result of a thorough description of the methods used in estimating radiation dose that are presented in our paper. Much radiation dosimetry is presented in the literature and in product brochures as merely results with no statement of the assumptions and methods used, an unfortunate situation that can lead to misunderstandings and misinformation.

The first point raised is that the radiation dose is overestimated because S values from the total body to the target organ are used instead of S values from the remainder of the body to the target organ. It is correct that this leads to an overestimate in the radiation dose from the total body presented in our Table 5 (*1*). Table 1 compares the results of total dose to the target organ using the theoretically correct formulation and the estimate that we used in our paper, which ignores this overestimate. This table also shows the difference and the percent difference between these two values. The differences for all the organs including the bladder are between 9 and 20 mrads/mCi and result in an overestimation of between 10 and 26%, except for the bladder. The overestimate in radiation dose to the bladder is 20 mrads/mCi or 4.5%. These results were obtained using the computer program, CAMIRD III (*2*).

The bladder is the critical organ for this procedure, even if a shortened voiding schedule is used. Because radiation safety guidelines are dictated by the critical organ dose, the small reduction in dose obtained by using the theoretically correct method has no effect on the use of 2FDG. In addition, the larger error in the estimate of 440 mrads/mCi due to biological variability overshadows the 4.5% reduction in dose obtained using the theoretically correct formula. In point of fact, the decrease of 4.5% for the bladder dose is minimal compared to the differences between the normal human subjects and the uncertainties in the estimate of radiation dose (including the uncertainties in the Monte Carlo calculation of the S value). For the other organs, the estimate of radiation dose, being based on animal biodistribution data, is even more uncertain.

According to Roedler (*3*) the approximate and formally exact solutions approach each other as the relative cumulated concentration in the target compared with the total body increases, which is the case for the bladder compared with the other organs, and for photon energies above 100 keV, which is the case for F-18. For these reasons, we chose to overestimate the doses using the computationally simpler formula for our publication.

The second point raised by T. Smith was that the cumulated activity of 420 μCi-hr for the bladder contents was used to calculate the contribution of the bladder activity to the radiation dose for the other organs. This cumulated activity corresponds to the assumption that 16% of the injected dose is present in the bladder at injection time and that it disappears only by physical decay. This value is based upon dog biodistribution studies used to obtain approval for the human use of 2FDG and represents an intentional overestimate.

TABLE 1. COMPARISON OF RADIATION DOSES FROM 2FDG USING APPROXIMATE AND THEORETICALLY CORRECT FORMULA

Target organ	Approximate formula	Theoretically correct formula	Difference	Percent reduction
	mrad/mCi	mrad/mCi	mrad/mCi	(%)
Kidneys	85	71	14	16
Lungs	76	60	16	21
Liver	75	58	17	23
Spleen	160	144	16	10
Red marrow	51	42	9	18
Ovaries	70	56	20	26
Testes	68	54	14	21
Bladder	440	420	20	4.5

The errors in the lung and ovary dose due to bladder activity were traced to an error in S-value tabulation, and we apologize for this error. It is corrected in the table presented here and results in a change of total dose to the ovaries of from 53 to 70 mrads/mCi and in the lungs from 78 to 76 mrads/mCi.

We are pleased to have confirmation of the linear reduction in the dose for voiding periods between 1 and 2 hr, which T. Smith obtained. We would endorse an analysis, as he suggested in his last paragraph, that would take the varying bladder volume and activity into account in the calculation of radiation estimates. We do feel, however, that they would not result in any significant changes in the conclusions of our paper (*1*).

The items discussed here in no way change the qualitative conclusions of this study. We recommend, however, that the numerical results presented in this letter be used for dosimetry purposes. The dose estimate to the bladder of 420 mrads/mCi, for a 2-hr void, defines this organ as the critical organ. This dose estimate is based upon human retention data and avoids the assumptions inherent in using animal biodistribution data.

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Unmasking of Asymmetrical Renal Perfusion After Exercise in Unilateral Renovascular Hypertension

Radionuclide renography is an important noninvasive method for the evaluation of possible unilateral renovascular hypertension, but the false-negative rate for this investigation has variously been reported as 10–27% (*1*,*2*). In the course of investigating a patient with significant left renal-artery stenosis, the renogram was found to be normal at rest, but evidence of unilateral renal ischemia was seen when the procedure was repeated immediately after exercise, suggesting that this physiological stimulus may increase the sensitivity of radiorenography in detecting significant unilateral renal ischemia.

CASE REPORT

A 37-yr-old woman was first noted to be hypertensive in the middle trimester of her fifth pregnancy. She had no past history

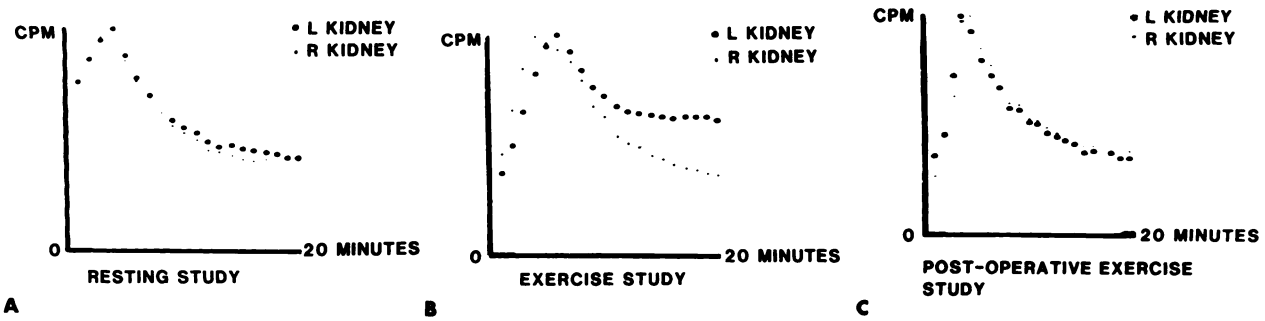

FIG. 1. Preoperative, background-subtracted renograms at one frame per minute, (A) at rest, showing complete symmetry, and (B) after exercise, where both peak activity and washout are delayed in left kidney, shown by larger symbols. Postoperatively (C) exercise renograms are symmetrical. (L = left; R = right).

of urinary-tract infection, renal disease, or analgesic abuse, and had been normotensive during four pregnancies 7–12 yr previously. A cesarean section was performed at 38 wk for fetal distress. The blood pressure remained elevated (160/100–180/110) and was difficult to control with conventional therapy. She was therefore assessed for possible secondary hypertension at 2 mo postpartum. Apart from a mid-line epigastric bruit, examination was normal. Intravenous pyelography showed the right kidney to be 12 cm long; the left was 11 cm long and showed late hyperconcentration of contrast. Full blood examination, chest radiograph, urea and electrolytes, serum creatinine, and urinary microscopy were normal; mean creatinine clearance was 2.4 ml/sec (n = 3, ref. range 1.5–2.5 ml/sec). A 12-lead electrocardiogram showed sinus rhythm with left-ventricular strain. Peripheral plasma renin activity was normal at 0.4 ng/ml-hr (ref. range 0.3–1.4 ng/ml-hr). Renal angiography showed that the origin of the left renal artery was normal, but the lumen was reduced to 1 mm diameter over a 3-mm-long section of the mid portion; the appearance was typical of fibromuscular dysplasia. The right renal artery was normal. Renal vein sampling showed predominant renin secretion from the left side, with suppression of the right-sided secretion. Basal renin levels were: right renal vein 0.4; left 1.1; inferior vena cava 0.4 ng/ml-hr. Ten minutes after 150 mg intravenous diazoxide, values were: right 1.1; left 3.3; inferior vena cava 1.3 ng/ml-hr, indicating predominant secretion from the left side with suppression of secretion from the right kidney (*3*). After five months, adequate control of her blood pressure had not been achieved with conventional antihypertensive therapy. The stenosis was therefore repaired with a vein graft. At follow-up eight months postoperatively she was normotensive without any medication; the epigastric bruit was no longer audible.

Preoperative and postoperative renograms were performed at rest and immediately after a symptom-limited graded exercise stress test, performed on an electronically braked bicycle ergometer (maximum load 600 KPM/min). The radiopharmaceutical used was 15 mCi Tc-99m DTPA, injected as an intravenous bolus. Gamma imaging was performed in the posterior projection, with the patient seated. Data were recorded on a computer at one frame per minute for 20 min. Data were analyzed using commercial software system, with modified curve-analysis and display routines. This investigation was performed three months after renal-vein sampling and angiography. The peripheral renin level was 0.7 ng/ml-hr at that time.

Figure 1 shows the preoperative, background-subtracted renograms obtained at rest (A), and after exercise (B). At rest there is complete symmetry. After exercise there is a 2-min delay in peak activity in the left kidney compared with the right, associated with marked delay in washout from the left kidney. These findings are consistent with left renal-artery stenosis. Using identical technique, 7 wk postoperatively, renograms at rest and after excerise (C) were symmetrical, indicating that the postexercise abnormality was no longer present.

Renal blood-flow studies were recorded at one frame per second for 1 min after tracer injection, both at rest and after exercise, pre- and postoperatively (Fig. 2). The ratio of left-to-right renal uptakes, integrated between 30–60 sec after tracer injection, was used as an index of relative renal blood flow (*4*,*5*). Preoperatively this ratio was normal at rest (0.98, Fig. 2A) but depressed after exercise (0.78, Fig. 2B); postoperatively the ratio was normal after exercise (0.97, Fig. 2C). In contrast to these computed values, scan images obtained on film transparencies at one frame per two seconds during the flow phase of renography failed to demonstrate any asymmetry.

There are many clinical situations where an appropriate physiological stimulus increases the information obtained from nuclear imaging. The effect of exercise on thallium-201 myocardial perfusion and radionuclide ventriculography in coronary disease are examples, but there is a growing list of other applications.* In the

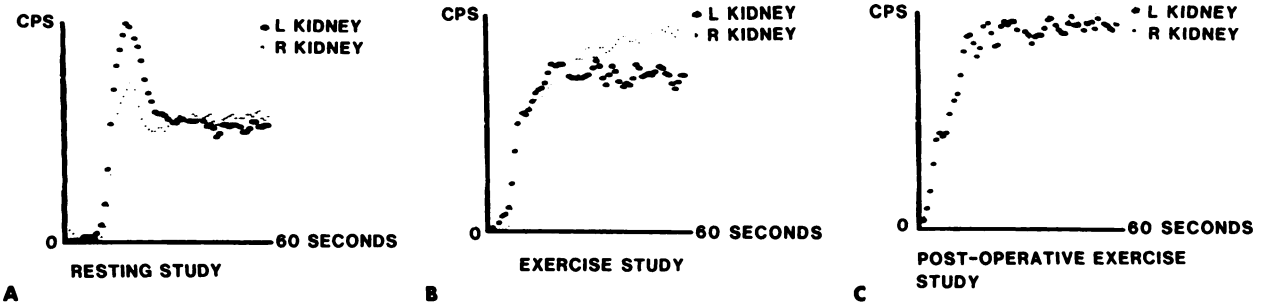

FIG. 2. Preoperative, background-subtracted renal blood-flow studies at one frame per second (A) at rest, showing symmetrical accumulation of renal activity between 30 and 60 sec after tracer injection, and (B) after exercise, where left renal uptake is slower than in right kidney. Postoperative exercise study (C) shows symmetry of renal accumulation in this phase. (L = left; R = right).

case presented here, radiorenography immediately after exercise appeared to be more sensitive than the resting scan in detecting asymmetry of renal perfusion. Further studies of patients with significant renal-artery stenosis, but who show no radiorenographic evidence of asymmetrical perfusion at rest, are clearly necessary to fully establish the value of exercise in this situation.

The effects of exercise on renal function are not well documented, but it is clear that blood pressure increases are associated with decrease in glomerular filtration and renal blood flow (*6*). The latter two changes persist after exercise and may not return to normal for at least 1 hr (*7*). It is difficult to be certain of the mechanism of the postexercise asymmetry, but if recovery of normal renal blood flow were slower on the stenotic side, clearance of the tracer would remain delayed longer on that side. It is possible that pharmacological agents may also be useful in unmasking asymmetry of renal perfusion, as with thallium-201 myocardial perfusion scanning (*8*). Drugs such as dipyridamole, or other vasodilator drugs such as diazoxide, may be interesting in this context.

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FOOTNOTE

* See *Seminars in Nuclear Medicine*, Volume XI, No. 2 and 3, 1981.

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Hepatobiliary Imaging: Pyeloureterectasis

The clinical utility of hepatobiliary scintigraphy is well established for the evaluation of acute cholecystitis and patency of the common bile duct. Many reports have shown fortuitous findings in the blood-pool, renal, hepatocytic, and biliary phases of the study. We wish to report a case of unilateral ureteral visualization noted during hepatobiliary scintigraphy, and the probable cause of this finding.

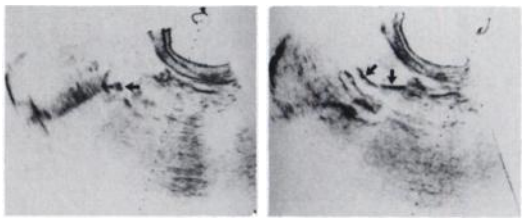

FIG. 1. Biliary ultrasonography. Gallbladder gives a single large internal echo (arrow) with prominent posterior shadowing, compatible with cholelithiasis (left). There may be other associated small stones. Common bile duct (two arrows) measured 12 mm, which indicates moderate dilation (right).

An 18-yr-old Mexican American female presented with a 1-wk history of midepigastric and right-upper-quadrant pain. Her past medical history revealed that she had delivered without complications approximately 5 wk before the current presentation. No blood products were used during delivery. She denied a history of hepatitis or known exposure to hepatitis. Admission laboratory values revealed mild leukocytosis and moderate elevation of all liver function tests, but renal function was normal.

Ultrasonic examination was obtained (Fig. 1). Hepatobiliary scintigraphy was likewise obtained to evaluate patency of the common bile duct (Fig. 2). The patient was explored surgically; chronic cholecystitis with cholelithiasis were discovered with an impacted stone at the ampulla.

On the fourth postoperative day urinalysis and urinary culture were unremarkable. The patient was discharged in stable condition.

Pyeloureterectasis during and immediately after pregnancy has been observed urographically for many years, but the cause of the dilatation remains undetermined and controversial; by itself this finding does not constitute proof of urinary-tract disease (*1*). Some degree of dilatation probably occurs during every pregnancy, but it usually subsides within two months after delivery although some reports document pyeloureterectasis persisting for much longer. The right ureter is dilated more commonly and usually to a greater degree than the left. Proximal ureteral dilatation is more common than distal dilatation. It is often difficult to segregate postpartum women with untreated asymptomatic bacteriuria during pregnancy (*2*). The interval of 4 to 6 mo is chosen to allow the ureteral dilatation of pregnancy to subside before further evaluation by intravenous pyelography (*3*).

Few fortuitous renal findings in patients undergoing hepatobiliary scintigraphy have been reported. After a search of the literature, we conclude that this patient represents the first reported hepatobiliary scintigraphic case of unilateral renal-ureteral visualization not representing a pathologic ureteral obstruction. The ureters normally dilate during pregnancy, and thus one should not rely solely on the finding of unilateral ureteral visualization to conclude that an obstruction of the ureter exists, particularly in postpartum females. Because of the high frequency of pyeloureterectasis in the postpartum population, a battery of serum creatinine, BUN, urinalysis, and urine culture is recommended for asymptomatic patients without a history of neoplasm or previous calculus formation. Intravenous pyelography should be used sparingly.

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