A Clinical Lecture ON DIAGNOSIS BY PYELOGRAPHY.*

(With Special Plate.)

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PYELOGRAPHY (πύελος, the pelvis; γραφή, a delineation) is the radiographic outline of the hollow part of the kidney, after it has been distended by means of a ureter catheter, with a solution opaque to x rays. Its field of usefulness has been widened to such a degree that its aid must be often invoked if an exact diagnosis is to be arrived at, not only for numerous lesions of the urinary tract, but also in some obscure abdominal lesions.

Pyelography dates from 1906, when Voelcker and von Lichtenberg first demonstrated the outlines of the renal pelvis and calyces. For several years, however, the value of this diagnostic aid was unrecognized, and its popularization has been largely due to the outstanding work of W. F. Braasch of the Mayo Clinic. Perhaps more difficult than the making of a pyelogram is its interpretation, and it is for our knowledge of the interpretation that urologists are so particularly indebted to Braasch. His book on the subject is monumental.

It is now possible to diagnose by pyelography conditions such as pyelitis, pyelonephritis, hydronephrosis, renal ptosis, tubercle, and growth, together with congenital cystic kidneys and ureteral stricture. It is also valuable as a means of diagnosis in essential haematuria, in renal and ureteral calculus, and in cases of obscure extra-urinary tumour, or in which unusual shadows are seen on radiography.

The principles in the interpretation of typical conditions which it is possible to recognize by pyelography will first be given; later, brief descriptions of the history of representative clinical cases will be given, each case being illustrated by its pyelogram, and in some instances accompanied by a photograph of the pathological specimen removed at operation.

A good x-ray plant is indispensable, and the best results are obtained when the combined measures of ureter catheterization, followed by radiography, can be carried out on the same couch without moving the patient. Voelcker used a solution of collargol which gave a good shadow, but occasionally it damaged the kidneys; therefore thorium nitrate was substituted, but this sometimes had the same deleterious effect, though to a lesser degree. Sodium bromide, 25 per cent. solution, was found by Weld to give an excellent shadow; it was cheap, and did not cause any real damage. It, however, in some cases caused an acute temporary irritation of the mucous membrane of the urinary tract. I now use a 13½ per cent. solution of sodium iodide, as recommended by Cameron; I have never known it cause inconvenience, either local or general, to the patient, and it is easily sterilized.

The sterilized solution can be run into the renal pelvis either by gravity or by means of a syringe. It must be done carefully, so as to avoid overdistension with the resultant renal colic; at the same time sufficient distension must be achieved, otherwise an incompletely filled pelvis or calyces may give a misleading picture. Wherever possible ureters should be catheterized without a general anaesthetic; a pyelogram should never be made when the patient is unconscious, for to do so invites disaster by rupturing the renal pelvis from overdistension.

Anatomical Points.

To appreciate a pyelogram the gross elementary anatomy of the kidney must be borne in mind—namely, that the kidney comprises solid and hollow portions.

The *hollow part* of the kidney consists of the funnel-shaped pelvis, into which drain the cylindrical-shaped

calyces. The calyces are usually grouped into three main divisions, named upper, middle, and lower (see Fig. 13, left side). Into each main calyx drain the minor calyces, which vary in number. Although this is the usual grouping of the calyces, there are many variations of the normal which require experience for their recognition. For variations of the normal see Figs. 6, 10, and 12 (all left side), and 13 (right side).

The *solid part* of the kidney is made up of the surrounding outer cortical portion, enclosing an inner medullary part. The cortical portion does not immediately concern us. The medullary part is an aggregation of cone-shaped masses, each mass having its base towards the cortex and each apex projecting into a calyx (see Fig. 1).

The *normal position* of the kidney must be kept in mind: it roughly corresponds to the last dorsal and upper three lumbar vertebrae.

The *size* of the kidney can be approximately gauged by building an imaginary solid portion around the renal pelvis and calyces, as demonstrated on the pyelogram.

Interpretation of Pyelograms.

The interpretation of the pyelogram depends primarily on understanding (1) that the solid medullary apex projects into the outer end of the tube-shaped calyx (see Fig. 9), and (2) that if this tube-shaped calyx is distended with fluid such fluid surrounds the solid medullary apex which is projecting into that calyx (see Fig. 1).

Normal Pyelogram.—Fig. 3 is reproduced from a normal pyelogram. If the individual calyces are observed they will be seen to have cup-shaped outer ends; these show that the sodium iodide has surrounded the normally projecting apex of the solid renal medullary cone. Normal pyelograms will be seen also in Figs. 7, 10, and 13 (all left side).

Pyelonephritis and Hydronephrosis.—Compare the diagrams (Figs. 1 and 2). Fig. 4 is from an abnormal pyelogram, where there has been absorption of the solid apex of the renal pyramids. It will be seen that the outer ends of the calyces (instead of being cup-shaped as in the normal) are “knobbed.” This alteration is due to the absence of a projecting solid apex (see Fig. 2). Such rounding is indicative of inflammation, and indicates pyelonephritis with destruction of some portion of the solid renal tissue; an advanced stage of this “knobbing” is seen in hydronephrosis (see Fig. 6).

Ptosis of Kidneys.—Patients suffering from renal ptosis commonly complain of vague, long-standing abdominal pains. In these chronic cases a combination of the separate results of pyelography and a barium enema will make the diagnosis of general visceroptosis. Kinks and twists in the ureter are common in renal ptosis (see Fig. 13). Their discovery by pyelography may or may not be of moment; it entirely depends on the presence of “cupping” or “knobbing” in the minor calyces. “Cupping” indicates medical treatment, for there is no back pressure; “knobbing” means back pressure due to obstruction, and nephropexy may be required to straighten out the ureter and ensure a free onward flow of the urine.

Congenital Cystic Kidneys.—In a congenital cystic kidney there is a general enlargement of the organ, which is shared by the hollow part—that is, the pelvis and calyces (see Fig. 5). The knowledge is used in diagnosing this condition by pyelography. The disease is always bilateral, but one kidney is in a more advanced stage of disease than the other—that is, one is usually the larger. When only one enlarged kidney is felt, it might be mistaken for growth or hydronephrosis; and the surgical removal of a congenital cystic kidney is usually fatal from uraemia. Recently a patient was sent to me with two enormous tumours occupying the whole abdomen. It was thought to be possibly a case of malignant ovarian cysts, and operation was desired. Fortunately pyelography provided a definite diagnosis of congenital cystic kidneys, and a useless risky laparotomy was avoided.

Tuberculosis.—The characteristic tendency of tubercle anywhere in the body is for it to undergo caseation and disintegration, when the contents are discharged, thus leaving a cavity. In the case of a disintegrating kidney focus the tuberculous debris escapes into the nearest calyx and is voided down the ureter with the urine. Therefore,

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when making a pyelogram, the sodium iodide injected through the ureteral catheter escapes from the calyx into the disintegrated tuberculous cavity situated in the solid part of the kidney; the sodium iodide has escaped the normal confines of the hollow calyx and has "run amok" in the solid part of the kidney. A tuberculous pyelogram shows, therefore, a blurring in connexion with one or more calyces, according to the extent of the tuberculous disintegration (see Fig. 8).

Hypernephroma.—A hypernephroma usually invades one or other pole of the kidney when it involves at least one main calyx. Depending on the extent of the lesion, the resultant pyelogram may show one or two normal calyces only, while the third main calyx is absent; and the pyelogram has the appearance as if the calyx had been amputated (see Fig. 10).

Essential Haematuria.—From time to time a surgeon is asked to see a case of painless haematuria. Where the physical signs, apart from the non-purulent haematuria, are negative, the case may be one of considerable anxiety. Cystoscopy may disclose a normal bladder, also evidence from which kidney the patient is bleeding. Among other things, the bleeding may proceed from a malignant kidney, or it may be a case of essential haematuria. The fact that the patient is bleeding from a kidney does not necessarily demand exploration or nephrectomy, for pyelography will help in a diagnosis. If the urinary tract x-ray shadows and pyelogram are normal; if the ureteral catheter end is in the renal pelvis of the affected side and the urine withdrawn contains blood; if the blood pressure is normal; if the urine is free from pus and renal casts; and if the painless haematuria has been long-standing—then the diagnosis of essential haematuria will probably be correct. Such a diagnosis can only be arrived at by pyelography. If the pyelogram is at all suspicious it should be repeated after an interval, when a careful comparison of the two pictures should be made.

Urinary Calculus.—A uric acid calculus which may not throw an x-ray shadow will sometimes do so after distending the renal pelvis and allowing part of the opaque solution to drain away; some of the solution may adhere to the calculus and cast a shadow.

Shadows near the Line of the Ureter.—Extraureteral shadows can be differentiated by ureterography during pyelography, owing to the presence of some sodium iodide in the lumen of the ureter.

ILLUSTRATIVE CLINICAL CASES.

CASE I.—*Pyelonephritis.*

M. W., aged 30, had right flank pain for ten years and occasionally it was accompanied by vomiting. Nine months earlier the appendix had been removed without giving relief to symptoms. Physical examination showed a tender spot behind the right kidney and the urine contained pus cells microscopically.

Pyelography (see Fig. 4) showed "knobbing" of the calyces of the right kidney without dilatation of the pelvis or calyces, enabling a diagnosis of chronic pyelonephritis to be made. A bacteriological examination of the urine gave a pure culture of staphylococcus, and vaccine treatment was recommended.

CASE II.—*Hydronephrosis.*

Annie L., aged 15, for some years had attacks of right-sided renal colic, associated with increased frequency of micturition. On one occasion only had there been haematuria. Her urine contained pus and albumin. There was tenderness behind the right kidney, but neither kidney was palpable. Nothing abnormal was disclosed in the rest of the abdomen or on rectal examination.

The double pyelogram (see Fig. 6) shows a normal left renal pelvis and calyces, and an enlargement of this (see Fig. 3) is used as my example of a normal pyelogram. It also shows marked hydronephrosis on the right side, both pelvis and calyces being involved. If it is carefully observed the grouping into the three typical main calyces can be seen—namely, upper, middle, and lower; further, there is an advanced degree of "knobbing" of the minor calyces, due to the atrophy of the solid part of the renal tissue. This is a further stage of pyelonephritis (see Fig. 4). If the photograph of the cut surface of the removed kidney (see Fig. 7) be compared with the pyelogram the points mentioned can be confirmed—namely, the dilatation of the pelvis and calyces; the arrangement of the three main calyces (each marked by a short piece of wire); and the marked thinning of the solid part of the renal tissue, with the disappearance of the apex of all renal pyramids. The hydronephrosis was due to a stricture at the outlet of the renal pelvis. The patient made a good recovery after nephrectomy.

CASE III.—*Congenital Cystic Kidneys.*

H. S., male, aged 28, for some months had been suffering from typical attacks of right-sided renal colic. There had been polyuria

with slight haematuria. Recently he had had rigors, intense thirst, frontal headaches on awakening in the morning, and had lost weight. On examination both kidneys were enlarged, movable, and tuberoso, especially the left-sided one. The urine was of low specific gravity and contained pus.

Pyelography (see Fig. 5) showed general uniform enlargement of the pelvis and calyces of both kidneys, particularly the right. The clear definition of the pelvis and calyces outlines excluded tuberculosis, growth, and hydronephrosis, and confirmed a diagnosis of congenital cystic kidneys.

CASE IV.—*Example of Tuberculous Kidney.*

Mary K., aged 20, for some years had occasional pain behind the left kidney. Six months prior to admission she began to have mild attacks of renal colic associated with strangury, but with haematuria on one occasion only. She had lost weight and was troubled with night sweats. Examination disclosed tenderness and rigidity over the left kidney, but neither kidney could be palpated. On vaginal examination the thickened terminal portion of the left ureter could be felt in the left lateral fornix. Cystoscopy showed ulceration around the left ureteric orifice, which masked the opening so much that its catheterization was a matter of considerable difficulty.

Pyelography showed a typical tuberculous left kidney: a definite diagnosis of tubercle limited to the upper half of the kidney was made, and a nephrectomy was done on February 12th, 1925. The patient made an uninterrupted recovery. The pyelogram (see Fig. 8) shows a normal main lower calyx; the upper and middle calyces, however, have lost their definition and have a "fluffy" appearance. This made possible the diagnosis of tuberculosis limited to the upper half of the kidney. On reference to the cut surface of the removed specimen (see Fig. 9) the tuberculous ulceration and cavitation is seen in the upper half of the kidney, and is particularly in communication with the upper main calyx. The lower normal main calyx can be seen, and into it projects the normal apex of a medullary cone.

CASE V.—*Example of Malignant Growth.*

T. G., aged 59, male. Six weeks before admission there was profuse painless haematuria immediately after having lifted a heavy weight; there were no clots. This painless bleeding was the only symptom; it was intermittent, and occurred on six occasions prior to admission. Except for this the patient was in excellent health in every way. On admission his urine contained bright red blood; no other abnormal physical sign could be elicited, but cystoscopy showed blood trickling out of the right ureteric orifice.

Pyelography disclosed a normal left-sided pyelogram with an abnormal right-sided one. A definite diagnosis of malignant right kidney was made and a nephrectomy was done. The patient made an uninterrupted recovery and has now returned to his work as a coal miner. The abnormal pyelogram (see Fig. 10) is hooked at its upper end with a large oval shadow at the extremity, the oval shadow corresponding to a calyx. The absence of the other calyces (they had been cut off) with the renal distortion sufficed to convince me that I was dealing with a hypernephroma which had destroyed at least half of the kidney. The cut surface of the specimen removed at operation (see Fig. 11) shows that the lower two-thirds of the kidney has been replaced by growth, and that the dilated renal pelvis was also occupied by malignant growth. The injected sodium iodide had tracked up between the growth and the upper margin of the pelvis, to reach the normal calyx in the upper pole of the kidney.

Microscopically, Professor Stuart McDonald reports: "This is a typical hypernephroma, portions of which are distinctly adenomatous. There is extensive necrosis of the tumour growth, which is of definite infiltrating type."

CASE VI.—*Example of Abdominal Tumour.*

Mrs. W., aged 42, was sent to me for pain in her left side which limited full inspiration; she had had haematuria of slight degree, but without frequency. A large tumour occupied her left ileo-costal space, which was justifiably taken to be an enlarged kidney. Her bowels were regular and she was not losing weight. On examination a large tumour could be felt in the upper part of the left ileo-costal space; it was dull on percussion, and this dullness was continued posteriorly to the middle line. The urine contained pus and blood; the blood examination showed a lymphocyte leucocytosis. Cystoscopy revealed an acute cystitis.

Pyelography (see Fig. 12) demonstrated that the left kidney had been displaced downwards so that the hilum of the organ, instead of pointing medially, was pointing towards the iliac fossa. The upper part of the ureter forms an acute angle with the lower portion. If an imaginary line be drawn above the shadow thrown by the renal pelvis and upper part of the ureter, the size of the splenic tumour can be gauged.

CASE VII.—*Ureter Kink.*

Janet R., aged 30, complained of haematuria on a single occasion, followed by acute pain behind the right kidney, but without increased frequency of micturition. When seen there were no abnormal physical signs. Cystoscopy showed a normal bladder.

Pyelography showed a ptosed kidney with a knot in the upper part of the ureter (see Fig. 13). The renal pelvis and calyces were normal, which is a definite indication that there was no obstruction to the onward flow of urine. The haematuria remained unaccounted for. A year later the patient was well and had had no return of her symptoms.

Some of the pyelograms reproduced with this paper were made in a private hospital. I am indebted for the others to the physician in charge of the radiography department of the Royal Victoria Infirmary, Newcastle-on-Tyne.

FIG. 1.—Diagram of section of normal kidney. Note the conical apex projecting into the calyx, producing the normal "cupping" of the calyx in a pyelogram.

FIG. 2.—Diagram representing pyelonephritis. Note the disappearance of the conical apex, thereby producing "knobbing" of the calyx in a pyelogram.

FIG. 3.—Normal Pyelogram. To illustrate the "cupping" on the minor calyces.

FIG. 4.—Pyelonephritis Pyelogram. Shows the "knobbing" of the minor calyces due to absorption of the renal pyramid apices.

FIG. 5.—Congenital Cystic Kidneys (double). Note each renal pelvis and each calyx are proportionately enlarged. The right kidney is the larger tumour. The size of each kidney can be gauged by filling in an imaginary solid portion around the pyelogram.

FIG. 6.—Hydronephrosis Pyelogram. See dilatation of the right renal pelvis and grouping of the three main calyces, with marked "knobbing" of the minor calyces. Fig. 7 is the specimen relating to this pyelogram.

FIG. 7.—Hydronephrotic Kidney. Shows dilatation of renal pelvis and calyces; thinning of the solid part, with disappearance of the pyramid apices; stricture of the pelvic outlet. The three main calyces are each indicated by pieces of wire. (Cf. Fig. 6.)

FIG. 8.—Tuberculous Kidney Pyelogram. Note lack of all definition of the upper and middle main calyces; the lower main calyx is normal. Fig. 9 is the specimen relating to the pyelogram.

FIG. 9.—Tuberculous Kidney. Note tuberculous ulceration and cavitation in upper half of the kidney, also lack of outline of the upper and middle calyces. Note also normal lower main calyx, with a pyramid apex projecting into a calyx. (Cf. Fig. 8.)

FIG. 10.—Malignant Kidney Pyelogram. Note normal left pyelogram with filling defect right side, where only one main calyx can be recognized, and that indistinctly. Fig. 11 relates to the removed specimen.

FIG. 11.—Malignant Kidney Section. The upper main calyx is the only one to be seen; the others have been "amputated" by growth. Note growth in renal pelvis, also in lower two-thirds of the kidney. (Cf. Fig. 10.)

FIG. 12.—Kidney displaced by Splenic Tumour. There is an angulation of the ureter, the horizontal part of which, together with the kidney, is displaced downwards by a splenic tumour. The convexity of the kidney is displaced towards the left iliac fossa.

FIG. 13.—Ureter Knot. Shows a knot in the upper end of the ureter in a ptosed kidney. There is no "knobbing" of the calyces—that is, there is no obstruction to the urine flow.