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RADIOGRAPHIC DIAGNOSIS OF RENAL LESIONS.

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Since the more general practice of nephrotomy has demonstrated the difficulty of diagnosticating cases of renal calculi with any degree of certainty, the demand for a more positive method has been apparent, and the discovery of Röntgen, twelve years ago, was at once eagerly seized upon as furnishing this method.

Radiographs of favorable subjects were made showing these lesions, and reports of these cases were heralded around the world, creating in the minds of the oversanguine the erroneous impression that the x ray furnished a simple and infallible solution of the problem. With the generally limited knowledge of the science then possessed, physicians, surgeons, and instrument makers at once provided themselves with x ray equipments and undertook to make radiographs of renal calculi with what would now be regarded as crude apparatus.

As a result radiographs were made, giving shadows which were interpreted as calculi, but which, in many cases, were not sufficiently distinct to justify a positive diagnosis, and in none of these early plates was there sufficient detail to warrant a negative diagnosis. Such diagnoses were, however, frequently made, and in many cases proved erroneous, with the result that this method fell into disrepute, and it is with considerable difficulty that it is becoming reinstated in its proper place.

Three years ago this spring, after making a number of satisfactory radiographs of the renal and ureteral region, I read a paper before the genitourinary section of the New York Academy on The Negative and Positive Diagnosis of Renal and Ureteral Calculi by the Ray of Selective Absorption, and demonstrated some plates which showed calculi distinctly where the diagnosis had been verified by operation, and others which showed the psoas muscle and the tips of the spinous process distinctly enough to justify a negative diagnosis.

In some of these cases the symptoms of renal calculi were so characteristic that the operation was performed, and in only one patient was a stone found that was not shown in the radiograph, and in that case the plate did not extend high enough up to include the area of the pelvis of the kidney, where the stone was found on operation.

This success continued until the two tubes I was using gave out, and with new tubes the results were not nearly so satisfactory, and for several months it was with great difficulty that I obtained radiographs showing sufficient detail to justify a negative diagnosis.

During the winters of 1904 and 1905 I devoted much time to experimental work on the ray of selective absorption, and the results of this line of work are fully described in the *Archives of the Röntgen Ray*, May, 1905, and further experiments along the same line in the *Archives of Physiological Therapy*, December, 1906, or in the transactions of the *American Röntgen Ray Society*. In brief, this resulted in the separation of the x ray into three distinct varieties: 1, The direct ray; 2, the indirect ray; and 3, the secondary, or Sagnac, ray.

The purely direct ray when it can be obtained gives, on a well timed and properly developed plate, the greatest amount of detail, not only the structure of the bones, but the muscles, fasciæ, fat, and even the blood in the veins show very distinctly.

The indirect rays from the average tube are equally as powerful and abundant as the direct rays, and their effect is simply to fog the plate and obscure the detail of the direct rays. It has been demonstrated by Professor J. J. Thomson that the secondary, or Sagnac, rays are generated in and emanate from all substances under the action of the x ray in inverse proportion to the density of the substance, and I am convinced by my own experiments that they are produced to a greater extent by the indirect than the direct rays, and the effect upon the plate is detrimental in the same manner as the indirect rays.

Compression Blend.—The use of a diaphragm or compression blend cuts off the indirect rays to some extent and helps very materially in obtaining good radiographs of the renal and ureteral region, but it does not convert any greater percentage of the energy into direct rays.

With an apparatus so constructed that one has a preponderance of direct rays and using a compression blend to eliminate the indirect rays and limit the field in which the secondary rays are generated, we can obtain enough detail to enable one to make a negative or positive diagnosis of renal or ureteral calculi of sufficient size to justify an operation.

Technique.—The patient should be prepared for the radiograph by thorough catharsis the night previous and an enema just before the exposure is made. This is especially important when the patient is constipated and the stools are hard and dry. The bladder should also be empty.

Diet.—It is desirable that only a light breakfast should be eaten, and that the stomach should be empty before the radiograph is made.

Clothing.—The clothing should be removed from the part of the body to be radiographed, not that the clothing interferes so much with the rays, but they are likely to contain buttons, hooks and eyes, or pins, that might lead to a misinterpretation of the negative.

Position.—The patient then lies with his back flat on the table and the thighs flexed so that the small of the back is in contact with the plate. Raising the head or shoulders sometimes assists in securing this position.

Large Plate for Genitourinary Tract.—If one large plate is to be used to include both kidneys, both ureters, and bladder, the tube is placed vertically over the umbilicus, twenty or twenty-two inches from the plate.

Size of Plate.—An 11 x 14 inch plate is the small-

est size that will include both kidneys, ureters, and bladder, and if the patient is tall this is not large enough. Just previous to adjusting the plate under the patient it is well to test the tube. As the kidney moves from one half to two inches during respiration, the patient should hold his breath during the exposure, otherwise the shadow of a calculus will appear ill defined and indistinct, and if very small will appear as a blurred line.

Exposure.—The time of exposure varies from ten to thirty seconds, according to the size of the patient and condition of the tube. The radiograph should include the eleventh and twelfth vertebræ and ribs above, and extend about one inch beyond the tip of the coccyx below.

Compression Blend.—Much more detail may be shown when a compression blend or diaphragm is used. The compression blend not only compresses the parts and holds the patient quiet, but it also prevents to a large degree abdominal breathing. At the same time it so limits the area exposed that its use requires five radiographs to show the entire genitourinary tract, one for each kidney and the upper part of the ureter, one for each ureter, and one for the bladder and lower part of each ureter.

Renal.—The radiograph of the kidney region should show the eleventh and twelfth ribs, and the first, second and third vertebræ (lumbar).

Ureteral.—The ureteral radiographs extend from the third lumbar vertebra to the brim of the pelvis.

Bladder.—The radiograph of the pelvis includes the pubis below and extends up as far as possible.

Full Set of Plates.—The necessity of making a full set of plates cannot be too strongly urged. An oculist would not limit his examination to one eye, or an aurist to one ear, nor would a diagnostician make a physical examination of one side of the chest, even although all the pain was on that side. Why should a radiographer make a radiograph of one kidney? In a number of cases, which I will mention later, calculi have been shown on the opposite side from which the pain occurred, or calculi have been present on both sides and only given symptoms on one. If an opinion is desired as to the size, shape, position, and density of the kidney, then surely a radiograph of both kidneys is necessary for comparison.

Interpretation of Plates.—The interpretation of the plate is more important and more difficult than making it, and lack of care and experience in this is the cause of most of the errors that have been made in the diagnosis of renal and ureteral calculi by the x ray.

A person unfamiliar with woodcraft is astonished at the way an old hunter can follow the track of an animal in the woods, yet when his attention is called to the barking of a fallen log, the slight imprint in the ground, the turned leaf, or broken twigs, etc., they are all apparent. It is much the same in reading x ray plates—the shadows are there, and any one can see them when they are pointed out.

It requires a careful study and comparison with other plates by a trained eye to detect slight shadows, and it requires experience to determine whether they are due to calculi or one of many other things which I will mention later. This has been especially impressed upon me during the preparation of this paper, when I have studied nearly fifteen hundred plates, made during my practice, some of the earlier ones showing shadows of what I then failed to recognize as possible calculi, requiring repeated exposures for verification.

It is unwise to make a diagnosis on a wet plate; drops of water and the glistening of the wet surface interfere with the detail. The plate should be allowed to dry slowly and the back of the plate thoroughly cleansed and polished. It should then be carefully studied and compared with other plates in a good even light. Some prefer an illuminating box where the light can be controlled with a rheostat, but personally I prefer a northern sky or daylight with a ground glass, holding the plate in my hands so that it may be tilted at different angles to show finer gradations of the shadow.

One is not justified in making a negative diagnosis of renal or ureteral calculus, unless a plate of the renal region shows the following detail, which is shown in Fig. 1: 1, The spine and transverse processes should show distinctly all the way to the tip. 2, The outer border of the psoas muscle must show. In some very flabby, fat patients it may not show as distinctly as the kidneys. 3, The eleventh and twelfth ribs should show distinctly, and in many cases the bony detail may be distinctly seen. 4, In about 75 per cent. of the cases the kidney may be seen more or less distinctly, and if special care in technique is used, it may be shown in nearly every case. 5, The liver is frequently seen, and at times it interferes with showing the convex surface of the upper pole of the right kidney. 6, The spleen also may be seen, especially if it is enlarged or congested. 7, Accumulation of gases in the colon and small intestines appear on circumscribed areas, and folds in the walls of the intestines are often seen traversing these areas. 8, Fæces in the intestines, especially in the colon, show very distinctly, and interfere very materially with the diagnosis of renal lesions.

Ureteral.—The plate of the ureteral region should include the third, fourth, and fifth lumbar vertebræ, and part of the sacrum and ilium. The bony detail should show distinctly, and the sacroiliac synchondrosis should be well defined. The outer border of the psoas muscle is clear, and the accumulation of gas and fæces are frequently seen in the cæcum or sigmoid. The course of the ureter is about on a line with the tips of the transverse processes, and at the sacroiliac synchondrosis. Calcified arteries are sometimes seen in the plates.

Pelvis.—This plate shows the pubes, bony structure of the spine of the ischium, sacrum, and coccyx all the way to the tip. The bladder distended with urine is sometimes well marked, also when injected.

Diagnosis.—Up to the present time the radiographic diagnosis of the genitourinary tract has largely been limited to the negative or positive diagnosis of renal, ureteral, or vascular calculi. We will therefore consider this subject first.

After having made and carefully studied about fifteen hundred plates of the genitourinary tract in about five hundred cases, I believe that a plate having the described detail will show any variety of

renal, ureteral, or vascular calculi of sufficient size to justify an operation—that is, one that is too large to pass.

In view of the fact that some of the best authorities disagree with me in this statement, it is with reluctance that I make it, but after carefully experimenting with the softest calculi that I could obtain, and in one case using the very stone it was stated would not show, I am convinced that I am justified in making this statement. I placed the stone behind a patient and made an exposure, and it showed very distinctly on a plate placed behind him. This, of course, is much easier than if it were in the kidney. I then placed it on the abdomen of a large man, and it showed distinctly. This was much more difficult than showing it in the kidney, because the further the calculus is from the plate the less distinct it is. Not satisfied with this, I imbedded this calculus in paraffin and placed it behind a patient the same distance from the plate that it would be if it were in the kidney, and it showed distinctly. Fig. 23 shows a cystine calculus, which is one of the varieties that some authorities claim cannot be shown by x ray.

Differential Diagnosis.—In some cases, Figs. 2, 3, 4, 5, 14, 15, 19, 20, 21, 23, and 24, the calculi are so distinct that there is no difficulty in making the diagnosis. In others, Figs. 6 and 7, on account of the size or indistinctness of the shadows, it requires the careful study of several confirmatory plates to make a positive diagnosis or to distinguish between calculi and the following: 1, Fæcal concretions; 2, gallstones; 3, calcified costal cartilages of the eighth and ninth ribs; 4, spiculæ of the bone; 5, small calcarious bodies or so called phleboliths; 6, folds of intestines; 7, enteroliths; 8, foreign bodies in intestines; 9, calcified arteries; 10, calcified lymphnoids; 11, prostatic calculi; 12, finger marks; 13, developing stains from uneven flood of developer; 14, flaws in plates; 15, tuberculous kidney; 16, shot in back; 17, unknown.

1. Fæcal concretions.—We are most frequently called upon to distinguish between the shadows of calculi and those of fæcal concretions, such as shown in Fig. 8, and it is unwise to make this distinction on one plate.

Calculus.	*Fæcal Concretions.*
If the patient has held his breath, the edges of the calculus will appear clear cut and well defined. The shadows are more dense for their size, and are only seen in the region of the kidney or ureter, and the most important thing is to give time for fæcal concretions to move out of the field or change position, and if the shadow remains in the same place it is not fæcal concretion.	The edges of the shadows are ill defined, and the shadows less dense than those of calculi of the same size. They are usually multiple and at least some are not in the region of the kidney or ureter, and if time is allowed to elapse between exposures and a cathartic and enema are given, the concretion changes its place or disappears entirely.

2. Gallstones.—Gallstones may be shown with patients on back, but are more clearly defined when patient lies with abdomen flat on the plate. The reverse is true of renal calculi. Shifting the tube slightly changes the position of the shadow of the gallstone more than it does the shadow of the kidney stone.

3. Calcified costal cartilages of the eighth and ninth ribs.—The calcified costal cartilages of the eighth and ninth ribs resemble renal calculi very closely. They may appear, as is shown in Fig. 9, in the kidney in the same positions in repeated exposures. There is usually more than one costal cartilage calcified, which gives the appearance of a calcarious deposit throughout the kidney, more than an isolated calculus, or two or three calculi, and are usually bilateral. They may be definitely distinguished from calculi by having the lip of the compression blend under the free border of the ribs; therefore, whenever the shape of a person is such that the compression blend must be on top of the free border of the ribs in order to include the renal region, these shadows must be distinguished from calculi.

4. Osteoplaques or spicula of bone.—In cases of osteoarthritis of the vertebræ, they resemble ureteral calculi. They are a trifle nearer the spine than the normal course of the ureter, and the other changes of the spine, such as lipping and destruction of the cartilages, are always present.

5. Small calcareous bodies or so called phleboliths.

Calculus.	*Calcified Bodies.*
Usually single and only on one side. If multiple they are arranged in lines which correspond with the course of the ureter, usually are irregular and have rough edges. If they are round, or small with rough edges, they change position between exposures with attacks of renal colic and blood in urine. They must be in line with the course of the ureter.	Calcified bodies near the lower end of the ureter usually are multiple and on both sides. When multiple they are arranged in a line running in the opposite direction to the course of the ureter. They are round with smooth edges and so small that were they calculi they would pass or change position between exposures. Usually they are one-quarter to three-quarters of an inch to the outer side of the ureter.

Ureteral catheterization, which is discussed later, aids very materially in distinguishing between these conditions.

6. Folds of intestines.—These are not as well defined as calculi; usually seen only accompanied by accumulation of gas and appear as long, narrow shadows instead of the shape of calculi. Unless the fold is permanent and held in place by adhesions, it does not appear in confirmatory plates.

7 and 8. Enteroliths and foreign bodies.—Enteroliths and foreign bodies change their position. A Murphy button in the stomach viewed edgewise might readily be taken for a large calculus, but sooner or later it would show the hole in the centre.

9. Calcified arteries.—Calcified arteries usually are bilateral and show the tortuous course of the arteries, and are not in the position of the kidney or ureter. Whether the shadow shown in Fig. 12 is a single calcified plaque in an artery which shows indistinctly, or a true phlebolith in a vein, is undecided, but it is certain that it is not a calculus in the ureter.

10. Calcified lymphoids.—Calcified lymph glands, especially those in the pelvis, resemble calculi very much. They usually, however, are multi-

ple and not in line with the normal course of the ureter.

11. Prostatic calculi.—Prostatic calculi are further down than ureteral or vascular calculi, and more closely resemble phleboliths.

12. Finger marks.—Finger marks made during the development of the plates might readily be mistaken for stone.

13. Developing stains from uneven flood of developer.—Irregular flooding of the plates during developing may leave a small area that resembles a stone.

14. Flaws in plates.—A slight flaw in a plate came as near causing me to make an error as anything I have seen. The case I have in mind, shown in Fig. 12, appeared as a small, well defined, round shadow with clear cut edges, exactly in the region of the kidney and about the place the patient had complained of the greatest pain. Up to this time I had only made confirmatory plates in doubtful cases, and this did not appear to be a doubtful case, but, fortunately, a confirmatory plate was made and the spot had disappeared. On closer study one could see it was a flaw in the plate.

15. Tuberculous kidney.—Some cases of tuberculous kidney may be very readily diagnosticated by x ray, as shown in Fig. 13. In this case the entire kidney was involved with an old, slow tuberculous process. A radiograph made two years previous to this one was the first in which I felt justified in making such a diagnosis. It was later confirmed by the finding of tubercle bacilli, but the patient refused operation, and we are thus able to watch the development of the case by a series of radiographs. In another case the process was so distinct that it was difficult to distinguish between it and calculus, but as the treatment for each was the same the differential diagnosis was not so important.

16. Shot in back.—Shot in the muscles of the back are more distinct and the edges more clear cut than calculi.

17. Aside from these possible mistakes we find well defined permanent lesions which I have been unable to diagnosticate.[1]

X Ray versus Exploratory.—Anyone who has hunted for a needle in a finger, even after a radiograph has shown its presence and apparently its exact position, realizes how difficult it is to find a foreign body. The finger is much smaller than the kidney, there is nothing to prevent cutting in all directions, hæmorrhages may be prevented, and all the circumstances are most favorable, yet few persons except radiographers know how prolonged and unsuccessful operations for foreign bodies frequently are. How often you hear this phrase: "The x ray showed a stone, but none was found on operation." No one would question for a minute the fallacy of the exploratory operation, especially if the kidney was split and the calices explored with the finger. The following cases would show the relative value of x ray and exploratory incision:

The writer radiographed a patient, as shown in Fig. 14, and made a diagnosis of six calculi, a large one in the pelvis, and five small ones apparently in the calices. An operation was performed by a very careful surgeon, the kidney was split and the large stone was found. A thorough search was made by the surgeon and his assistant for the small ones. The calices were explored with the finger of each of the operators. Assuming that the nodules on the calculus were what I had interpreted as five small calculi, they informed me that the radiographic diagnosis of a large calculus was correct, but that there were no small ones present. About six weeks later the patient had a severe attack of renal colic and passed five of the largest calculi that could possibly pass. The large calculus was in such a position that the small ones could not possibly have slipped past into the ureter before or during the operation.

A number of cases are on record where the calculus had been shown in radiographs and not found on operation, but later the diagnosis has been verified by removal of the kidney, when the calculus has been found. Are surgeons justified in saying that the calculi are not present after an exploratory operation, when a satisfactory radiographic examination and positive diagnosis have been made?

Catheterization versus X Ray in the Diagnosis of Renal and Ureteral Calculi.—Comparing the relative value of catheterization and x ray, so much depends on the technique of the one and the dexterity with which the other is performed that we will only compare the results of the best of each. Each has its dangers.

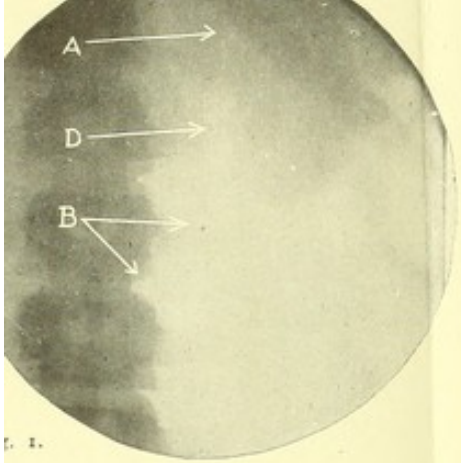
In x ray there is the danger of the so called burn, but with the short exposures of thirty to fifty seconds this is practically eliminated. The danger of infection and shock from ureteral catheterization you are in a position to know better than I am, and the discomfort, to say the least, well—the patient is the best judge of that, and most of them have very decided views on this subject.

As to their value, each has its place. Many things can be determined with the catheter that cannot be with the x ray, but in the diagnosis of renal calculus, if you cannot find a stone in the kidney when it is split open by examining each calix with your finger, how do you expect to make a negative diagnosis of calculus at the other end of a catheter sixteen inches long? And with what certainty can one say that he touches a stone in the pelvis of the kidney? In the diagnosis of ureteral calculi the catheter is of more value than in renal, as one can say with certainty that he meets with an obstruction so far from the bladder, and with wax tips or other devices, in some cases may be reasonably sure it is a stone, but whether it is small or large, smooth or rough, and whether it will move or not, it is impossible to say.

A radiograph as reproduced in Fig. 15 will show the size, shape, and position of a calculus, and with a little experience one can tell whether it will pass or not. A small, rough one will lodge, while a smooth one of astonishing size will pass. On the other hand, small calcified bodies near the lower ends of the ureters, called by many phleboliths, are frequently mistaken for calculi. The characteristic differences between these are described early in this paper, but a combination of catheterization and x ray, as shown in Fig. 16, is of greatest value, using a styleted catheter and making a radiograph.

As I said, these phleboliths are usually about one half to three quarters of an inch to the outer side

[1]These are not reproduced because of lack of space.



g. 1.

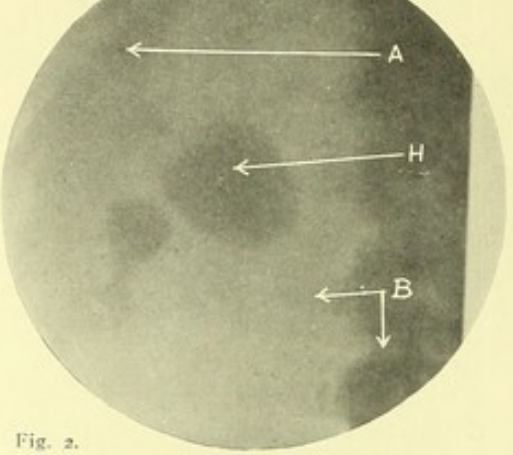


Fig. 2.

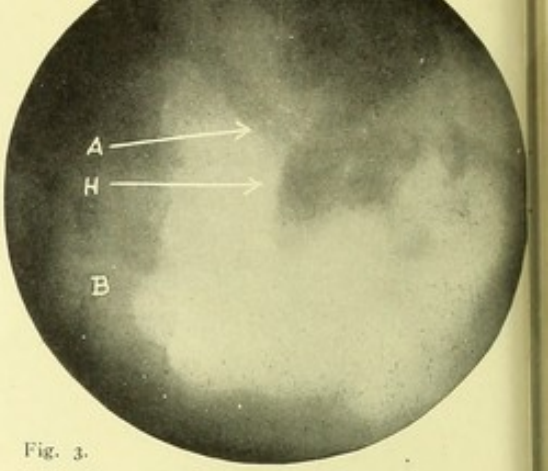
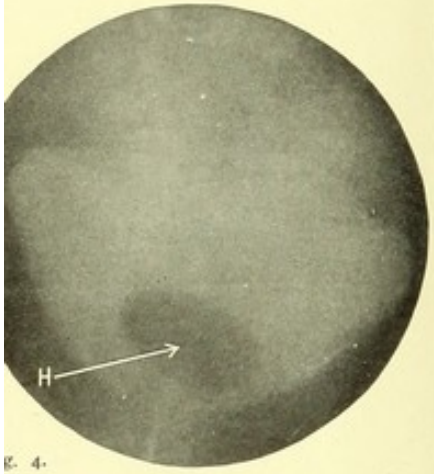


Fig. 3.



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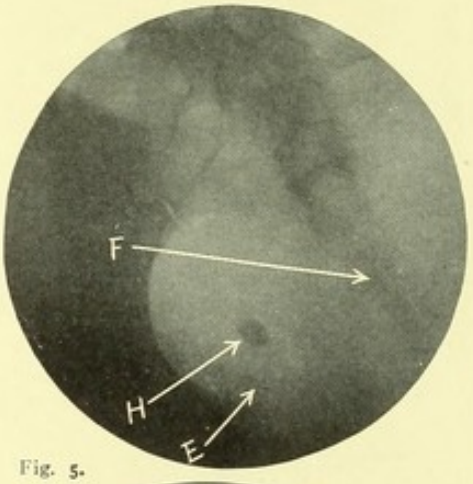


Fig. 5.

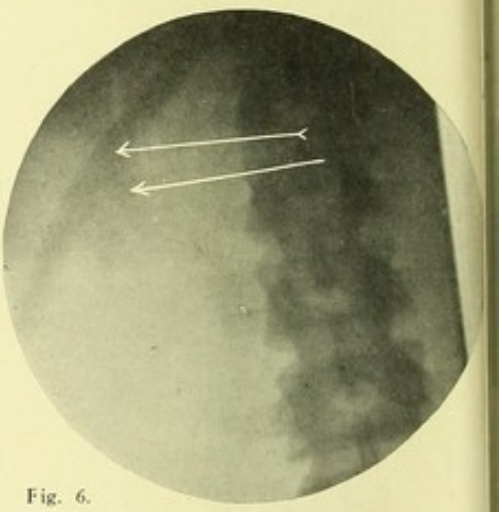
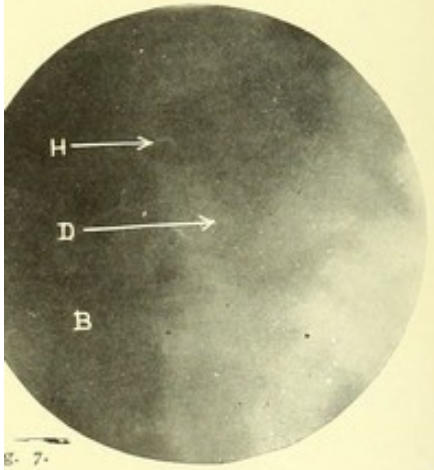


Fig. 6.



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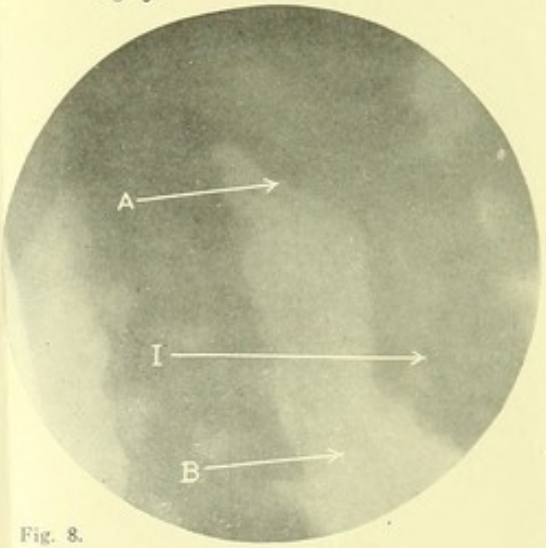


Fig. 8.

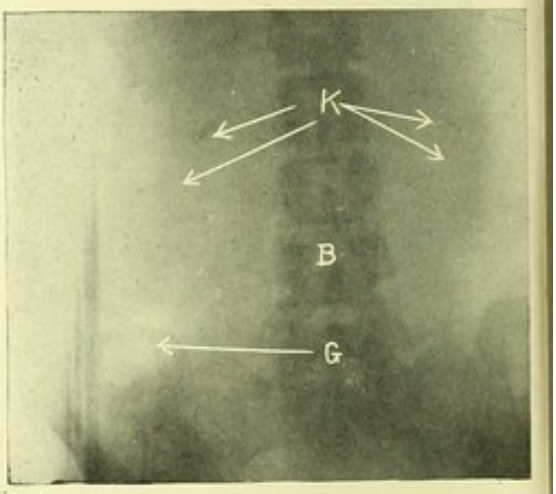
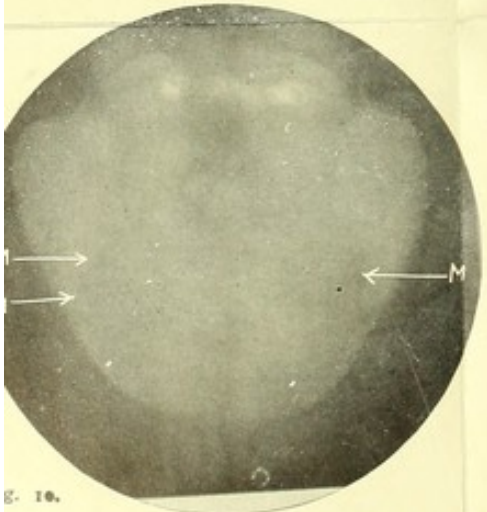


Fig. 9.



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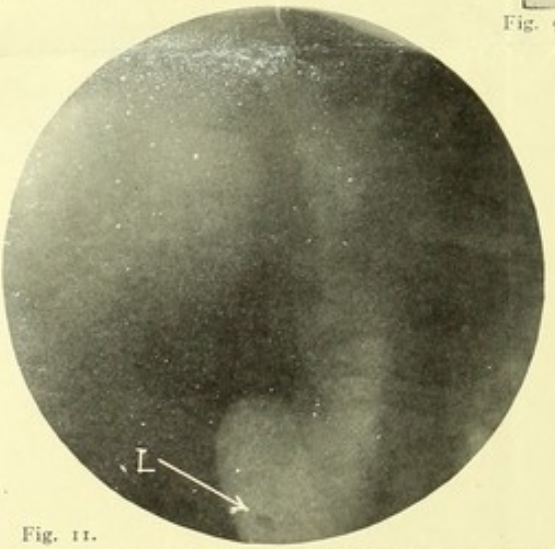

Fig. 11.

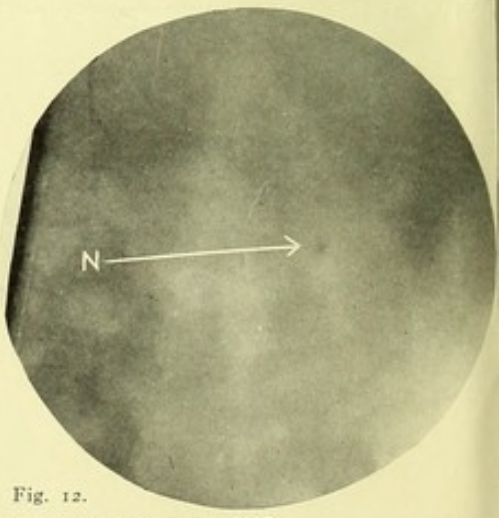

Fig. 12.

ILLUSTRATING DR. COLE'S ARTICLE ON ROENTGENOLOGICAL DIAGNOSIS OF RENAL LESIONS.

Key to the illustrations: *a*, ribs; *b*, spine and transverse process; *c*, psoas muscle; *d*, kidney; *e*, spine of ischium; *g*, gas in intestines; *h*, calculus , fæcal concretions; *k*, calcified costal cartilages; *l*, calcified artery; *m*, phleboliths or calcified bodies; *n*, flaw in plate; *o*, tuberculous kidney; *p*, styletted ca heter in ureter. Fig. 1, normal kidney; Fig. 2, two large calculi in kidney; Fig. 3, large branching phosphatic calculi; Fig. 4, large vesical calculus; Fig s, ureteral calculus; Fig. 6, small soft renal calculus; Fig. 7, renal calculus; Fig. 8, fæcal concretions resembling calculus; Fig. 9, calcified costal cartilages Fig. 10, phleboliths or small calcarous bodies resembling ureterocalculi; Fig. 11, calcified plaque in artery or vein; Fig. 12, flaw in plate resembling small cal culus.

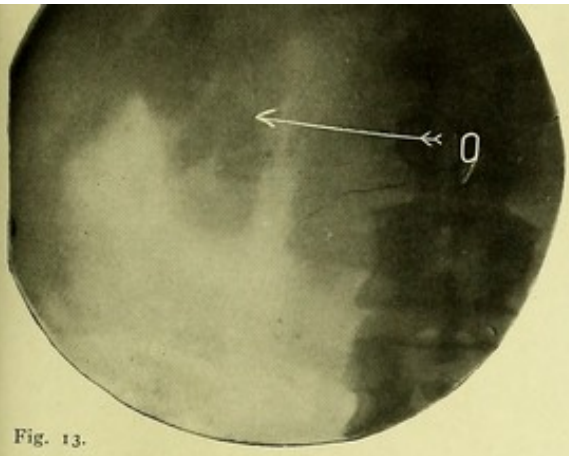

Fig. 13.

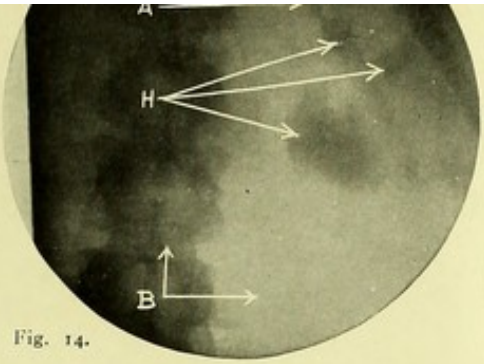

Fig. 14.

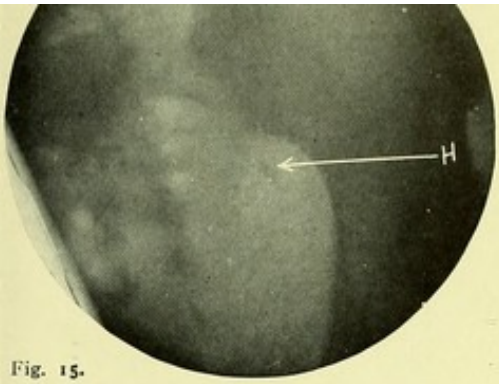

Fig. 15.

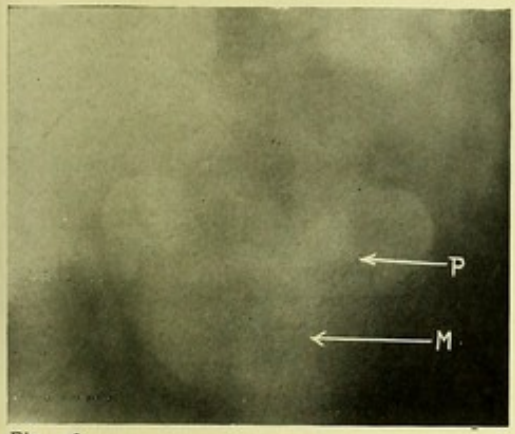

Fig. 16.

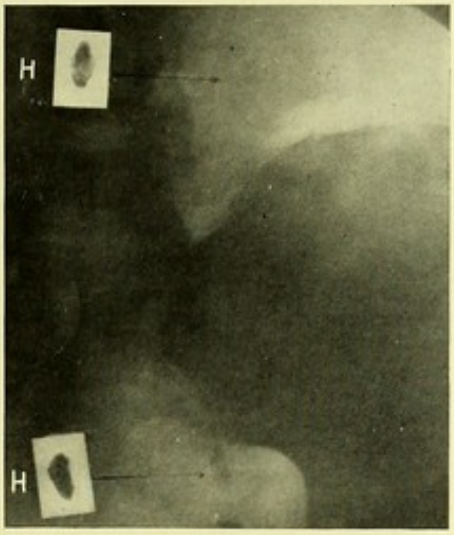

Fig. 17.

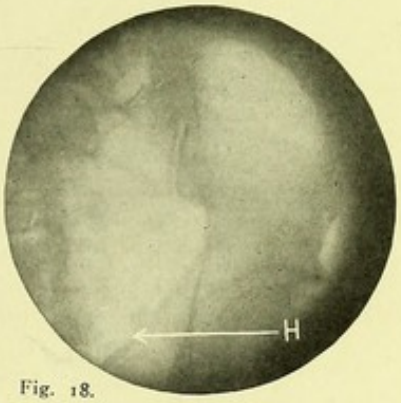

Fig. 18.

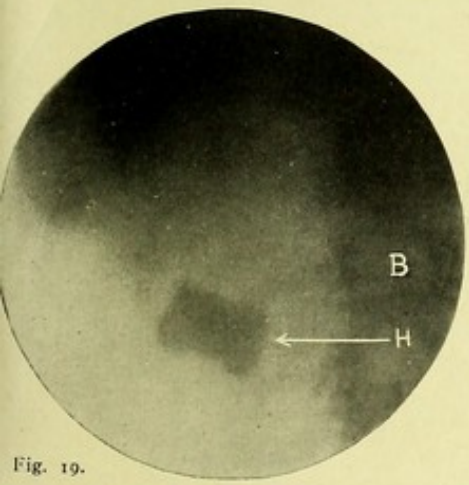

Fig. 19.

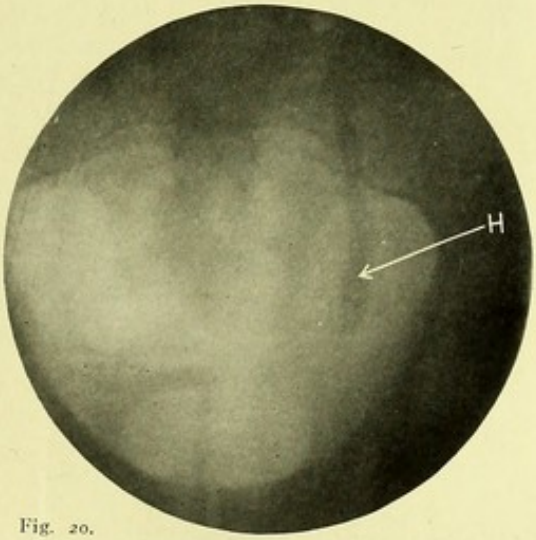

Fig. 20.

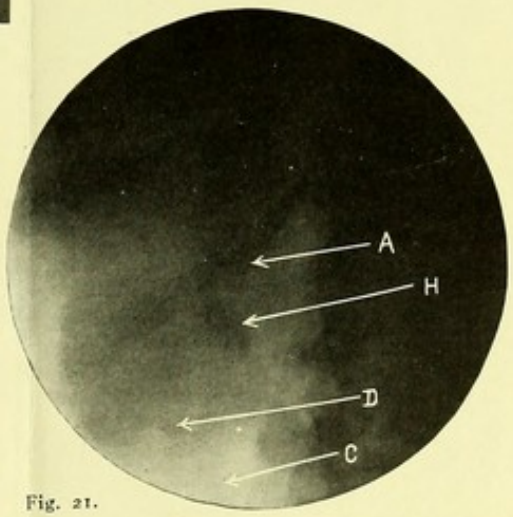

Fig. 21.

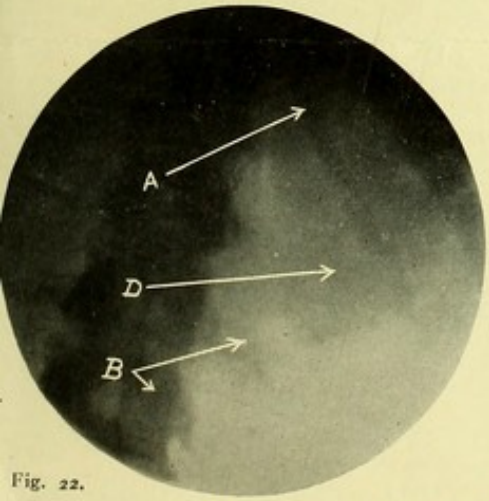

Fig. 22.

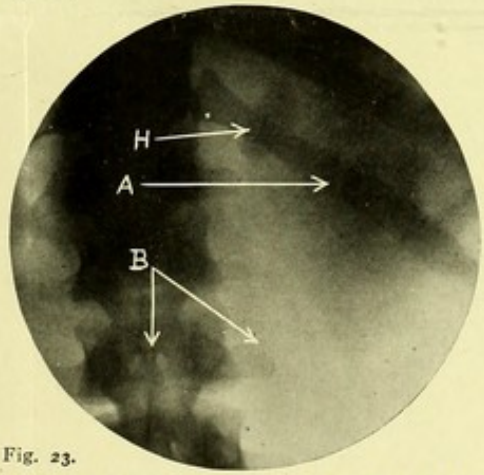

Fig. 23.

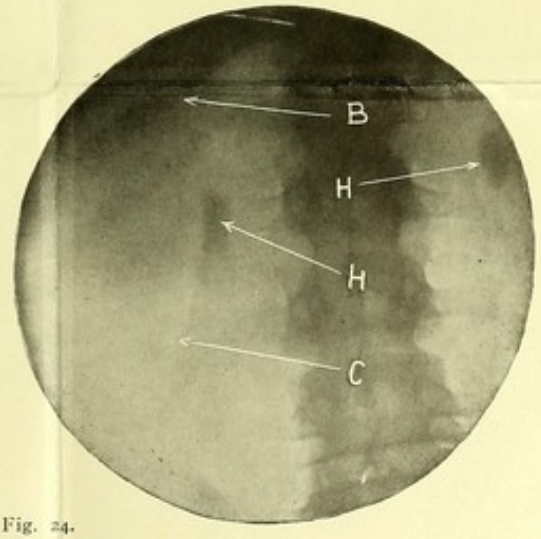

Fig. 24.

ILLUSTRATING DR. COLE'S ARTICLE ON ROENTGENOLOGICAL DIAGNOSIS OF RENAL LESIONS.

Key to the illustrations: *a*, ribs; *b*, spine and transverse process; *c*, psoas muscle; *d*, kidney; *e*, spine of ischium; *g*, gas in intestines; *h*, calculus; , fæcal concretions; *k*, calcified costal cartilages; *l*, calcified artery; *m*, phleboliths or calcified bodies; *n*, flaw in plate; *o*, tuberculous kidney; *p*, styletted ca-heter in ureter. Fig. 13, tuberculous kidney; Fig. 14, one large and five small renal calculi; Fig. 15, ureteral calculus; Fig. 16, styletted urethral cathe-er showing course of ureter and phlebolith; Fig. 17, two ureteral calculi passed; Fig. 18, calculus migrating through ureter; Fig. 19, renal calculus; Fig. 20, ureteral calculus; Fig. 21, renal calculus and kidney; Fig. 22, congested kidney; Fig. 23, cystine calculus; Fig. 24, renal calculi in both kidneys.

of the course of the ureter, but sometimes directly in line with the ureters, and in the x ray appear to lie against the catheter. It is wise to make two radiographs at different angles to prevent this source of error. The following cases will show the fallibility of making a negative diagnosis of ureteral calculus, even though the catheter passes all the way to the kidney with little or no obstruction.

Case I.—The first case of ureteral calculus that I radiographed showed a well marked shadow at the lower end of the ureter, oval in shape and about one centimetre long. It appeared in several plates. Ureteral catheterization showed no obstruction at this point. An exploratory operation was performed and on palpation no calculus could be felt. The ureter was opened and a catheter was passed down into the bladder without meeting with an obstruction. Aa that time I was not familiar with so called phleboliths, and insisted there must be a calculus, so just before the wound was closed a further search was made and the calculus was found in a pocket it had formed in the ureter just before it passes into the bladder. It was pushed out of the pocket into the ureter and out of the opening near the kidney.

Case II.—The second case was where a young woman was catheterized by one of the most eminent genitourinary surgeons in the country, with a wax tipped catheter, and the catheter was passed up to the kidney without obstruction, but with a scratch on the wax tip. Preparations were made for an operation, but an x ray failed to show the calculus in the kidney. The ureter was again catheterized and there was no obstruction in the ureter, or scratch on the wax tip of the catheter. The operation was indefinitely postponed, and later the case was referred to me by another surgeon. Fig. 5 shows very distinctly a calculus about one half inch in diameter near the lower end of the ureter. An operation verified the findings of the radiograph. The surgeon says the calculus passed from the kidney to the lower part of the ureter between the time of his last examination and my first. This, of course, I cannot disprove.

Considering the previous case and the following case which I am about to describe, it seems possible, at least, that the calculus was in the ureter and the catheter passed it with little or no obstruction.

Case III.—The third case was referred by Dr. Bangs and Dr. Pederson, and their history of the case and record of operative procedure is as follows:

First attack of renal colic took place on July 12, 1907. It was severe on the right side; there was frequent vomiting; the pain was confined to right kidney region; no radiations; no bladder symptoms. Hæmaturia was not noted, perhaps because the patient did not look for it.

Second attack occurred the following day. It persisted for seven days with varying severity, some vomiting during first day. The pain remained localized as before.

For a month thereafter he suffered nagging pain every few days, lasting from a few seconds up to a few minutes.

Third attack happened on December 21, 1907. Very severe, no radiation.

Fourth attack took place on December 24; *the pain ceased suddenly.*

Fifth attack happened December 26th, and lasted from 10 p. m. until 5 a. m. Again *the pain ceased suddenly.*

Cystoscopy, performed on December 27th, showed no calculus in the bladder, and nothing distinctively pathological in its appearance.

Radiographic examination, December 28, 1907, showed two calculi (Fig. 17), one just below the brim of the pelvis and the other opposite the transverse processes of the fourth lumbar vertebra.

Cystoscopy and catheterization of right ureter was performed on January 8, 1908. No obstruction was encountered, no grating sensation was perceived.

Second radiographic examination, January 11, 1908, showed that the calculus, which was near the brim of the pelvis had descended to the lower end of the ureter, but that the upper one was in the same place, opposite the transverse processes of the fourth lumbar vertebra.

The lower stone was passed from the bladder, 11 a. m., January 12, 1908.

Cystoscopy and catheterization of right ureter performed on January 13th. Again no obstruction was felt. Patient was now free from all pain and tenderness over the right ureter.

Another attack of pain in the right kidney region, lasting ten minutes, during the night of February 24. Patient passed another almond shaped calculus similar in shape and size to the first calculus on February 11th. The patient when last seen (February 24th) had been entirely free from symptoms of any kind.

Radiographs of both calculi were made after he passed them, and these are reproduced in Fig. 17 with the first radiograph made of him.

These cases demonstrate that it is unwise to make a negative diagnosis of ureteral calculus, even if there is no obstruction in the ureter.

Do Calculi Perforate or Migrate Through the Walls of the Ureter?—The case just described, where a stone was found in a pocket near the lower end of the ureter and another case (Fig. 18), where a calculus was found to be imbedded in the walls of the ureter, seem to suggest this possibility, and Dr. Keyes told me of a case where a stone containing urinary salts was found in the abdominal cavity. In another case the catheter met with an obstruction about one and one half inches from the ureteral orifice. The case was radiographed at the patient's request to ascertain the size and shape of the stone and the possibility of its passing. No calculus was shown at this point, but there was a well defined one in the kidney, which was verified on operating.

One of the most important points that the writer has to make is, that many of the cases having *typical* attacks of renal colic do not have a stone in any part of the genitourinary tract, and when a calculus is shown in this class of cases it is usually so small that it will pass without an operation other than ureteral catheterization.

On the other hand, most of the cases in which renal calculi have been demonstrated by x ray have had no symptoms that were sufficiently characteristic to justify an operation, and only those that engage in the ureter or obstruct the pelvis cause typical renal colic. They may have pain either in the back or side, especially on jolting or riding in a car, tenderness over the kidney, dull aching, or especially what is described by them as a sense of weight or heavy feeling in the back. Figs. 19 and 20 demonstrate this class of cases very clearly. Fig. 19 shows a large rectangular calculus, in the pelvis of the right kidney, and Fig. 20 shows a calculus four inches long in the lower end of the right ureter of the same patient (in process of reproduction the plates are reversed, which causes it to appear on the left side), and yet the symptoms were not sufficient to designate which side the trouble was on. The patient had been treated for many months or a year for stomach trouble.

A great many of the cases diagnosticated as lumbago or rheumatism of the back have renal calculi. Whether the calculus is the cause of the lumbago, or the lumbago the cause of the calculus, is not for me to decide.

Calculi giving symptoms of chronic appendicitis are very common. Several of the cases in which

calculi have been demonstrated were diagnosticated as appendicitis, and radiographs have been made just to eliminate the possibility of calculus. This has occurred in so many cases that some physicians are having nearly all cases of obscure abdominal lesions radiographed. The wisdom of this is particularly shown in the following cases:

CASE IV.—A woman, fifty years, complained of symptoms which were diagnosticated as appendicitis (chronic). She traveled a great deal both in this country and abroad, and her hobby was to get the opinion of the best authorities in every country, and strange as it may seem, they nearly all agreed that it was appendicitis in some form or another. She finally came under the care of a physician who had many of his obscure abdominal lesions radiographed, particularly those of appendicitis, to distinguish them from renal calculi. This case, as shown in Fig. 7, had a stone in the pelvis of the kidney, and repeated urinary analysis had given no indication of stone.

Ten or eleven of the fifty-four cases in which I have demonstrated renal calculi have complained of all the pain, or the most severe pain, on the opposite side from that on which the calculus was found. Fig. 21 shows one of these cases. This is such a peculiar fact, requiring a detailed history of each case to make it complete, that it seems unwise to incorporate it in this paper; I therefore merely mention it here to show the necessity of making radiographs of both sides.

Besides making a positive or negative diagnosis of renal or ureteral calculi, much information may be gained by a radiograph having sufficient detail to show the kidney distinctly. The density, shape, size, and position may help very materially in making the diagnosis of tuberculosis, new growth, prolapse, and congestion of the kidney, and ascertaining the presence of the kidney on the opposite side.

The kidney may be seen more or less distinctly in about 75 per cent. of the cases, and if special care in technique and selection of tubes is used, it may be shown in nearly every case. Strange as it may seem, the size of the patient has very little influence—indeed, in large, fat persons it is more frequently seen than in thin ones. This may be accounted for by difference in density between the kidney and fat it is imbedded in; the more fat the greater this difference is. The soft tissues of some patients are much more dense to the rays than others, and where this is so the kidney shows very distinctly compared with the spine, which in these cases shows indistinctly.

The repeated appearance of one kidney and not the other, or the increased density of one compared with the other, or with the psoas muscle, indicates a change in the kidney, and if this density is uniform, and the kidney is not mottled, it is due, probably, to congestion of that organ, as shown in Fig. 22. If the kidney appears mottled, as shown in Fig. 13, or of irregular density, it would indicate tuberculosis or new growth, and if the contour of the kidney is changed in addition to the irregularities of density and mottleness, it increases the probability of new growth. Several confirmatory plates are necessary, and these shadows must be differentiated from the same things calculi are, particulary fœcal accumulations.

Size.—The size of the kidney compared with the opposite one may be fairly accurately determined but it must be remembered that it is slightly enlarged in the radiographed. The amount of this depends on the distance of the x ray tube from the kidney, and the distance of the kidney from the plate. In a person of ordinary size, with the tube eighteen inches from the plate, the radiograph represents the kidney about one half to three quarters of an inch larger than it really is. In some cases the pelvis of the kidney and the ureter show distinctly, but it is doubtful if this is of any pathological significance unless it is thickened and irregular, which would indicate tuberculosis (Fig. 13).

The position of the kidney at the time the radiograph is made may be demonstrated very accurately if the position of the tube is considered. If the kidney is shown to be out of place, the diagnosis of floating kidney is positive, but if it is shown to be in its normal place it does not indicate that it is not movable, as the position of the patient, and particularly the pressure of the compression bleno tend to cause it to assume its normal position.

Résumé.—The principal points that should be remembered are:

With a limited knowledge of the science, radiographs have been made which did not have sufficient detail to justify a negative or positive diagnosis, and persons without sufficient experience have made negative or positive diagnosis on these plates.

The separation of the x ray into three varieties. The value of the direct in radiography and the detrimental effect of the indirect and secondary.

The interpretation of the plate is more important and more difficult than making it.

The amount of detail necessary for a negative diagnosis.

Technique, diet, clothing, catharsis, position, exposure, etc.

Necessity of making full set of plates.

Reasons for believing that one is justified in making a negative diagnosis of calculus when detail as described is present.

Things calculi must be distinguished from.

X ray versus exploratory examination in the diagnosis of calculi.

X ray versus ureteral catheterization in the diagnosis of calculi.

Most patients having typical attacks of renal colic do not have stones, and, on the other hand, only very few of the patients who have calculi have symptoms sufficiently characteristic to justify an operation.

Similarity of symptoms of chronic appendicitis and renal or ureteral calculi.

About one quarter of the patients in whom calculi are found have the most pain on the opposite side.

Value of the x ray in the diagnosis of tuberculosis, new growths, and nephroptosis.

One cannot expect any great amount of success in renal radiography when work requiring so much attention to detail is turned over to hospital orderlies, nurses, even physicians without any training or experience along this line.

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