KIDNEY VISUALIZATION WITH ^{131}I-ORTHO-IODOHIPPURATE IN PATIENTS WITH RENAL INSUFFICIENCY

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Assessment of renal size may be of considerable importance in evaluating the severely azotemic patient. Normal-sized kidneys suggest reversible acute disease while bilaterally small kidneys suggest chronic end-stage renal disease.

Conventional intravenous urography will generally not visualize the renal outlines adequately when the serum creatinine concentration exceeds 5 mg/100 ml (*1*). Schwartz, Hurwit and Ettinger (*1*) and Ross *et al* (*2*) used high-dose (at least 60 ml) triiodinated contrast media in azotemic patients to gain better anatomic definition of the urinary tract. They obtained adequate visualization in patients with plasma creatinine concentrations between 1.5 and 5.0 mg/100 ml with this method (*1*). The use of laminography (*1*) or drip infusion urography has also been advocated in the presence of renal insufficiency (*3,4*).

Another approach for obtaining anatomic information about the failing kidney is bilateral retrograde pyelography, but increased risk of infection from ureteral catheterization (*5,6*) may make this procedure undesirable.

The radiomercury-chlormerodrin renal scan (*7*) gives excellent delineation of renal size with little danger of nephrotoxicity. However, in the severely azotemic patient, chlormerodrin is concentrated in the liver, and there is inadequate renal activity for scanning. On occasion, studies from 6 to 24 hr after injection allow limited visualization of the failing kidney (*8*).

Rosenthall (*9*) used the Anger scintillation camera to study the excretion of ^{131}I-ortho-iodohippurate (hippuran) by both normal and abnormal kidneys. He discovered that in some cases of renal failure the transit time of hippuran through the kidney is prolonged, allowing surprisingly good visualization. This prolonged transit time of hippuran in diseased kidneys has been confirmed by Blaufox and Comroy (*10*).

The present study was undertaken in an attempt to determine whether the prolonged transit time would permit conventional rectilinear scans of the kidneys in varying degrees of renal insufficiency and to define the limits of usefulness of this method.

METHOD

Twelve female and seven male patients from 17 to 83 years of age with varying degrees of parenchymal renal impairment were studied with ^{131}I-hippuran scanning (Table 1). Renal scans with ^{197}Hg-chlormerodrin were also performed in 18 of the cases. High-dose infusion intravenous urography was used in 13 of the 19 patients (Table 1).

The renal scans were performed utilizing a photoscanner (Picker Magnascanner) with a 3- or 5-in. NaI(Tl) crystal. In three cases, a scintillation camera (Nuclear-Chicago Pho/Gamma III) was used in addition to the rectilinear scanner. The ^{197}Hg-chlormerodrin was used first intravenously in a dose of 1.5 μCi/kg, and this was followed by a 250-μCi dose of ^{131}I-ortho-iodohippurate. A pulse-height analyzer counted the 78-keV peak gamma photons of ^{197}Hg separately from the 364-keV gamma rays of ^{131}I. The two studies were usually performed within 24 hr of each other.

Scans with radiochlormerodrin were begun approximately 1–2 hr after injection, and in several instances delayed studies at 6 or 8 hr were attempted to determine if better kidney delineation could be obtained.

The hippuran studies were usually started 5–10 min after injection at which time sufficient levels of renal activity provided a favorable target-to-background count ratio.

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TABLE 1. USEFULNESS OF ^{131}I-ORTHO-IODOHIPPURATE SCANNING IN SEVERELY AZOTEMIC PATIENTS

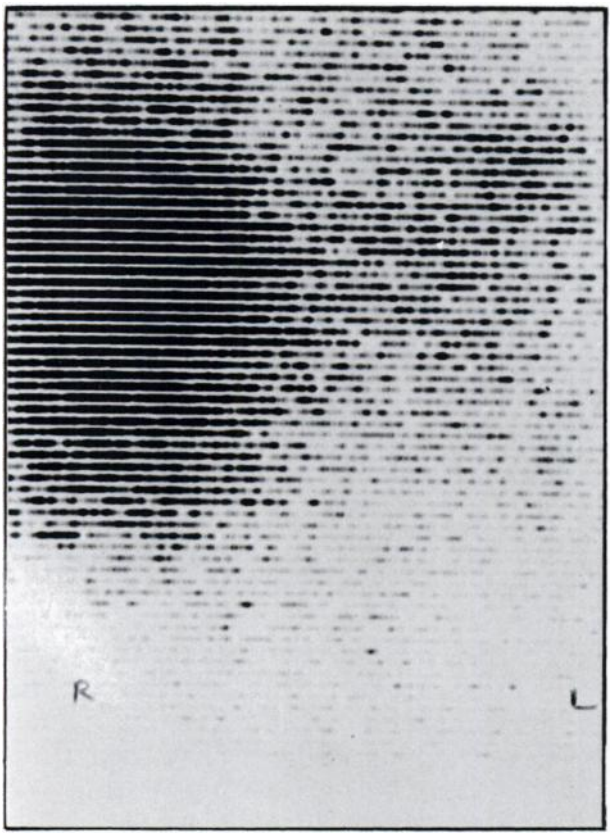
Patient	Age	Sex	Blood urea nitrogen* (mg/100 ml)	Plasma creatinine* (mg/100 ml)	^{197}Hg-chlormerodrin scan	^{131}I-hippuran scan	High-dose intravenous urogram†	Clinical diagnosis
1	37	F	146	17.2	Nonvisualization	Normal-sized kidneys	—	Chronic renal parenchymal disease; cause undetermined
2	41	F	95	8.6	Nonvisualization	Both kidneys small	Small kidneys bilaterally	Chronic pyelonephritis
3	25	F	77	7.1	Nonvisualization	Bilaterally small kidneys; in particular, left; right kidney looks round	Small kidneys bilaterally; particularly the left; right kidney is round	Congenital renal dysplasia with or without superimposed pyelonephritis
4	46	F	83	11.8	Nonvisualization	Single small right kidney	—	Chronic pyelonephritis; post left nephrectomy
5	62	F	80	6.4	Nonvisualization	Bilaterally small kidneys	Bilaterally small kidneys	Chronic pyelonephritis
6	17	F	62	7.3	Faint visualization; no size determination	Normal-sized kidneys	Normal-sized kidneys	Chronic glomerulonephritis
7	63	F	298	26	Nonvisualization	Nonvisualization	—	Chronic renal parenchymal disease; cause undetermined
8	70	F	69	3.5	Faint visualization; no size determination	Normal-sized kidneys	Normal-sized kidneys	Chronic renal parenchymal disease; cause undetermined
9	57	F	112	5.5	Nonvisualization	Normal-sized kidneys	Normal-sized kidneys; nephrogram only	Chronic renal parenchymal disease; cause undetermined
10	60	M	70	4.4	—	Kidneys smaller than normal, particularly right	Small kidneys bilaterally; nephrogram only	Chronic pyelonephritis
11	76	M	84	3.6	Nonvisualization	Kidneys smaller than normal	Kidneys slightly smaller than normal	Chronic obstructive uropathy secondary to carcinoma of bladder
12	77	F	120	—	Nonvisualization	Bilaterally small kidneys	Faint nephrogram of small kidneys bilaterally	Chronic renal parenchymal disease; cause undetermined
13	50	M	80	—	Nonvisualization	Bilaterally small kidneys, particularly the right	Small kidneys bilaterally	Chronic pyelonephritis
14	31	M	102	16.8	Nonvisualization	Kidneys smaller than normal	Nonvisualization	Chronic renal parenchymal disease; cause undetermined
15	57	F	69	6.1	Nonvisualization	Normal-sized kidneys	Normal-sized kidneys with poor excretion	Chronic renal parenchymal disease; cause undetermined
16	75	M	149	5.3	Faint visualization; no size determination	Normal-sized kidneys	—	Multiple myeloma with renal involvement

* Values at the time scanning studies were performed.
† Generally performed after hydration and other therapeutic measures.
— Study not performed.

TABLE 1. USEFULNESS OF ^{131}I-ORTHO-IODOHIPPURATE SCANNING IN SEVERELY AZOTEMIC PATIENTS (Contd.)

Patient	Age	Sex	Blood urea nitrogen* (mg/100 ml)	Plasma creatinine* (mg/100 ml)	^{197}Hg-chlormerodrin scan	^{131}I-hippuran scan	High-dose intravenous urogram†	Clinical diagnosis
17	60	M	103	8.7	Nonvisualization	Bilaterally small kidneys	Small kidneys bilaterally	Nephrosclerosis and chronic pyelonephritis
18	25	F	104	11.8	Nonvisualization	Normal-sized kidneys; upper pole on left visualizes best	—	Chronic renal calculous disease
19	83	M	130	13.2	Nonvisualization	Kidneys smaller than normal	—	Chronic obstructive uropathy secondary to prostatic hyperplasia

* Values at the time scanning studies were performed.
† Generally performed after hydration and other therapeutic measures.
— Study not performed.



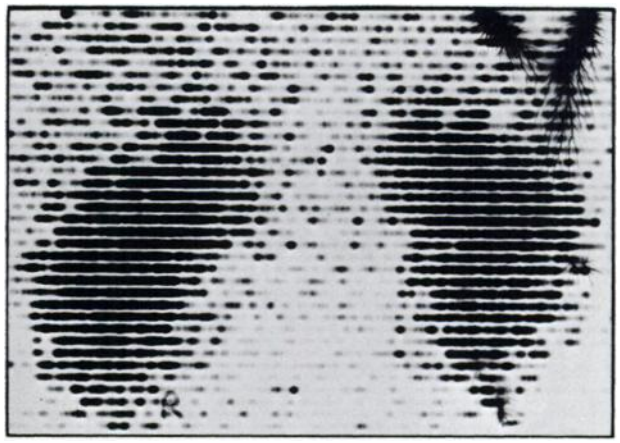


FIG. 1. Renal scans in 37-year-old female with renal insufficiency. At time these studies were done, blood urea nitrogen and plasma creatinine concentrations were 146 and 17.2 mg/100 ml, respectively. Left figure, 6-hr ^{197}Hg-chlormerodrin scan, fails to show any renal activity. Note the marked hepatic activity in right upper quadrant signifying renal failure. Right figure, ^{131}I-hippuran scan started 10 min after injection, demonstrates normal-sized kidneys.

RESULTS

The ^{131}I-hippuran scans let one determine renal size in 18 of the 19 patients studied (Figs. 1 and 2). The blood urea nitrogen and plasma creatinine concentrations in these patients at the time of study ranged from 62 to 146 and 3.5 to 17.2 mg/100 ml, respectively. The one failure to obtain an adequate scan was in a patient with a BUN of 298 mg/100 ml and creatine of 26 mg/100 ml. The hippuran scan did not help in differentiating chronic obstruction from nonobstructive disease.

In 15 of the 18 patients scanned with ^{197}Hg-chlormerodrin, the kidneys were not visualized even on delayed studies. In the other three cases, the kidneys were faintly visualized but insufficiently to determine renal size. Hepatic visualization was present in all of these cases, frequently obscuring the right kidney.

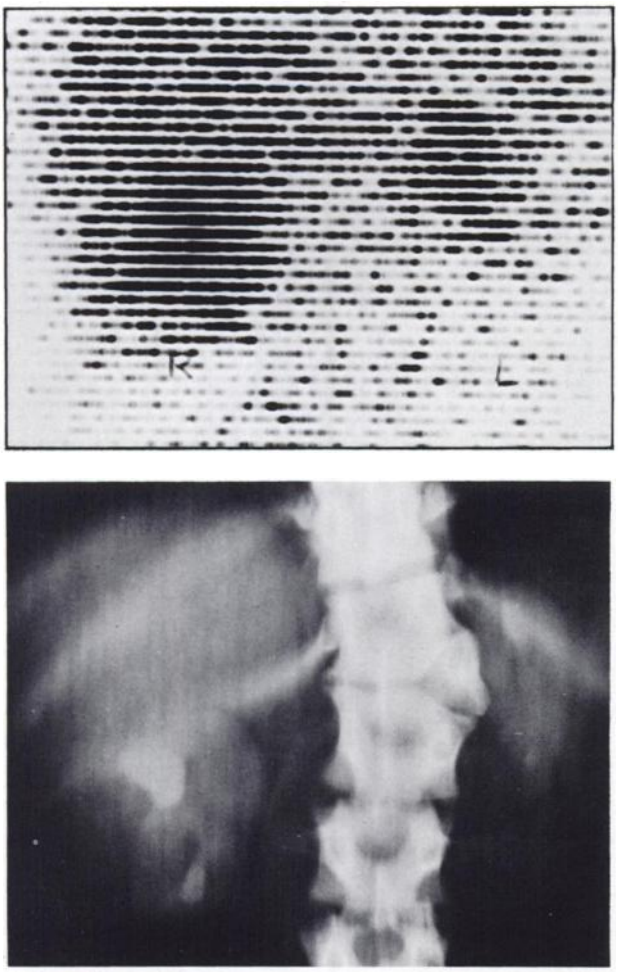


FIG. 2. ^{131}I-hippuran scan and intravenous urogram in a 25-year-old female with probable congenital renal dysplasia. Top figure, hippuran scan started 10 min after injection, shows asymmetrically small kidneys with left being smaller. Vertical diameter of right kidney is particularly short, producing a rounded configuration. BUN and plasma creatinine were 77 and 7.1 mg/100 ml, respectively, at time of study. Small amount of hepatic activity is present which does not interfere with size determination of right kidney. ^{197}Hg-chlormerodrin scan performed on previous day failed to show any kidney visualization. Bottom figure is urographic laminogram performed after BUN was brought down to 50 mg/100 ml with hydration. Note very small left kidney and moderately small, round right kidney. Findings correlate well with hippuran scan. There is also developmental abnormality in vertebrae (T12-L1) that supports impression of congenital renal dysplasia.

High-dose infusion urography was performed in 13 of the 19 patients after renal function had improved with supportive therapy as reflected by lower blood urea nitrogen and plasma creatinine levels. In 12 of the 13 cases visualization of at least the nephrographic phase was obtained. In all 12 instances the size determinations made on the urogram confirmed the findings seen previously on the hippuran scan.

An analysis of the findings by ^{131}I-hippuran scanning in relation to the level of renal function at the time is presented in Table 1.

DISCUSSION

The mean transit time of hippuran through the normal kidney is about 2.92 ± 0.30 min (*10*). This rapid transit time makes hippuran renal scanning difficult with conventional rectilinear scanners. Continuous infusion methods (*11*) and stop-flow techniques (*12*) can be used in special situations but are not practical for routine use. In the patient with normal renal function, ^{197}Hg-chlormerodrin is generally used for routine kidney scanning. Although the scintillation camera has now made visualization of the kidneys with ^{131}I-hippuran practical (*9*), this equipment is presently available in relatively few hospitals; for this reason, ^{197}Hg-chlormerodrin remains the major radiopharmaceutical in use for kidney scanning.

Kidney scanning with ^{197}Hg-chlormerodrin in the severely azotemic patient, however, is unsatisfactory. The chlormerodrin is concentrated by the liver when renal function is impaired (*13*). One of the newer renal imaging agents, ^{99m}Tc-Fe complex also gives poor kidney visualization in patients with severe renal insufficiency (*14*).

Since the transit time of ^{131}I-hippuran is greatly prolonged in patients with renal insufficiency (*9,10*), we have been able to delineate the kidney size in 18 out of 19 azotemic patients using radiohippuran and conventional scanning equipment. The other procedures were not so successful. Retrograde pyelography was not used because of the risks of infection (*5,6*).

The reason for the prolonged transit time of ^{131}I-hippuran in renal failure is unknown. The hippuran appears to be concentrated by the kidney when chlormerodrin concentration is not apparent. Hippuran, like chlormerodrin, is increasingly excreted by the liver as renal function is impaired (*15*). This hepatic excretion of hippuran is much slower than that of chlormerodrin even in the complete absence of the kidneys (*15*). For this reason, it is generally not apparent on the scan where it could conceivably interfere with visualization of the right kidney.

The radiation dose to the normal kidney from 250 μCi of ^{131}I-hippuran is 17.5 mrads (*16*). This figure is based on a transit time of approximately 3 min. Since the renal retention of the radiopharmaceutical is considerably longer in the severely azotemic patient, correspondingly greater dose is delivered to the kidneys. The total dose, however, still appears to fall well within safety standards.

In the course of this study, the rapid excretion of hippuran into the collecting system was not observed. The hippuran renogram in the azotemic patient typically reveals a lower initial accumulation

and a gradual rise in activity during the first hour. This represents accumulation of hippuran without excretion which explains the satisfactory scans and prolonged transit time. Sufficient levels of radioactivity for scanning have been observed for several hours after injection. Even in the presence of marked renal impairment, the kidney can still concentrate hippuran.

From these observations, it is suggested that the ^{131}I-ortho-iodohippurate renal scan is a valuable adjunct to existing techniques of kidney visualization in the study of the severely azotemic patient. It may be the safest and simplest manner of assessing renal size. At this time, the method does not permit differentiation of obstructive from nonobstructive renal disease. The information which may be obtained relates to renal size which provides an indirect assessment of the duration of the renal disease. In addition, the method will demonstrate the presence of two kidneys in patients where renal biopsy is contemplated.

SUMMARY

Scans made with ^{131}I-ortho-iodohippurate successfully visualized the kidneys in 18 of 19 patients with blood urea nitrogen and plasma creatinine concentrations ranging from 62 to 146 and 3.5 to 17.2 mg/100 ml, respectively. Intravenous urography and ^{197}Hg-chlormerodrin renal scanning were inadequate in these patients when attempted at the time of the hippuran scans.

The ^{131}I-ortho-iodohippurate is excreted slowly by the failing kidney. The prolonged transit time of this radiopharmaceutical in the diseased kidney allows sufficient time for adequate scanning studies with conventional rectilinear scanning equipment. The method is rapid, safe and easy to perform. It is recommended as a potentially useful means of evaluating kidney size in the severely azotemic patient. It provides an indirect assessment of the duration of the renal disease. At this time the method does not permit differentiation of obstructive from nonobstructive kidney disease.

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