Importance of Correctly Identifying Kidney Structure When Performing Quantitative Analysis in Bilateral Renal Scintigraphy

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Occasionally, clear visualization of the kidneys in the early phase of bilateral renal scintigraphy is not readily apparent. Knowledge of the normal sequence of the injected bolus of Tc-99m-DTPA and of kidney morphology and its variations aids in distinguishing the kidney from surrounding structures. However, various hypervascular structures, such as the spleen, may mislead the technologist who performs differential count analysis. All or part of the spleen may be included if there is poor visualization of the left kidney. If the technologist mistakenly compares the right kidney to the spleen on the left side, the end results or quantitation will be misleading and incorrect. By viewing both the dynamic and static images collectively, the technologist is able to define kidney tissue and proceed with the quantitative analysis.

The use of Tc-99m diethylenetriamine pentaacetic acid (DTPA) as a renal function imaging radiopharmaceutical has been well documented. The biological behavior of DTPA coupled with the physical properties of the Tc-99m 140 keV photon makes this compound optimal for scintillation camera imaging (*1*). In the kidney, Tc-99m DTPA is excreted by glomerular filtration (*2, 3*), as opposed to I-131 Hippuran, which combines tubular secretion and glomerular filtration. Because of the recent increase in renal scintiscans performed at our institution and the demand for quantitative measurements, we have developed the following technique and protocol to evaluate bilateral renal function.

Method and Materials

Photoscans are produced using the low energy, all-purpose (LEAP) collimator attached to a Searle large-field-of-view scintillation camera (LFOV) interfaced with an Ohio-Nuclear Series 150 Datasystem™. The patient is imaged in the supine position and properly centered so that both kidneys and bladder are included. Following the intravenous injection of 10 mCi of Tc-99m DTPA, sequential 3-sec images are taken for 30 sec and stored on magnetic tape. Static images are then obtained at 1, 2, 3, 4, 5, 10, 20, and 30 min. The first image is taken at a preset count of 600K and the remaining images are preset for the time taken from the 1-min image in order to show relative renal function. All images are recorded on 70-mm film. In addition, the first five images of the static phase are also recorded on magnetic tape. Differential count analysis is performed on one of these five images, i.e., before the radiopharmaceutical reaches the collecting system of the kidneys. On completion of the 30-min image, a decision is made as to whether or not the patient is to return for delayed views; these usually take place 2–24 hr following the time of injection. Delayed images are obtained when there is delayed excretion or delayed appearance of renal activity.

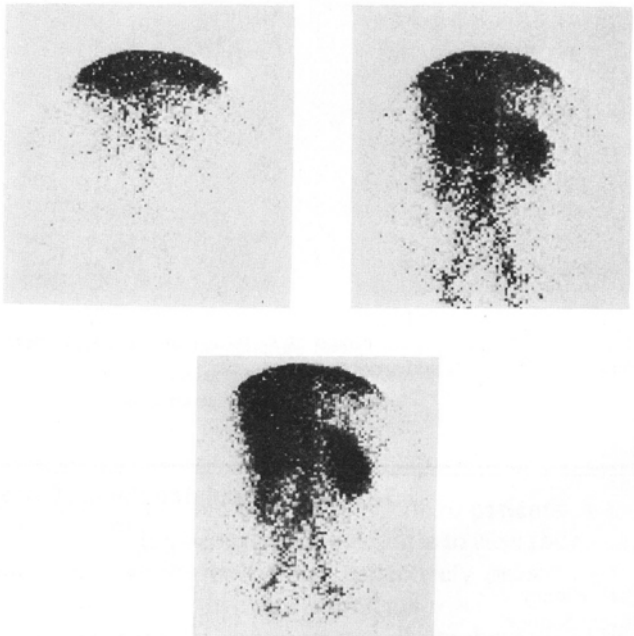

FIG. 1. Serial 3-sec images of dynamic phase. Starting with upper left image and following left to right to center, images are 7–9, 10–12, and 13–15 sec, respectively.

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The patient's study is retrieved from the memory, and the dynamic portion of the study is reviewed by the technologist in its entirety. Serial 3-sec imaging begins when activity is first noted in the abdominal aorta and continues to the end of this phase (Fig. 1). The timing sequence is noted and recorded on the corresponding image. These images are then arithmetically summed and smoothed in order to display an integrated dynamic image (Fig. 2). The data console is then programmed for quantitative analysis; irregular areas of interest are positioned over the region that has been designated as kidney on one of the early static images—before the radiopharmaceutical is seen in the kidneys' collecting system. Previously, our equipment did not allow for irregular areas of interest—areas other than squares or rectangles. With installation of a joystick control, we now have greater flexibility to produce a more realistic outline of each kidney, thereby producing better assessment of renal quantitation (Fig. 3).

We use the 16 K (128 × 128 matrix, eight bits deep) resolution when performing quantitative measurements. The kidney area is outlined with the joystick control; this area is then filled (painted) in. Once this has been achieved, the total number of counts contained within this area and the total number of memory locations covered by this same area are displayed in the alphanumeric readout on the display. When correcting for blood–background activity, we take one-tenth the total memory locations (cells) and round this number to the next highest digit. We then produce this number fairly medially to each kidney. Once this has been achieved, the total number of counts are noted on the display and copied. This number is then multiplied by ten, representing an approximate blood–background value (Table 1). A possible alternative for those departments that are limited in producing irregular areas of interest is to divide the kidney into sections and use multiple areas of interest (Fig. 4). Our method produces a more accurate quantitation of renal function since it lends itself to the natural configuration of the kidney. The inadvertent inclusion of contributing activity from both liver and spleen is also reduced. However, errors may occur if the multiple areas overlap each other. These geometrical areas must remain constant when obtaining blood–background subtraction values.

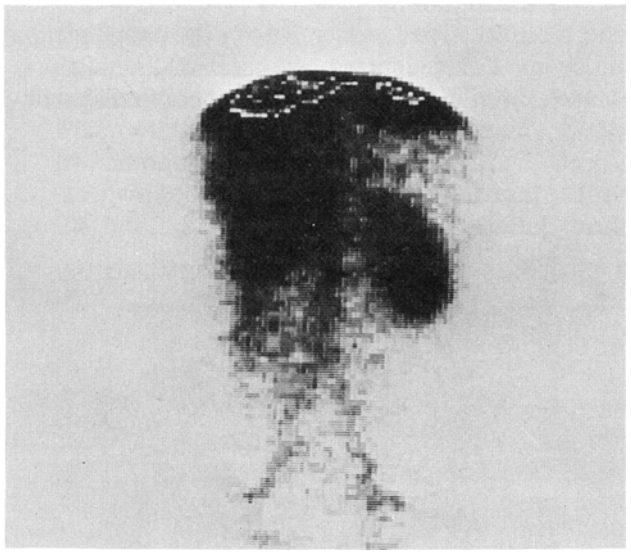

FIG. 2. Integrated dynamic image of 7–15 sec that has been arithmetically summed and smoothed.

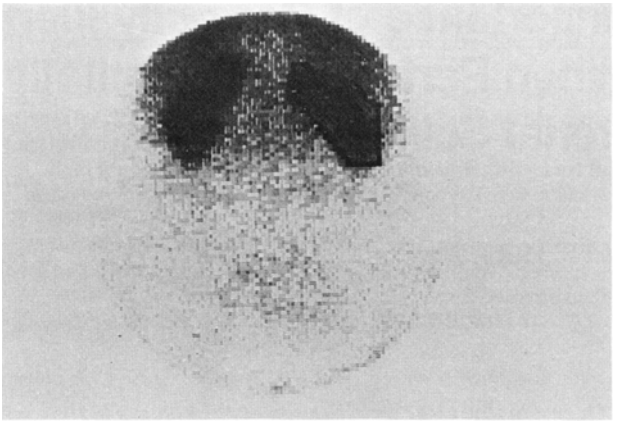

FIG. 3. Posterior projection shows right kidney outlined using a joystick control.

Results and Discussion

Areas of interest allow quantitation of differential

TABLE 1. Calculated Values Performed in Bilateral Renal Scintigraphy

	Kidney Tissue		Blood–Background Subtraction	
	Total No. of Counts over Kidney Tissue	Total No. of Memory Locations	Total No. of Counts	Total No. of Memory Locations
Left Kidney	55,152	0428	2114 × 10	43 × 10
Right Kidney	40,802	0328	1662 × 10	33 × 10

			Left Kidney	Right Kidney
55152	40802	24182		
−21140	−16620	+34012	$\frac{34012}{58194} = 58\%$	$\frac{24182}{58194} = 42\%$
34012	24182	58194		

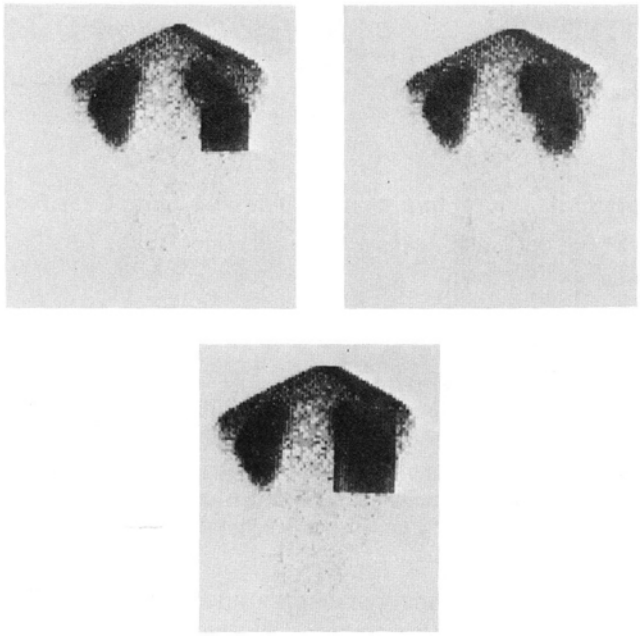

FIG. 4. Using multiple areas of interest produces a more accurate quantitation of renal function as opposed to using one area to cover the entire kidney.

renal function. In order to correctly produce reliable quantitative measurements in the static phase of bilateral renal scintigraphy, knowledge and understanding of the normal vasculature and anatomy are imperative. The sequence of the appearance of the injected bolus is: abdominal aorta, kidneys and spleen at approximately the same time, and finally the hepatic blood pool. Difficulty

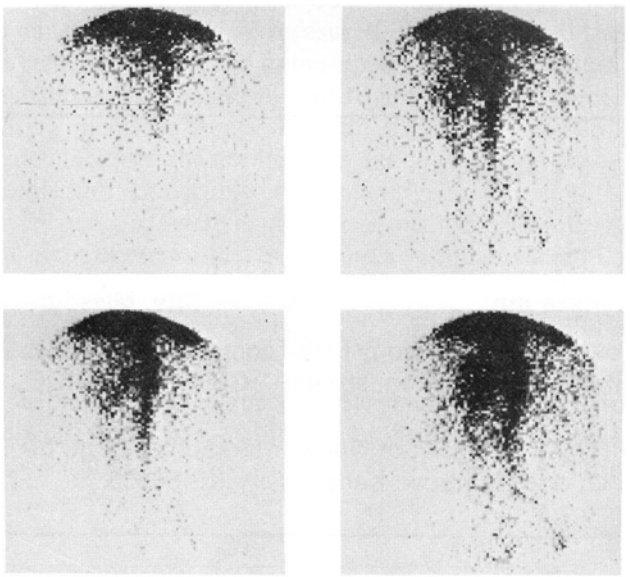

FIG. 5. Serial 3-sec images show large hypervascular structure in left upper quadrant; this is apparently spleen.

arises in approximating kidney tissue on the left side because of the close proximity of the spleen and its normal splenic blush (Fig. 5). Hypervascular structures other than the spleen tend to make quantitation difficult (Fig. 6).

In the past we performed quantitative analysis on the static renal images prior to examining the study in its entirety. Problems occur with this method when deciding what is normal renal structure with its variations compared to extrarenal tissue and the surrounding structures. At times it is possible to differentiate vascular structures in the early stages of bilateral renal scintigraphy. However, delineation of both kidneys from adjacent structures

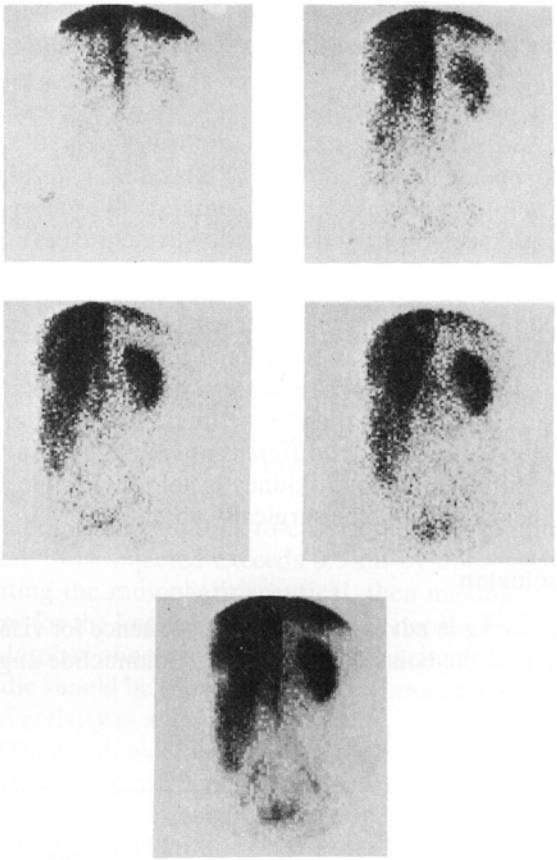

FIG. 6. Hypervascular structure occupies much of the left abdomen and overlapping lower pole of left kidney; this may be related to mesenteric structures.

was easily observed in only 15 out of 70 patients. A refined approach to our initial method is to view the entire dynamic and static images collectively prior to performing quantitative measurements.

After evaluation of all frames, the technologist then decides what is renal tissue and where it is exactly located. In those cases where kidney tissue may still remain unidentifiable, the nuclear medicine physician may be requested to assist the technologist in determining kidney

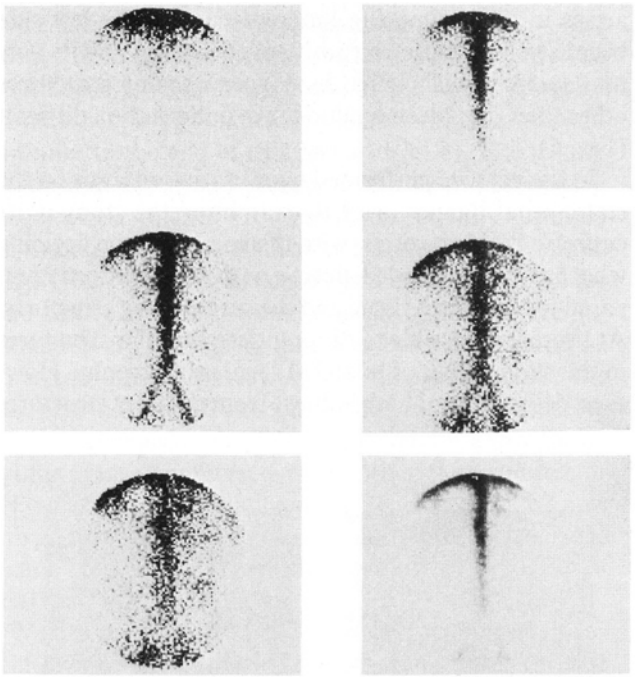

FIG. 7. Serial 3-sec images show poor bilateral renal function.

structure. Quantitative measurements are not performed on patients showing marked bilateral impairment of function (Fig. 7). In these cases we feel that quantitation will add little information to the final interpretation of the study. In addition, differential counts are waived when either left or right kidney is not identifiable and may be presumed to be surgically absent (Fig. 8).

Conclusion

Knowing in advance the normal sequence for visualization of the bolus during a renal radionuclide angiogram and the normal renal appearance and its variations is essential to obtain correct data that is to be included as part of a patient's study. The problem of correctly identifying renal structure may be somewhat simplified if the entire study is viewed collectively before quantitative measurements are performed. Owing to lack of time, to inexperience, or to both, the technologist may be tempted to mistakenly compare the right kidney to the spleen on the left side, thus yielding incorrect data.

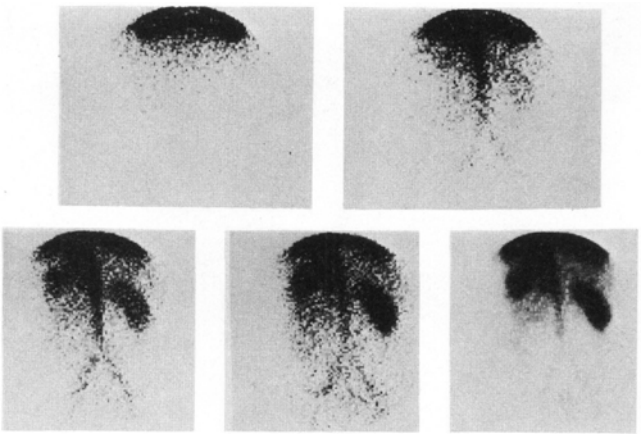

FIG. 8. Rapid sequence images show grossly normal perfusion to the right kidney and to the spleen on left side. Left kidney is not identified, presumably because of surgical resection.

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