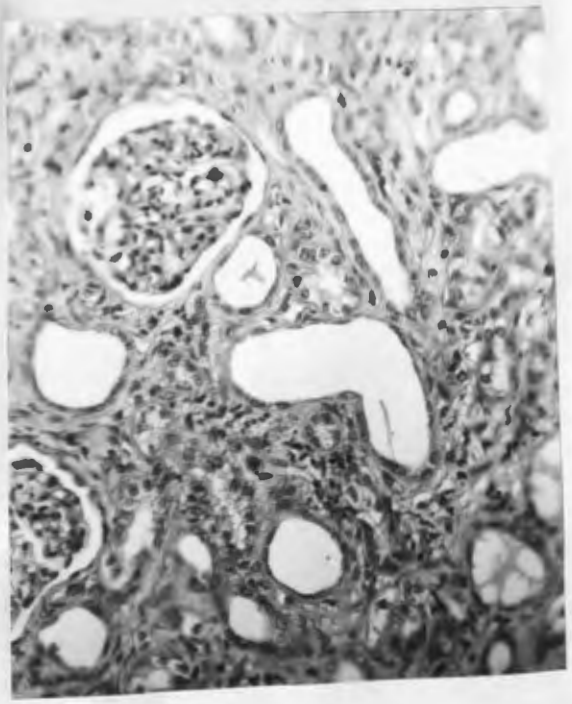


Fig. 46. Experiment 123. Photomicrograph (X200). Higher magnification of Fig. 45.

REFERENCES

1. Braasch, W.F.: Recent developments in pyelography. Ann. Surg., 1910, 645-653; The value of pyelography. Jour. Am. Med. Assn.,1911, lvii, 1886-1888.

2. Braasch, W.F. and Mann, F.C.: Effects of retention in the kidney of media employed in pyelography. Am.Jour. Med.Sc., 1916, cliii, 336-347.

3. Braasch, W.F., and Wilder, F.S.: Pyelography. Internat. Abstr. Surg., 1915, xx, 117-123.

4. Brödel, M.: The intrinsic blood-vessels of the kidney and their significance in nephrotomy. Bull. Johns Hopk. Hosp., 1901, xii, 10-13.

5. Buerger, L.: Collargol in the renal parenchyma. Am.Jour. Urol., 1912, viii, 166-168; Concerning renal lesions after pyelography. Surg., Gynec. and Obst., 1914, xix, 536-540; Argyrol in the parenchyma of the kidney after pyelography. New York Med. Jour., 1914, xcix, 1057.

6. Burns, J. E.: Thorium - a new agent for pyelography: preliminary report. Jour. Am. Med. Assn., 1915, lxiv, 2126-2127; Further observations on the use of thorium in pyelography. Jour. Am. Med. Assn., 1917, lxviii, 533.

7. Burns, J.E., and Hopkins, P. B.: A comparative study of the effect of thorium and other substances on the renal parenchyma when retained. Jour. Urol., 1918, ii, 145-159.

8. Burns, J.E., and Schwartz, C.O.: Absorption from the renal pelvis in hydronephrosis due to permanent and complete occlusion of the ureter. Jour. Urol., 1918, ii, 445-455.

9. Cameron, D.F.: Aqueous solutions of potassium, and sodium iodids as opaque mediums in roentgenography. Jour. Am.Med.Assn., 1918, lxx, 754-755.

10. Cameron, D.F., and Grandy, C.C.: Sodium and potassium iodids in roentgenography. Jour. Am. Med. Assn., 1918, lxx, 1516-1517.

11. Crowell, A.L.: Collargol in pyelography with report of an interesting case. Jour. Am. Med. Assn., 1914, lxiii, 1387-1389.

12. Dederer, C.: Studies in transplantation of whole organs. I. Autotransplant of the left kidney to the neck with right nephrectomy in the dog. Jour. Am. Med. Assn., 1918, lxx, 6-9.

13. Eisendrath, D. N.: Influence of collargol injections into the pelvis of the kidney. Internat. Jour. Surg., 1914, xxvii, 161-163; The effect of injecting collargol into the renal pelvis. Jour. Am. Med. Assn., 1914, lxii, 1392; The effects of collargol as employed in pyelography; an experimental study. Jour. Am.Med. Assn., 1915, lxii, 128-132; Ascending infections of the kidney. Jour. Med. Research, 1917, xxxv, 295.

14. Eisendrath, D.N., and Schultz, O.T.: Lymphogenous ascending infection of the urinary tract. Tr. Sect. Genito-Urin. Dis. Am. Med. Assn., 1916, lxvii, 300-309.

15. Huber, G.C.: The arteriolae rectae of the mammalian kidney. Am.Jour. Anat. 1907, vi, 392-406.

16. Kelly, H. A., and Lewis, R.M.: Silver iodide emulsion - a new medium for skiagraphy of the urinary tract. Surg., Gynec. and Obst., 1913, xvi, 707-708.

17. Keyes, E.L. Jr., and Mohan, H.: The damage done by pyelography. Am.Jour. Med.Sc., 1915, cxlix, 30-41.

18. Krotoszyner, M.: Untoward results of pyelography. Surg., Gynec. and Obst., 1914, xix, 522-527.

19. Mason, J.M.: Dangers attending injections of the kidney pelvis for pyelography. Jour. Am.Med.Assn., 1914, lxii, 839-843.

20. Quinby, W.C.: The function of the kidney when deprived of its nerves. Jour. Exper. Med., 1916, xxiii, 535-548.

21. Smith, O. E.: Sudden death following pyelography. Am. Jour. Urol., 1914, x, 121-123.

22. Tennant, C.E.: The cause of pain in pyelography, with report of accidental and experimental findings. Ann. Surg., 1918, lvii, 888-893.

23. Thomas, G.J.: An apparatus for the injection and lavage of the pelves of the kidneys and ureters. Jour. Am.Med.Assn., 1913, lx, 184.

24. Vest, C.W.: Observations following the use of collargol in pyelography,. Bull. Johns Hopk. Hosp., 1914, xxv, 74-77.

25. Weld, E. H.: The use of sodium bromide in roentgenography. Jour. Am.Med. Assn., 1918, lxx, 1111-1112.