Radiation Exposure Sustained by Sonographers After Renal Scintigraphy

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Renal scintigraphy complemented with sonography plays an important role in the management of renal transplant patients. When performing a renal sonogram shortly after the completion of a renal scan, the sonographer is exposed to potentially significant levels of radiation originating from the patient. To quantify this, we measured exposure rates up to 28 hrs postinjection in 5 renal transplant patients who underwent 6 studies with 20 mCi of technetium-99m DTPA. Whole body and hand exposure rates were 4.9 and 19.8 mR/hr, respectively. Since the radiation exposure of the sonographer who performs the study is significant, a table is provided for use as a guide for the maximum number of patients that could be studied and the maximum number of examination hr that can be accrued before the annual limits recommended by the National Council on Radiation Protection are exceeded. Recommendations are given to reduce the exposure to as low as reasonably achievable.

Renal scintigraphy is an important technique in the management of renal transplant patients (*1–5*). The use of this imaging procedure complemented by ultrasonography has been established in many institutions as a technique to evaluate graft performance as well as to monitor and diagnose certain renal allograft complications (*1–7*).

As the incidence of renal allografts has dramatically increased, the number of renal scintigraphic and sonographic studies has increased concomitantly. Hence, there is a distinct possibility that a renal ultrasound study may need to be done a short time after the completion of a renal scintigraphic study. In such instances, the ultrasonographer will be exposed to radiation originating from the patient.

The magnitude of such possible exposure has not been reported to date in the scientific literature. Our investigation was directed at determining hand and whole body exposure sustained by an ultrasonographer who performs a renal ultrasound study on a renal transplant recipient shortly after a renal scintigraphic study.

MATERIALS AND METHODS

Radiation exposure measurements were performed on five renal transplant recipients undergoing clinically indicated

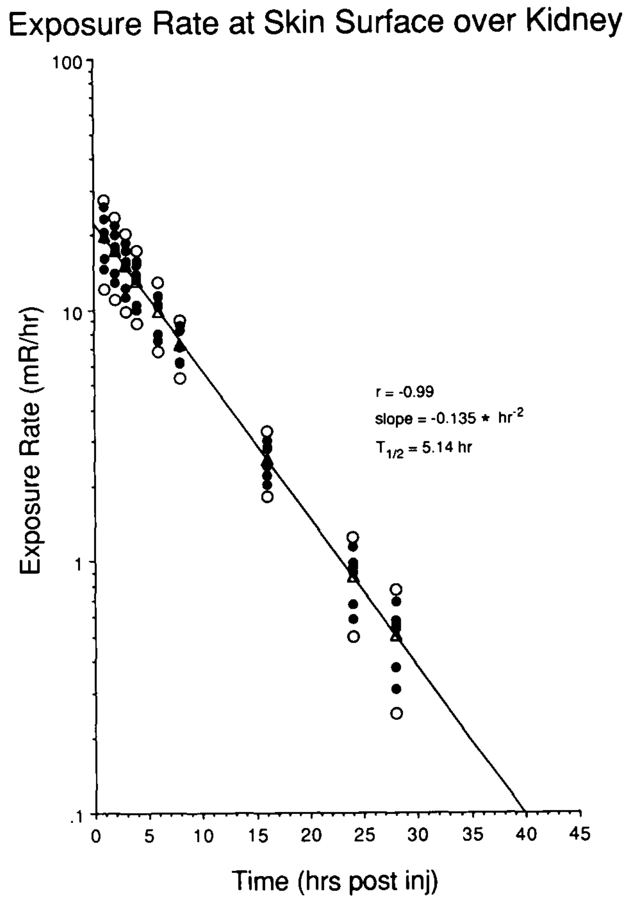

FIG. 1. Exposure rate at skin surface over kidney plotted against hours postadministration of technetium-99m DTPA. Mean exposure rate is represented by triangles and s.d. of ±2 by open circles. Individual readings from each study are presented as scatter plots (closed circles).

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renal scintigraphy. One patient was studied twice. These patients had a mean serum creatinine concentration of 5.97 mg/dl with a range of 2.1 to 10.2 mg/dl. Each patient received 20 mCi of technetium-99m (^{99m}Tc) DTPA.

Following completion of the imaging study, exposure rates were determined with a G-M detector equipped with an HP-270 energy-compensated probe. Measurements were made at the skin surface and one foot from the skin over the upper, middle, and lower portions of the transplanted kidney as well as over the bladder. These anatomic sites were defined while the patient was under the gamma camera with the Am-241 marking wand, and were then marked on the patient's skin with a skin marker. Serial readings were taken at various time intervals up to 23–28 hr postinjection. For each sampling time, the highest value obtained over the kidney was used in the analysis.

The four sets of data representing the exposure rates at skin surface and one foot from the skin over the kidney and the bladder were subjected to regression analysis to determine the mean exposure rate as a function of time for each site. The regression lines so obtained and the individual data points were plotted on semilog graph. The regression analysis permitted the calculation of exposure rates for specific time intervals after initiation of the scintigraphic study. The correlation coefficient, the slope, and the effective clearance half-time ($T_{1/2eff}$), are reported for each of the sites analyzed.

RESULTS

The mean exposure rates over the kidney and bladder at skin surface and at one foot, are shown in Figures 1, 2, 3, and 4. Each figure shows the individual data points as well as the mean exposure values and the range based on ±2 s.d. from the mean. Since exposure values fall exponentially with time, the $T_{1/2eff}$ and slope are also given.

The mean exposure rate over the kidney 1 hr postinjection of 20 mCi of ^{99m}Tc DTPA was 19.8 ± 7.7 mR/hr at the skin surface and 4.9 ± 1.4 mR/hr at a distance of 1 ft from the skin. Over the bladder, the mean exposure rate value was 22.6 ± 15.6 mR/hr at the surface and 5.4 ± 1.3 mR/hr at 1 ft.

DISCUSSION

The data presented indicate that sonography shortly after renal scintigraphy imparts sufficient radiation to the hand and whole body of the ultrasonographer to merit special consideration. The radiation exposure of an individual is directly proportional to the length of exposure. Therefore, for a sonographer who requires an average working time of 0.33

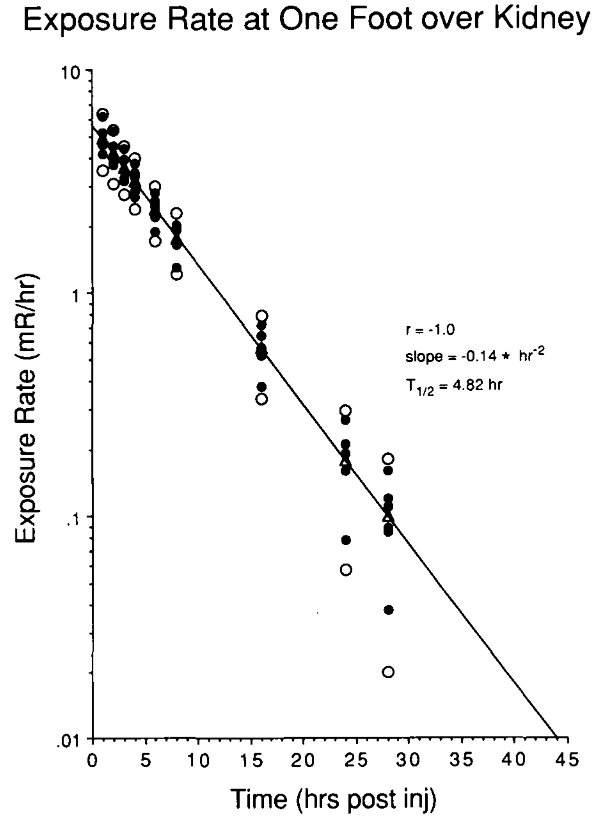

FIG. 2. Exposure rate at one foot from skin surface over kidney plotted against hours postadministration of technetium-99m DTPA. Mean exposure rate is represented by triangles and s.d. of ±2 by open circles. Individual readings from each study are presented as scatter plots (closed circles).

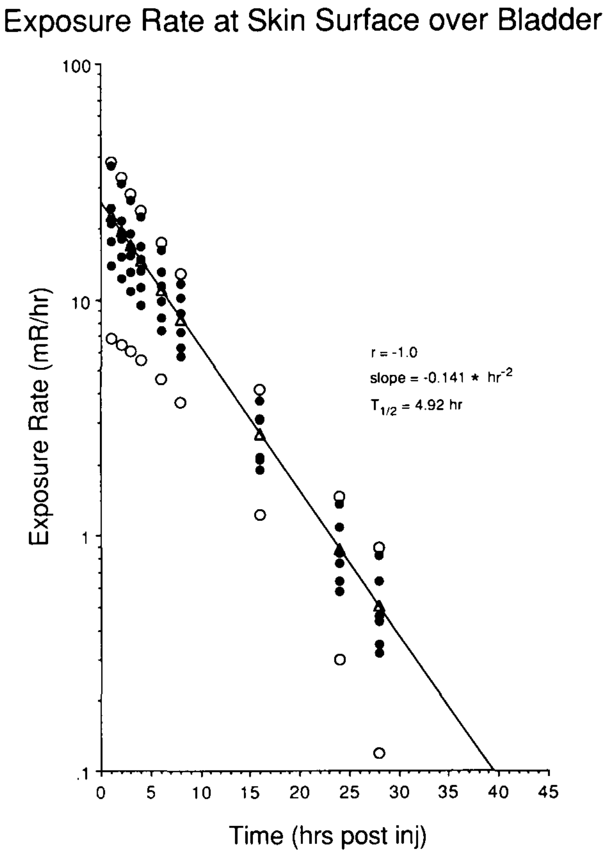

FIG. 3. Exposure rate at skin surface over bladder is plotted against hours postadministration of technetium-99m DTPA. Mean exposure rate is represented by triangles and s.d. of ±2 by open circles. Individual readings from each study are presented as scatter plots (closed circles).

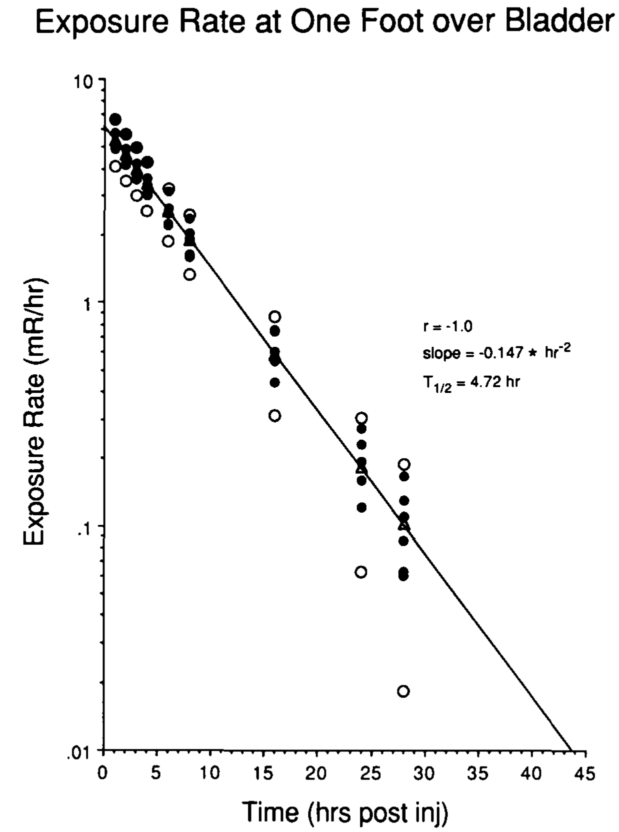

FIG. 4. Exposure rate at one foot from skin surface over bladder is plotted against hours postadministration of technetium-99m DTPA. Mean exposure rate is represented by triangles and s.d. of ±2 by open circles. Individual readings from each study are presented as scatter plots (closed circles).

hr per patient and who performs the renal sonogram 1 hr after the injection of 20 mCi of ^{99m}Tc DTPA, the mean radiation exposure to the hands is between 6.5 and 7.5 mR. The values reflect the mean exposure levels at skin surface over the kidney and the bladder, respectively. Using the data at 1 ft above the kidney and the bladder as an indicator of whole body exposure, we calculate whole body exposures of 1.6 to 1.8 mR per examination.

For the conditions cited above, Table 1 lists the maximum number of patients that can be examined and the maximum number of examination hours that can be accrued before the annual exposure limits recommended by the National Council on Radiation Protection and the Nuclear Regulatory Commission are exceeded (*8*).

The exposure rates may be significantly higher in patients with abnormal renal function. For example, the highest exposure rates observed in this study occurred in a patient who had an abnormally enlarged bladder with excessive retention of urine and radiotracer within the bladder. The close proximity of an enlarged bladder with abnormal retention of urine contributes to increased exposure rate over the kidney as well.

Using the ALARA concept as the operational objective of all radiation safety practices (*9*), we suggest several recommendations to reduce radiation exposure.

1. Whenever possible, perform the renal ultrasound study first. This arrangement meets the ideal of no radiation exposure from any source. It is recognized, however, that this may not be achievable at all times due to

TABLE 1. Calculation of Maximum Number of Patients and Working Hours Per Year

		Over Kidney		Over Bladder	
	Limits in mrem/yr	Maximum no. of patients/yr	Maximum no. of working hrs/yr	Maximum no. of patients/yr	Maximum no. of working hrs/yr
A. Based on Data at Skin Surface (Hand Exposure)					
Nuclear Regulatory Commission (MDP for radiation workers)	75,000	11,538	3,807	10,000	3,300
As low as reasonably achievable (ALARA, 10% of MDP)	7,500	1,154	380	1,000	330
National Council on Radiation Protection (radiation workers)	50,000	7,690	2,538	6,670	2,201
B. Based on Data at One Foot From Skin Surface (Whole Body Exposure)					
Nuclear Regulatory Commission (MDP for radiation workers)	5,000	3,125	1,031	2,778	916
As low as reasonably achievable (ALARA, 10% of MDP)	500	313	103	278	91
Nuclear Regulatory Commission (MDP for public)	500	313	103	278	91
National Council on Radiation Protection (public infrequent exposure)	500	313	103	278	91
NCRP (public frequent exposure)	100	63	20	56	18

conflicts in scheduling and because, frequently, an ultrasound study is indicated based on scintigraphic findings.
2. Perform the ultrasound study several hr after the nuclear medicine study, when the exposure rate will be lower; i.e., wait longer between studies. This will decrease the radiation exposure significantly by a factor that is predictable from the $T_{1/2}$ of the exposure curve. Performing the study 4 hr postinjection will decrease the hand exposure by almost half for both the kidney and the bladder.
3. Reduce the ^{99m}Tc DTPA dose to 15 or 10 mCi. This will result in a proportional decrease in the exposure.
4. Insist on having patients void before the ultrasound examination. If it can be done safely, hydration between the nuclear medicine and ultrasound examinations will not only facilitate effective preultrasound voiding but will also promote faster clearance of the ^{99m}Tc DTPA from the renal collecting system.
5. Empty urine collection devices, if applicable, before starting the ultrasound study.
6. Keep ultrasound exam as short as possible.
7. Rotate ultrasonographers if several are available.

Finally, each institution should review current scheduling procedures for renal transplant patients to assure optimum patient care while minimizing the radiation exposure of ultrasonographers.

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