RADIOISOTOPE RENOGRAPHY*

L. GECELTER, M.B., B.CH. (RAND), F.R.C.S., F.R.C.S.E., *Renal Unit and Department of Urology, Johannesburg Hospital and the University of the Witwatersrand*

Radioisotope renography as used in its present form was introduced by Nordyke *et al.*[1] in 1960. ^{131}I-labelled ortho-iodohippurate (Hippuran) has been the isotope used in this method of investigation. It is cleared from the blood at a rapid rate and exclusively by the kidneys, 75% being recovered in the urine of normal patients 30 minutes after intravenous injection.[2] It produces the highest functional peak of all agents tested to date, rapidly reaching this peak in 4 - 6 minutes. The normal renogram is completed 8 - 12 minutes after injection of the labelled Hippuran.

METHODS

The Picker clinical analyser, Model 5802B, is used incorporating dual 1 inch sodium iodide scintillation detectors. These are connected to a rate meter and then to dual rectilinear recorders and are mounted on mobile adjustable arms. The crystals are recessed 4 cm. and a 36° wide-angle collimator is used. A standard cesium (^{137}C) source is used to calibrate the probes.

Since its inception various methods have been employed to obtain the most satisfactory radio-renographic curves. This has required different doses of the isotope, alteration in the position of patient and/or placement of scintillation probes, different time constants and range of counting. A standardization method used allows for uniformity of results and for technicians to be trained fairly quickly. The whole procedure then can be performed by them except for the intravenous injections of the radioisotopes.

The method used here has been standardized as follows: Where possible a straight X-ray of the abdomen or intravenous pyelogram is used to localize the kidneys. When a retrograde pyelogram or renal arteriogram has been performed, this is used in preference. The centre of the kidney is taken as being 1 cm. lateral to the middle calyx. This is usually found 8 - 12 cm. above the iliac crest and 6 - 9 cm. lateral to the mid-dorsal spines, which are the surface markings used as reference points.

It should be remembered that a straight X-ray of the

*Radio-renography has been used at the above centre for the past 18 months in a wide variety of renal conditions. The purpose of this article is to discuss the clinical applications and limitations of this test.

abdominal pyelogram and aortogram are taken in the supine position. If the radioisotope renogram is performed in the sitting position, a descent of as much as 2 vertebral spaces may occur.[2] This is more marked on the right. When the IVP is used, the difference can be obviated by taking at least one of the excretory pyelograms in the sitting or standing position.

To obviate the problems involved in using the sitting position and the placement of the scintillation probes according to the X-ray position in the supine position, an intravenous injection 2 μc. of ^{203}Hg chlormerodrin (Neohydrin) is given at least 10 minutes before the commencement of the test.[10] The patient is then placed in the prone position on a mobile table with a soft pillow under the abdomen.

The scintillation probe is used to localize each kidney separately in the position in which the test is done. The available X-rays are used as a guide to the position of the kidneys. Often the two will coincide, but a preliminary X-ray is not necessary with the present method. The ^{203}Hg Neohydrin remains in the kidney where it is selectively transported by the tubules, and probing will record the maximum counting obtainable for that kidney, taking position rotation, thickness of kidney mass, function and depth from skin into consideration.

The site of maximum counting rate is marked for each kidney and a $\frac{3}{8}$ inch lead shield measuring 4 × 6 inches is placed in the mid-vertical position between the two kidneys.[11]

The scintillation probes are then placed 10 cm. from the skin parallel to each other and perpendicular to the floor. The probes are placed at this distance from the skin to give a wide field, and the lead shield is used to prevent a cross-irradiation from one kidney to the contralateral probe. In this way minor errors in positioning will be overcome.[7]

In Fig. 1 a cross-sectional view of the placement of the patient and the scintillation probes are illustrated, showing the lead screen to prevent cross-irradiation from one kidney to the contralateral probe. The probes are recessed to obviate any error in inaccurate placement. The probes are placed parallel to each other and perpendicular to the floor.

A dose of 1 μc./7 kg. body-weight Hippuran is then given intravenously in the antecubital fossa as rapidly as possible. Subcutaneous leakage will affect the renogram. Occasionally the dose of Hippuran will be adjusted to age, renal function and disease studied. Generally a young patient will require a smaller dose and patients with a raised urea or poor renal reserve will require a greater dose. Patients with obstructive uropathy will require less, since the Hippuran may be retained by the affected kidney and concentrated to a greater degree.

The recordings are started before the administration of the radio-Hippuran, and the paper speed is adjusted to 12 inches per hour. The time constant is fixed at 10 seconds. More rapid paper speed at the commencement of the test[17] to define the first from the second phase is not necessary and adds to the technical problems.

The recording is made for approximately 15 minutes, but may be allowed to continue for a longer period if necessary, particularly when obstruction is present.

At present, an investigation has been started in pregnant women. The standard procedure, as described above, has been modified to minimize the radiation hazard. This includes a dose of Lugol's iodine 2 - 3 days before the test to block the foetal uptake of the radioactive ^{131}I in the Hippuran. A smaller dose of 2·5 - 4 μc. is given and the test is done in the sitting position. This is done to ascertain the effect of gravity and uterine compression.

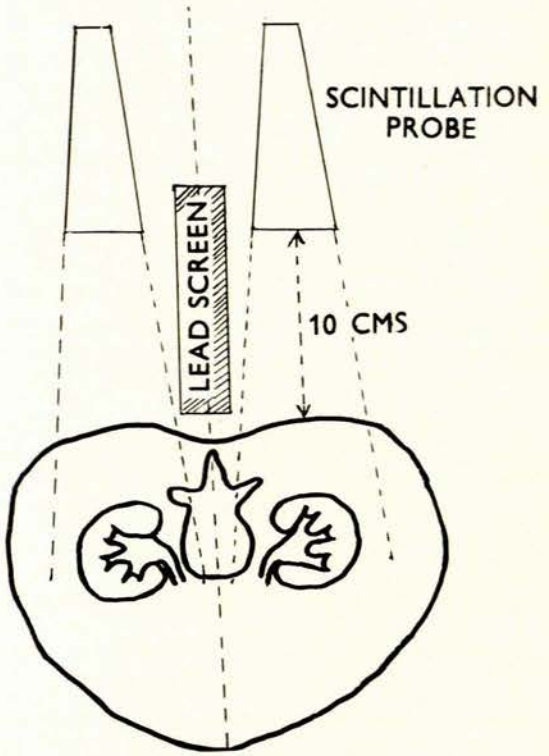

Fig. 1. See text.

The patient is told that she is going to be given a tiny dose of radioactive material which is less than 1/2,000th of a routine chest X-ray[2] (disregarding the ^{203}Hg Neohydrin) and pregnant women are required to sign consent according to regulations laid down by the Atomic Energy Commission.

No X-rays are taken nor Neohydrin given before the test. The kidney is localized according to the method of Winter.[2] The left kidney is usually centred at the lower border of the 12th rib. The right lies a little lower.

THE NORMAL RENOGRAM

The renogram is divided into 3 phases which are currently termed phase I, II and III.

Phase I occurs after an interval of 10 - 20 seconds, this period being determined by the circulation time of the injected radioisotope from vein to kidney.

It takes about 60 seconds to complete. The rapid rise in counting over the kidney area, originally believed to be due to the vascular capacity of the kidneys[3] (vascular spike) is now believed to be due mainly to extrarenal vascularity (90%) and only slightly to the vascular capacity of the kidneys (10%). This has been proved by administra-

tion of ^{131}I-radioalbumin, which is not taken up selectively by the kidney,[4] and by comparing this with background activity in nephrectomized patients.

This phase can be more clearly demonstrated by lowering the time constant and increasing the paper speed. From a practical point little information can be gained by trying to demonstrate this phase as a separate entity from phase II, and in our series we are often unable to differentiate the two clearly.

Phase II is shown by a slower and greater increase in counting rate till a peak is reached which is due to maximum concentration of the radio-Hippuran in the kidneys. This is reached in 3 - 5 minutes and is then followed by phase III.

Phase III is due to a greater excretion of the radio-Hippuran from the kidney than its concentration by it. The initial excretion is rapid with a slower fall off later.

The whole curve is usually completed in 15 minutes, but the graph does not return to base-line as the Hippuran has not been completely cleared in the period of the graph.

Various authors record different parameters as being important and correlate these with findings on separate renal function tests.[5]

The parameters include:

Amplitude of phase I (S)
Amplitude of peak (P)
Amplitude at 10 min. = f
Time to peak (Tp) or (Tmax)
P10 = % of maximum radioactivity after 10 minutes

$$P10 = \frac{f}{p} \times 100$$

If the height of maximum uptake alone is used (P), a greater than 20% difference between the two sides occurs in 45% of apparently normal kidneys as judged by IVP differential renal functional test and aortography.[6]

Fig. 2 shows the tracing of a normal renogram with right and left superimposed for comparison and to save space. (P = amplitude of peak, Tmax = time to peak—time of injection to point of maximum counting, and $T\frac{1}{2}$ = time from point of maximum counting rate to point where counting rate has fallen to half maximum.) Note indistinct transition from phase I to phase II. The usual difference between left and right graphs becomes less significant when Tmax and $T\frac{1}{2}$ are taken into consideration.

Only two parameters correlate well with other tests of separate renal function tests: (a) Tmax and (b) $T\frac{1}{2}$ (see above).

The amplitude of peak is determined by the dose administered, the sensitivity of the detectors and the distance from the source, geometric factors as well as physiological factors—the most important normal variables being accuracy of placement of probes, posture of patient, hydration and urine flow rate.

Alteration of Normal Renogram

The normal renogram may be altered in the same patient by changing the following variables:

1. Urine flow. Anything that impedes the removal of urine from the kidney will result in a 'slow flow' pattern; this will increase the amplitude of peak and delay time to peak. Conversely, a diuresis as occurs with mannitol or urea, will decrease time to peak and amplitude of peak.

If a marked difference of urinary flow occurs between each kidney, a significant disparity may occur in the renogram. This is most marked at flows of between 3 - 5 ml./min. 'Slow flow' patterns occur in acute renal vein thrombosis, hypotension, neurogenic shock, ureteric obstruction and renal artery stenosis.

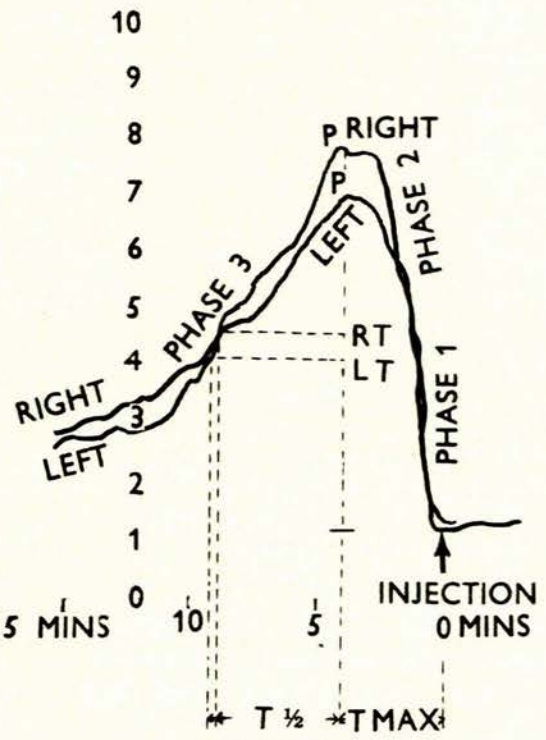

Fig. 2. See text.

2. Alteration in position. The scintillation probe is so placed to record maximum counting and, if siting is inaccurate, all parameters of the renogram will be diminished.

In the sitting position, the peak is lower and all parameters are lower than in the prone position. This suggests that gravity plays an important role in drainage of urine.

3. Effect of blockage of tubular transport. Competitive inhibition by para-aminohippurate (PAH) loading will decrease the amplitude of peak and cause a slow excretion.[5]

Probenecid also depresses tubular transport and depresses amplitude of peak.[9] Both PAH and probenecid have no effect on glomerular filtration rate or blood flow to the kidney, yet the amplitude may be depressed by as much as 70%.

4. Experimental studies on dogs[8] have led to uniform alterations in renograms. Ischaemia decreases amplitude of phase I and II. Occlusion of renal vein and ureter in acute experiments increase amplitude of peak; time to peak is prolonged and excretion is delayed. ($T\frac{1}{2}$ is prolonged.) Various drugs also affect the renogram. Vasopressors such as noradrenalin and the more active angio-

tensin increase the time to peak and decrease amplitude of peak.

Histamine increases amplitude and prolongs the duration of peak. Mannitol causes a decrease in amplitude and time to peak. This may be due to its effect on urine flow rate.

In practice, as phases I and II are not usually defined as separate phases, and since phases II and III are dependent upon and influenced by such physiological factors as age, blood supply, urinary flow rate, tubular transport, glomerular filtration rate, it is clear that any disease including renal artery stenosis, chronic pyelonephritis and nephrosclerosis[6] can diminish peak height and delay rate of excretion. It becomes obvious that an abnormal pattern, when compared with the contralateral kidney, is not pathognomonic of any specific disease. Moreover, it is a qualitative and not a quantitative test. At best it is a screening test.

INDICATIONS FOR RADIOISOTOPE RENOGRAPHY

Clinical indications for the test at present are not clearly defined. Its role at present is both diagnostic and prognostic. Because of ease of performance, low radiation hazard and the great facility with which it may be repeated at frequent intervals, serial renograms may be undertaken more regularly than pyelography or renal angiography.

Renal Artery Stenosis

In the assessment of renal artery stenosis as a cause of hypertension, Schwartz and White[12] have shown in necropsy studies that renal artery stenosis may occur in patients with normal blood pressures, and confirms the views of others that renal artery stenosis is common in both normotensive and hypertensive patients. Thus, an anatomical demonstration of renal artery stenosis by aortography may indicate the effect of hypertension and not its cause. The problem is further complicated by the fact that severe main renal stenosis on one side is only associated with a normal contralateral main renal artery in 9 - 18%,[12] and the contralateral side is severely stenosed in 55 - 64% of cases.

Before corrective surgery is undertaken, it is necessary to assess the function of each kidney and to correlate this with anatomical changes in the vessels.

When differential renal function studies do not correlate with angiographic findings, selection of patients for surgical treatment should be made with great caution.[14]

Using radioisotope renography as a screening test in hypertension. Wax and co-workers[15] have had a 24% false positive and a 7% false negative result and Stewart and Haynie[6] a 45% false positive and over-all false negative result of 25%. Different parameters were used by each.

Renograms are not specific for renovascular disease, and abnormalities indistinguishable from those in this condition may occur in the unilaterally contracted kidney of chronic pyelonephritis and hypoplasia. In both conditions the vessels are adequate. (Hypertension may result from both these conditions, although the mechanism is believed to be different to that in renal ischaemia.)

Fermelanti *et al.*[16] believe that the radio-renogram serves as a screening test in ± 70% to eliminate unilateral disease of renovascular parenchymal or obstructive nephropathy.

In renal artery stenosis the time to peak is delayed, amplitude of peak is smaller and there is delayed excretion of the dye. The rate of decline in the radio-renogram may be dependent upon greater sodium and water absorption on the stenotic side. These differences can be diminished by an osmotic diuretic (such as mannitol) in which greater sodium and water absorption does not take place to the same degree. The slow urine flow rate on the affected side may also result in a 'slow flow' pattern on renography (see above) with a false negative or a delayed time to peak and a higher peak on the affected side, thus giving the impression of diminished function in the unaffected kidney.

Radio-renography in hypertension is a screening test in which a false positive result is not a handicap and which, in the best hands, has a false negative result of 7%. It will not diagnose renal artery stenosis from pyelonephritis of hypoplasia and occasionally may give a false localiza-

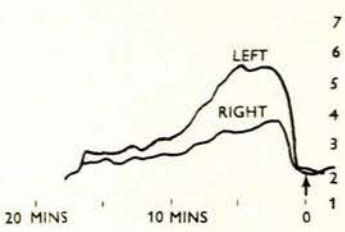

Fig. 3

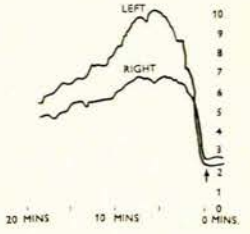

Fig. 4

Fig. 3. Radio-renogram in 49-year-old man with labile hypertension (weight 149 lb.). Shows marked difference in amplitude of peak (P) with Tmax and T½ differences. Aortography confirmed the presence of right main renal artery stenosis.

Fig. 4. Renogram in a 29-year-old man with hypertension of 10 years duration. BP 160/110 mm.Hg. On reserpine. Urea 47 mg./100 ml. IVP shows calyectasis of left kidney. Left kidney 14 cm. (on nephrogram phase of aortogram) and right kidney 11·3 cm. Cortical scarring. No renal artery stenosis. Renographic abnormality in right kidney diminished P, Tmax indefinite and flattened, with T½ prolonged. Indistinguishable from renal artery stenosis.

tion of the side involved for reasons already discussed (Figs. 3 and 4).

Nevertheless it is of value as a screening test and should be used as an indication to seek confirmatory evidence with differential renal function tests via ureteric catheterization and aortography. A good result can be expected in corrective surgery if the arteriographic (anatomical) radio-renographic and differential ureteric functional tests correspond. The isotope study then is more than just a screening test in these circumstances, but also indicates the functional significance of the stenosis.

Renal artery stenosis also occurs in patients with nephroptosis.[18] Excess renal mobility is often associated with hypertension and fibromuscular hyperplasia in young women.

Radioisotope renography in the prone and erect position may demonstrate a difference in blood flow with change in position and should be performed in patients with hypertension associated with renal ptosis.

This may also be helpful in demonstrating an obstructive pattern due to stretching of the renal artery over the pelvi-ureteric function causing a hydronephrosis in the upright position.[19]

An alteration on renography, suggestive either of ischaemia or obstruction in the upright position, should be confirmed by renal arteriography in the erect position. This will straighten out any kinking of the renal arteries and give much better definition of the renal as well as the adrenal arteries.[18]

Obstructive Uropathy

The radioisotope renogram is pathognomonic in acute urinary obstruction. Experimentally, in animals with a completely occluded ureter, the renogram shows a rising pattern in the third phase which is due to the accumulation of the Hippuran in the kidney and pelvis. Renal function for the first 48 hours will be unimpaired, and therefore phase I and II will be identical when compared with the contralateral kidney.[17] The renogram in acute renal vein occlusion which is produced experimentally, is identical to that in ureteric obstruction (Fig. 5).

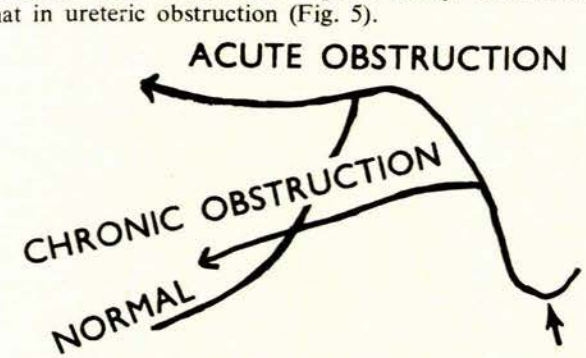

Fig. 5. Expected pattern in acute and chronic obstruction with normal superimposed.
Acute obstruction shows P to be same as normal but with greater concentration of dye and therefore a rising curve ('slow flow pattern').
Chronic obstruction P is indefinite and is lower than the expected normal or contralateral side. As no dye is being excreted, it will not show a normal phase III. If the graph is allowed to continue long enough, there will be a slowly diminishing phase III which is due to excretion of the radio-Hippuran by the contralateral kidney.

After 48 hours, tracings show a progressive loss of tubular function as evidenced by a flattening of phases I and II, and after 72 hours of complete ligation the tracing becomes indistinguishable from that of renal failure.

Renography is useful in obstructive disease to assess the degree of functional obstruction, which, if painless and not the cause of infection, may be treated expectantly. Progress of a stone may be assessed by repeated renography which can be done more often than retrograde pyelography.

Although a stone has been successfully removed from a ureter, the renogram may still show an obstructive pattern for the following 3 - 4 days. This should be taken into consideration when doing a check radio-renogram.

An incomplete obstruction, such as occurs in hydronephrosis, ptosis in the erect position (in some cases), extra-ureteric pressure, pregnancy ureterocoele, reflux and infravesical obstruction, will produce a pattern in which phase III rises to a lesser degree. The time to peak is delayed and peak height is higher.

Doubtful hydronephrosis, demonstrating functional obstruction, can be detected without resort to ureteric catheterization and determination of pelvic emptying times (Figs. 6 and 7).

The Differential Diagnosis of Acute Uraemia

Radio-renography has a definite place in the management of the azotaemic patient. It is more accurate in those cases in which the azotaemia is of recent or acute onset and less so when the disease is chronic. The radio-renographic changes are then non-specific and difficult to differentiate as to origin.

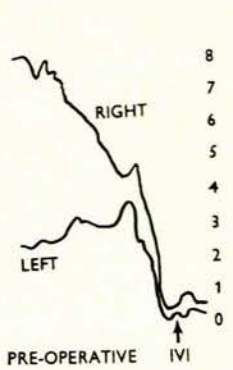

Fig. 6(a)

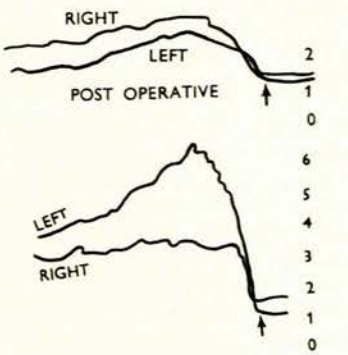

Fig. 6(b) (above) Fig. 7 (below)

Figs. 6(a) and (b). Renogram taken before and after operative removal of opaque calculus from the right lower ureter in a 29-year-old man.
Pre-operative renogram shows typical acute obstructive pattern with retention of radio-Hippuran in the obstructed kidney.
The postoperative renogram (10 days later) shows the renogram has returned to near normal.
The difference in pattern pre- and postoperatively may be due to technical differences and does not necessarily denote functional alteration of kidneys.

Fig. 7. Radio-renogram in a 46-year-old female with carcinoma of cervix and involvement of right ureteric orifice and vesicovaginal fistula on cystoscopy.
Intravenous pyelogram shows non-functional right kidney with early clubbing left kidney.
Retrograde pyelography shows minimal hydronephrosis of the left kidney, but dye excreted within 20 minutes.
Right hydronephrosis of marked degree. Non-function due to obstruction.
Renogram shows pattern on affected side indistinguishable from any chronic disease with renal failure. Pattern of this type seen commonly in both kidneys in chronic uraemia from any cause.

From a functional point of view, uraemia may be pre-renal, renal or postrenal, and the radio-renographic changes may differ in the 3 types. Occasionally a graph will be obtained in which the changes are non-specific, showing a high uptake and maintained peak. The exhibition of an osmotic diuretic, such as mannitol, will cause a diuresis in the dehydrated patient and a falling off in the excretory phase of the renogram. The obstructive pattern will be aggravated and the excretory pattern will continue to climb. The uraemia of renal origin will be unaltered (Figs. 8 and 9).

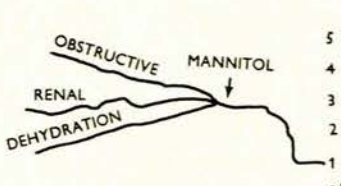

Fig. 8

Fig. 9

Fig. 8. Renograms in the 3 main functional types of acute renal failure. The 'renal' type of anuria is a direct tracing in a man of 64 years with acute renal failure due to tubular necrosis. The 'obstructive' and 'dehydrated' patterns are superimposed and are hypothetical. The effect of mannitol is shown.

Fig. 9. Renogram on a 29-year-old man done as an emergency on admission with a history of anuria of 24 hours duration. BP 140/90 mm.Hg. Urea 490 mg./100 ml. K 6.7 mEq./l. Na 127 mEq./l. Cl 69 mEq/l. CO_2 content 13 mEq/l.
No response to dextrose saline (? dehydration) and mannitol. Renographic diagnosis: renal cause of acute uraemia. Clinically acute on chronic renal failure. Confirmed at postmortem.

In obstructive uropathy it is particularly valuable as a preliminary test before retrograde pyelography, and the findings may obviate the necessity for pyelography. It is likewise useful to exclude obstruction where a preliminary urinary diversion (ileal conduit or ureto-sigmoidostomy) has been done, where retrograde catheterization fails or is difficult or hazardous to do as in the early postoperative period.

Pregnancy

Pyelitis and backache are two common problems in the pregnant patient. As a rule their management is standardized and not problematic. Occasionally one is confronted with pain or pyelitis that is persistent and does not respond to accepted measures. It then becomes important to exclude an underlying urological cause that may require more active treatment such as ureteric catheter drainage or surgical exploration.

X-rays constitute a relative or absolute contraindication and even cystoscopy may aggravate an already unstable pregnancy.

Radio-renography in these circumstances does have a definite role to play. The radiation dose is approximately 1 - 3% that of a routine chest X-ray. This small risk should be weighed against the hazard of missing a condition which may require active treatment.

Radio-renography has been tried on a limited scale in this hospital in this group of patients after the first trimester, when the diagnosis has been equivocal or when the response to management of pyelitis has been unsatisfactory. The patients were all informed of the slight risk.

The results have been illuminating, and there appear to emerge 3 main types of renographic appearance in pregnancy.

1. Backache or pyelitis in which drainage has been relatively normal (Fig. 10).

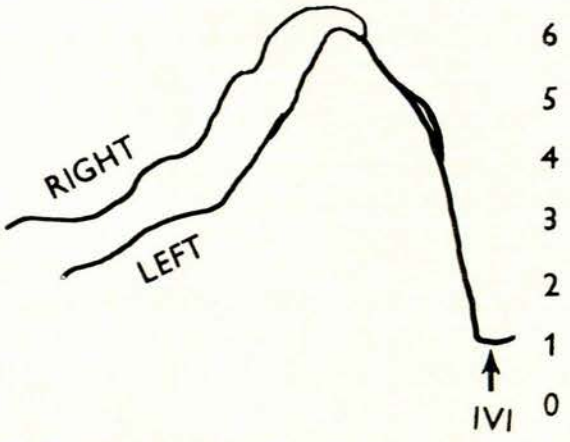

Fig. 10. Renogram of a 14-week-pregnant woman with severe right lumbar pain, increased frequency and burning on micturition, with nocturia. BP normal. No past history of disease. Urine: Numerous polymorphs, and culture *E. coli* more than 100,000 organisms/ml.
Renogram essentially normal with possibly 'slow flow pattern' of right kidney compatible with an acute pyelonephritis. No severe obstruction. Responded to conservative treatment. Renogram not repeated.

2. Pyelitis with unilateral or bilateral lumbar pain in which drainage as judged by the renogram has been poor on both sides and remains so after cessation of symptoms (Fig. 11).

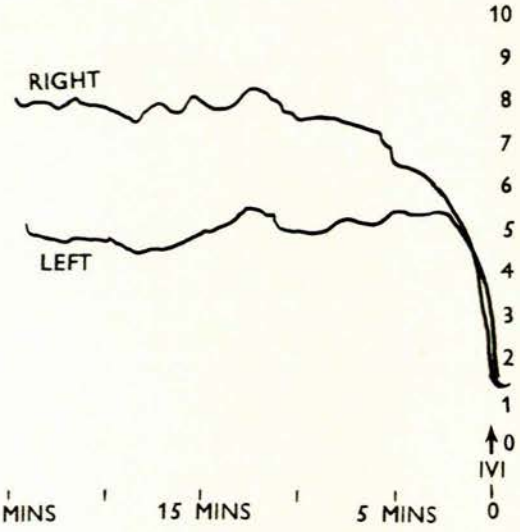

Fig. 11. Renogram in a 19-year-old woman 22 weeks pregnant.
History of bilateral lumbar pain, rigors, nausea and vomiting. Abortion of first pregnancy. Temp. 102° F. Tender both renal angles. Urine 15,000 WBC/ml. *E. coli.* more than 100,000 organisms/ml. Clinical diagnosis of acute pyelonephritis of pregnancy.
Renogram shows obvious abnormality with obstructive pattern in both kidneys, the right worse than left.
Responded to appropriate antibiotics, strict bed rest with foot of bed raised.
Renogram repeated when asymptomatic showed no appreciable difference to one above.

3. Unilateral renal pain typical of pyelitis of pregnancy which shows a characteristic obstructive pattern, persisting after symptoms have disappeared [Figs. 12(a) and (b)].

This may be due to extrinsic pressure on the ureter (usually on the right in our experience) or to an underlying obstructive uropathy such as hydronephrosis or ureteric calculus. As symptoms and signs have abated, no further investigation or treatment has been instituted.

The patients have been advised to return for full urological investigation after pregnancy when correlation with renographic changes will be made.

Miscellaneous Conditions

Radio-renography has been helpful on one occasion in which all methods of investigation for unilateral renal bleeding in a case of 'essential' haematuria proved negative, including repeated intravenous and retrograde pyelography and selective renal arteriography.

A 29-year-old doctor complained of recurrent haematuria for the past 8 years associated with pain in the left lumbar region radiating to the loin and associated with tubular blood clots. He had been investigated in London, Paris and Stockholm, but all the tests were negative.

Radio-renography showed a greater uptake of dye on the affected side. Since the height of the graph is a summation of vascularity, background activity and the glomerular and tubular function, the only factor which was suspected of being excessive was the vascularity. As it did not show on selective arteriography of the kidney, it was concluded that a capillary haemangioma was the cause of his recurrent bleeding (Fig. 13).

This was found at exploration when a frozen section confirmed the diagnosis and a nephrectomy was performed for a diffuse capillary haemangioma surrounding all the calyces of the left kidney.

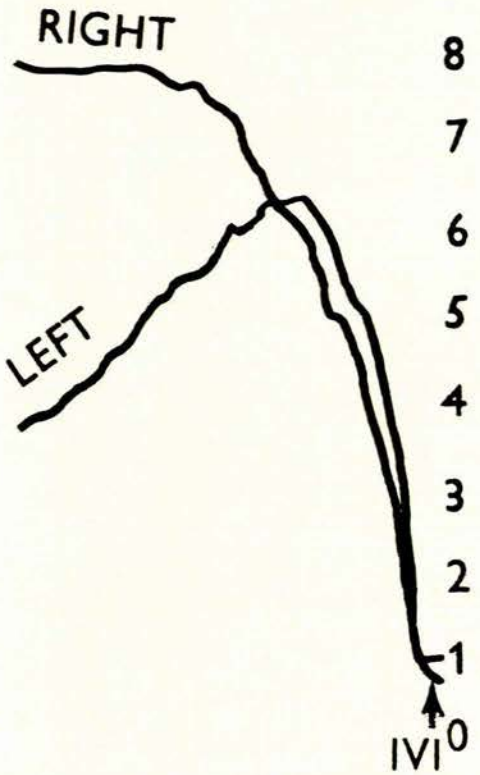

Fig. 12(a)

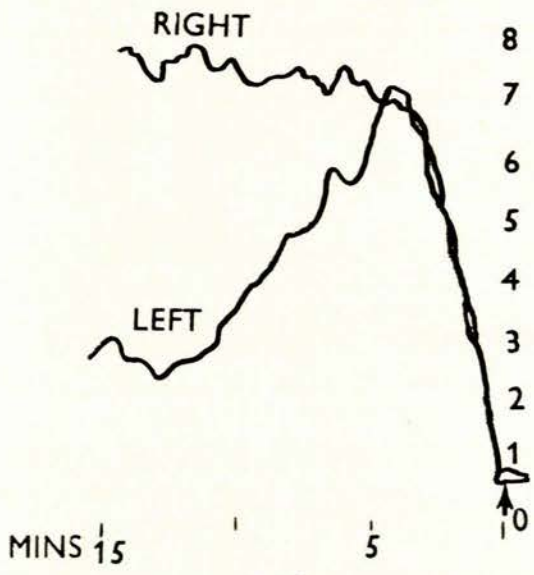

Fig. 12(b)

Fig. 12 (a) and (b). Renogram on a 20-year-old pregnant woman (24 weeks). Right renal pain. No past relevant history. No X-rays. Responded to bed rest and antibiotics.
(a) during height of attack.
(b) 14 days later. Asymptomatic and ambulant.
No change in renogram.
Diagnosis. Probable pyelitis of pregnancy. Underlying renal disease not excluded.

This is the first recorded case of haemangioma of the kidney diagnosed pre-operatively by radioisotope renography. Johnston,[10] who has done over 3,000 radio-renograms, concurred with these renographic interpretations.

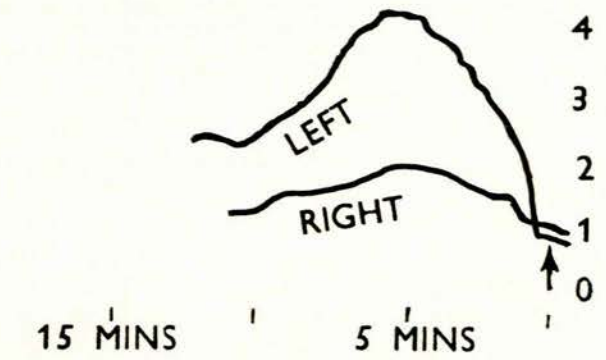

Fig. 13. Renogram of 29-year-old doctor with capillary haemangioma of left kidney. Intravenous, retrograde pyelography and left selective renal angiography normal.
Relatively flat curve on normal right kidney is due to 3K range required to keep the graph on the paper.
Note greater uptake and normal excretion on left.
Renogram repeated with same result.

CONCLUSIONS AND SUMMARY

The advantages of the radioisotope renogram are its rapidity and ease of performance.[2] It is non-traumatic, gives immediate results, qualitatively tests and compares both kidneys, no preparation is required, no anaesthetic is given and it may be repeated after an hour. The disadvantages of the test are the initial cost of equipment, the necessity for air freight of radioisotopes used, and the fact that the test does not furnish a diagnosis but provides qualitative information which, like any special investigation, must be taken in conjunction with the rest of the findings.

It is useful as a screening test for renovascular causes of hypertension and should be correlated with anatomical changes found on renal arteriography. The two tests are complementary.

Obstructive uropathy shows as a very characteristic pattern on renography, and progress may be followed by repeated renography at frequent intervals.

Acute renal failure due to prerenal, renal and postrenal causes may be differentiated on renography.

Renal ischaemia or hydronephrosis associated with ptosis and occurring only in the erect position, may be diagnosed by renography performed in the prone and erect position.

Its use in pregnancy and in the detection of vascular tumours has been demonstrated.

In the present series it has been used also to detect obstruction after diversion operations, such as ureterosigmoidostomy and uretero-ileostomy. It has given superior information to IVP on several occasions in these conditions.

It has been used in a variety of other conditions where it has been of limited value, including space-occupying lesions of the kidney such as cysts, tumours and abscesses.

Chronic uraemia from any cause produces a non-specific renogram and the test is of little value.

In no case has there been any untoward effect on renal function nor has any allergic reaction been noted.

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