Renal Cortical Imaging and the Detection of Renal Mass Lesions

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Tc-99m gluceptate renal imaging was compared with the intravenous urogram in 41 patients. While the specificity of the examination was essentially the same for both techniques, the sensitivity for the detection of renal mass lesions was better with gluceptate imaging. The study suggests the desirability of a shift in emphasis from the IVU to the Tc-99m gluceptate scintigram in the early evaluation of suspected renal mass lesions, and merits further clinical evaluation.

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The intravenous urogram (IVU) is used as the initial screening procedure for the detection of renal mass lesions, whereas radionuclide renal imaging (*1,2*) and ultrasonography (*3,4*) have been applied in selected cases to evaluate a suspected renal mass before angiography and/or surgery.

This paper presents the results of a comparative evaluation of the IVU and Tc-99m gluceptate* renal imaging in the detection of renal mass lesions. The accuracy, sensitivity, and specificity of the two modalities are compared in 41 cases, as well as their agreement with the final diagnosis as established by angiography and/or surgery.

PATIENT POPULATION

Between April 1974 and January 1977, Tc-99m gluceptate was used in 275 patients for renal imaging. All patients were informed of the investigational nature of the procedure and informed consent was obtained. Of these patients, 55 also had an IVU and subsequent angiography and/or surgery. The IVUs and gluceptate renal images of 47 patients were available for blind reinterpretation, and form the basis of this report. The patients' ages ranged from 1 mo to 85 yr, with two patients being under 18 yr of age.

METHODS

The intravenous urogram. IVUs were performed with 30 to 50 cc of diatrizoate meglumine (Reno-M-60) with a routine 5-min anteroposterior (AP) view and another AP and both oblique views at 15 min. Tomograms were obtained at the discretion of the attending radiologist and occasionally were obtained later using a drip infusion of diatrizoate meglumine. All patients received an oral laxative on the evening before examination.

The gluceptate renal scan. Adult patients received 15 mCi of Tc-99m gluceptate and children a proportionately smaller dose based on weight. The maximum bolus size was 1 cc and in most cases a renal blood flow with sequential 2-sec images was obtained at the time of the i.v. injection. Static images of 300,000 counts in the posterior, posterior oblique, and lateral projections were obtained 3–4 hr after injection, although images obtained as late as 24 hr postinjection were of good quality. Scintillation gamma cameras with high-sensitivity collimators were used for the flow studies and with high-resolution or converging collimators for the static images.

Angiography. Angiography was performed using the Seldinger technique via the femoral artery, with aortic flush and selective renal artery injections. Subtraction studies were generally obtained.

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TABLE 1. DISTRIBUTION OF 41 CASES SHOWING CORRELATION WITH ESTABLISHED DIAGNOSIS FOR EACH OBSERVER

	TP*	TN	FP	FN	Sensitivity	Specificity	Accuracy
IVU 1	21 (84%)	12 (75%)	4 (25%)	4 (16%)	84%	75%	80%
IVU 2	19 (76%)	13 (81%)	3 (19%)	6 (24%)	76%	81%	78%
Gluceptate 1	23 (92%)	12 (75%)	4 (25%)	2 (8%)	92%	75%	85%
Gluceptate 2	25 (100%)	12 (75%)	4 (25%)	0 (0%)	100%	75%	90%

* TP = true positive, TN = true negative, FP = false positive, FN = false negative.

Comparative evaluation. Each study was reviewed independently by two observers without benefit of clinical history. Reviewers were requested to interpret the study and to determine whether it was of adequate quality for interpretation. The reviewers of the IVUs were asked to note any other significant abnormality identified. All 47 radionuclide studies were felt to be adequate, but eight urograms were considered inadequate by one of the reviewers and six inadequate by both. These six cases were excluded, giving a total of 41 cases for comparison of techniques.

RESULTS

Categorization of cases. Of the 41 cases studied, subsequent angiography and/or surgical confirmation yielded 16 negative and 25 positive cases. Seventeen patients had angiography alone, ten underwent surgery without angiography, and 14 had both angiography and surgery. In these 14, the surgical findings were considered the final diagnosis. Table 1 illustrates the distribution of each observer's interpretation as compared with the final diagnosis. For purposes of categorization, an IVU or gluceptate study that was interpreted as demonstrating a mass lesion in either kidney was considered an abnormal study regardless of which kidney was considered abnormal, since such interpretations generally result in additional studies. True-positive and true-negative studies for each observer were defined as those IVU and gluceptate interpretations that agreed with the final diagnosis as established by angiography or surgery, and vice versa. If a study failed to demonstrate a kidney or part thereof, and subsequent examinations revealed a mass lesion, the study was considered a false-negative, or if normal a false-positive. Categorization in this way was done because failure to demonstrate adequately a part or all of a kidney requires further investigation, since it provides no definite information as to the presence or absence of a renal mass.

Sensitivity and specificity. Sensitivity† is defined as the ability of the procedure to detect a mass lesion when one is present, while specificity‡ is defined as the ability of the procedure to correctly identify those patients having no mass lesions. Application of these definitions to the results in Table 1 yields an average sensitivity of 96% for the gluceptate images and 80% for the IVU. The average specificities are 75% for the gluceptate images and 78% for the IVU observers.

Interobserver comparison. Table 2 is a cross-classification comparing the interpretations of the several observers with each other, based on the agreement of each interpretation with the final diagnosis. We note that the gluceptate interpreters concurred in their interpretation in 39 of 41 cases (95%), whereas the IVU interpreters concurred in only 29 of 41 cases (80%), although the ratio of correct interpretations to total concurrences was

TABLE 2. INTEROBSERVER COMPARISON IN TERMS OF AGREEMENT OR DISAGREEMENT WITH ESTABLISHED DIAGNOSIS

		Gluceptate 1		Gluceptate 2		IVU 2	
		A*	D	A	D	A	D
IVU 1	A	30	4	32	1	29	4
	D	4	3	5	3	4	4
IVU 2	A	28	5	30	3	—	—
	D	7	1	7	1	—	—
Gluceptate 2	A	35	2	—	—	—	—
	D	0	4	—	—	—	—

* A = observer interpretation agreed, or D = disagreed, with established diagnosis of normal or abnormal kidney.

essentially the same with both techniques (89% and 87%, respectively).

DISCUSSION

Early renal imaging was done with mercury-labeled chlormerodrin. Hg-203 was found to be undesirable because of its excessive radiation dose, and the low energy of Hg-197 caused imaging difficulties. These characteristics prevented this agent from gaining wide usage as a screening technique for renal disease.

Technetium-99m has excellent imaging qualities and has been used to label numerous compounds for renal study, most notably diethyelenetriamine-pentacetic acid (DTPA). Tin-DTPA is cleared rapidly by glomerular filtration except for a small protein-bound fraction. With this agent routine imaging detects renal masses but multiple sequential images may be required because of its rapid excretion. We have found these images unsatisfactory for evaluation of renal structure. Iron ascorbic DTPA has been of greater use for cortical imaging because of its tubular localization.

Technetium-labeled gluceptate* (*5*) and dimercaptosuccinic acid‖ (*6*) are also tubule-seeking renal agents (*7*). Both of these tracers have sufficient retention to allow satisfactory imaging as late as 24 hr after injection. Minimal hepatic and splenic concentrations occur early with both agents, and in cases of severe renal failure much of the material will be seen within the liver at the time of delayed imaging, although renal imaging is usually possible.

The normal gluceptate study at 4 hr (Fig. 1) shows a very small amount of the agent in the liver, with excellent definition of the renal contour. Although not demonstrated by this case, filling defects will occasionally be noted in the region of the pelvocalyceal structures due to absence of tracer. Imaging for the first 3–4 min after injection will define these structures and prevent subsequent misidentification as renal mass lesions. Figure 2 is the same patient's IVU, which was interpreted by both reviewers as showing a possible mass lesion on the inferior margin of the right kidney. Arteriography was normal and the patient was subsequently proven to have squamous cell carcinoma of the lung.

Nephrotomography, as advocated by Bosniak (*8*), was not used in this study, although it has shown the ability to detect most renal mass lesions. This technique involves considerable exposure of the patient to high doses of both radiation and iodine, with the attendant potential for untoward reaction. While not mentioned by Bosniak, routine nephrotomography in patients referred for an IVU is also impractical because of time and cost. Thus the IVU, without nephrotomography, has remained as the screening procedure when renal disease is suspected.

Inadequate renal visualization as a result of poor bowel preparation imposes a potentially significant handicap to the interpretation of an IVU, whereas gamma imaging, which is performed from the posterior projection, is not influenced by bowel contents, including barium. Figure 3 shows a typical case. While both IVU reviewers noted the presence of considerable colon con-

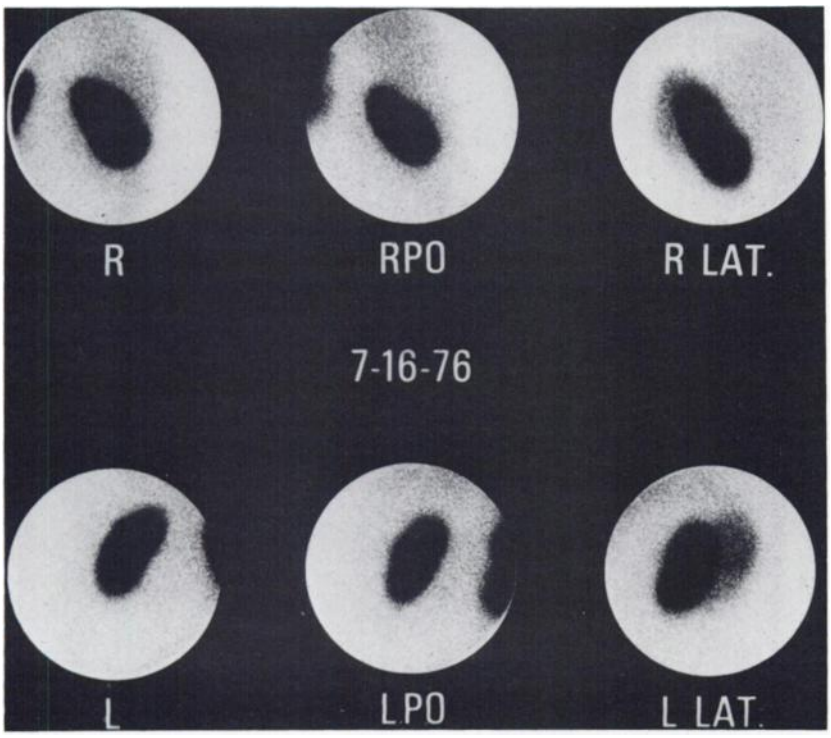

FIG. 1. Normal gluceptate scintigram 4 hr after injection. Note minimal liver uptake.

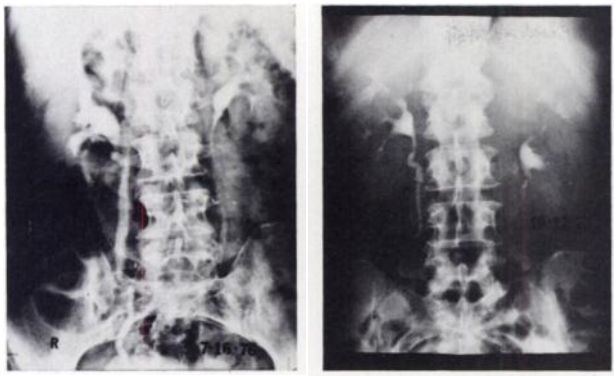

FIG. 2. (left) IVU of patient in Fig. 1, showing possible mass lesion on lateral aspect of right lower pole.

FIG. 3. (right) IVU with minimal distortion of left upper collecting system but no definite mass lesion.

tent, they felt the only abnormality was bilateral renal enlargement. Subsequent gluceptate images (Fig. 4) and arteriography demonstrate a large hypernephroma in the left kidney.

Renal tumor, cyst, infarction, and abscess may have essentially the same appearance on gluceptate static images. Figure 5 is a typical renal cyst diagnosed by all modalities. Although the margins of the cyst are relatively well demarcated on the gluceptate study, it is difficult to differentiate the cyst from the tumor in Fig. 4. We have not found the radionuclide flow study, obtained at the time of injection, to be reliably helpful in evaluating the vascularity of mass lesions, and are now assessing the usefulness of the flow studies performed after the lesion has been located. Ultrasound proved very useful in this particular case and is well established as a means of differentiating solid from cystic lesions.

Improved renal imaging is not the only advantage to the use of gluceptate: the gonadal radiation dose is reduced, the calculated dose being 0.02 rads/mCi, or 0.3 rads/15 mCi adult dose (*9*). Compare this with 2.0 rads for five films (*10*) with an IVU, although these figures do not take into consideration recent advances, particularly improved collimation and rare-earth screens. The ability to image Tc-99m gluceptate at several times following administration, without an increase in patient radiation, is a distinct advantage over the IVU and nephrotomography. In addition, there are no known adverse reactions or toxic side effects with gluceptate. Finally, the use of gluceptate alleviates the problems of bowel preparation and potential hazards of dehydration. Although the possibility of missing extrarenal intra-abdominal disease, calcifications, and mass lesions in particular, exist if only radionuclide studies are performed, a single supine abdominal film would prevent such oversights. In the current series, no significant extrarenal disease that would have altered patient management was detected by the IVU reviewers.

CONCLUSIONS

Gluceptate renal studies performed on 41 patients, who had angiography and/or surgery as well as an IVU, were reviewed. All studies were re-interpreted without benefit of history by specialists in the respective fields.

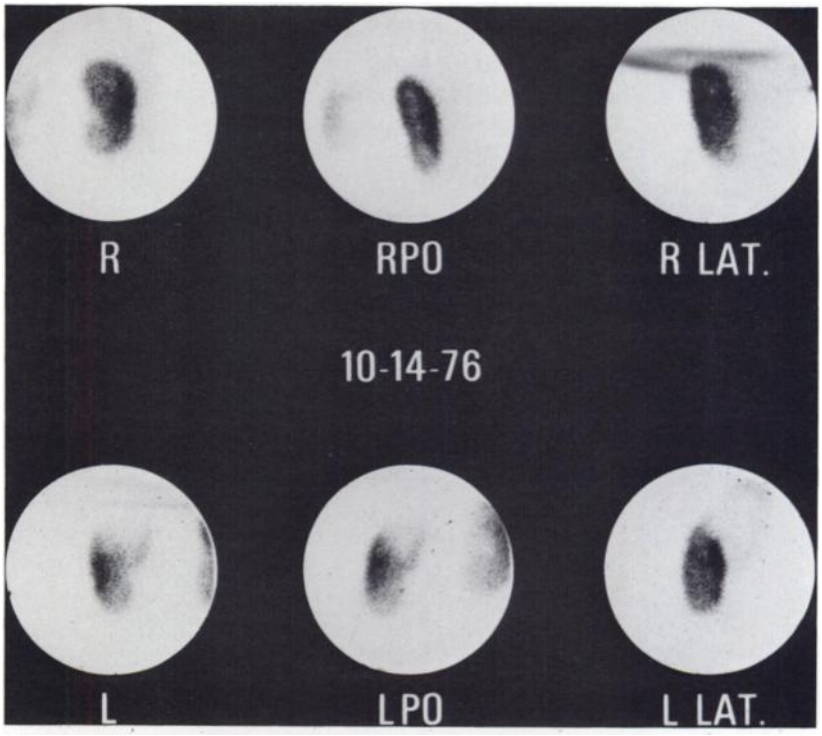

FIG. 4. Gluceptate scintigram of patient in Fig. 3, with lucent zones in right kidney corresponding to calyceal system and large mass lesion in left upper pole.

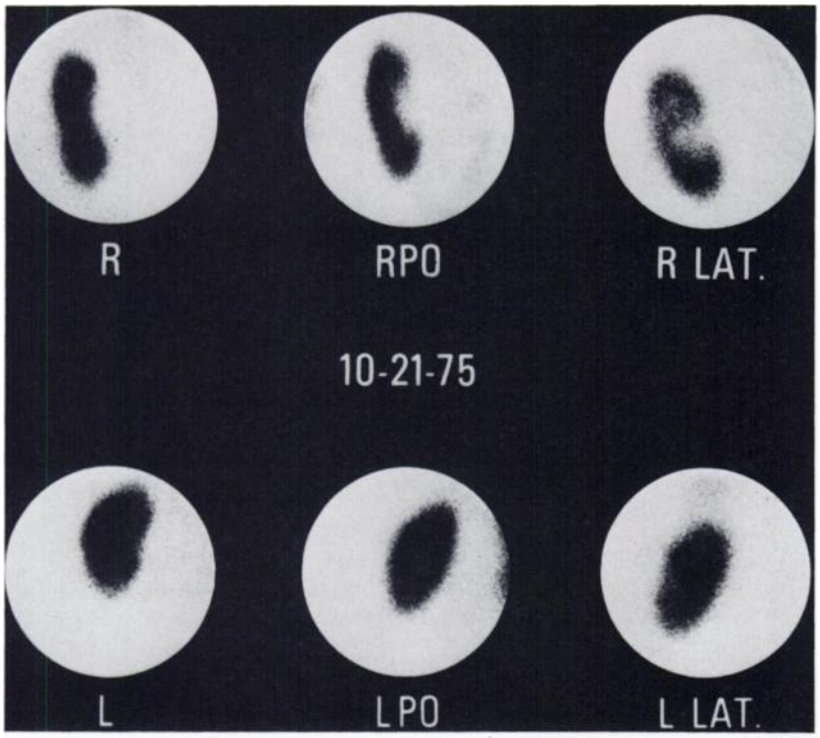

FIG. 5. Right renal cyst proven by ultrasound and cyst puncture. Liver uptake is essentially absent.

Gluceptate images provided greater accuracy than the IVU (85% against 71%) in the evaluation of patients with suspected renal mass lesions. Improved accuracy with gluceptate results from excellent renal concentration, permitting examination of the kidneys in multiple projections without image degradation by abdominal contents. Additionally, gluceptate imaging is associated with lower gonadal radiation dose, the absence of any known toxicity, and does not require patient preparation.

We feel these results indicate the need for a shift in emphasis from the IVU toward Tc-99m gluceptate renal studies in patients suspected of having mass lesions before angiography and/or surgery. Gluceptate also seems indicated in patients with nonvisualization of the kidneys, or with inconclusive studies using standard techniques, before resorting to more invasive studies.

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FOOTNOTES

* Glucoscan, New England Nuclear Corp., North Billerica, MA.

† Sensitivity = $\frac{TP}{TP + FN} \times 100$.

‡ Specificity = $\frac{TN}{TN + FP} \times 100$.

‖ DMSA, Medi-Physics.

REFERENCES

1. MACEWAN DW, ROSENTHALL L: Assessment of extretory urography and radioisotope renal scanning in diseases of the kidneys. *Am J Roentgenol* 86: 1010-1020, 1966
2. POLLACK HM, EDELL S, MORALES JO: Radionuclide imaging in renal pseudotumors. *Radiology* 111: 639-644, 1974
3. GREEN WM, KING DL, CASARELLA WJ: A reappraisal of sonolucent renal masses. *Radiology* 121: 163-171, 1976
4. SHERWOOD T: Renal masses and ultrasound. *Br Med J* 4: 682-683, 1975
5. KAHN PC, DEWANGEE MK, BROWN SS: Routine renal imaging after ^{99m}Tc-glucoheptonate brain scans. *J Nucl Med* 17: 786-787, 1976
6. LIN TH, KHENTIGAN A, WINCHELL MS: A ^{99m}Tc-chelate substitute for organoradiomercurial renal agents. *J Nucl Med* 15: 34-35, 1974
7. WILLIS KW, MARTINEZ DA, HEDLEY-WHITE ET, et al: Renal localization of ^{99m}Tc-stannous glucoheptonate and ^{99m}Tc-stannous dimercaptosuccinate in the rat by frozen section autoradiography. *Radiation Res* 69: 475-488, 1977
8. BOSNIAK MA: Nephrotomography: A relatively unappreciated but extremely valuable diagnostic tool. *Radiology* 113: 313-321, 1974
9. Stannous Glucoheptonate Kit, Package Insert, New England Nuclear, 1973
10. PENFIL RL, BROWN ML: Genetically significant dose to the United States population from diagnostic medical roentgenology, 1964. *Radiology* 90: 209-216, 1968