LETTERS TO THE EDITOR

Re:Radiation Absorbed Dose from Tc-99m Diethylenetriaminepentaacetic Acid (DTPA)

With reference to the recent MIRD Dose Estimate Report No. 12, on the radiation absorbed dose from Tc-99m diethylenetriaminepentaacetic acid (DTPA) (*1*), the authors make the important point that the report applies only for Tc-99m DTPA formed by the method they described. On the other hand, the clinical categories of the 11 patients, on whose whole-body retention data the report is based, are not defined. These patients appear to comprise an arbitrary group with some degree of renal impairment, since the average total-body retention equation includes a 40% component with an elimination half-time of more than 9 hr, suggesting a glomerular filtration rate of the order of 20 ml/min. Our own data observed in normal volunteers show a markedly different retention pattern, with more rapid excretion of Tc-99m DTPA prepared by the method described in the MIRD report. With the increasing awareness of the legal requirements relating to the use of diagnostic radiopharmaceuticals in both patients and volunteers, it is becoming customary to distinguish between normal and abnormal physiology in the estimations of radiation absorbed dose. Impaired renal function can have a pronounced influence on the dosimetry of dynamic renal radiopharmaceuticals, since they are excreted rapidly in the normal case. Elliott et al. (*2*), for example, have illustrated the effects of various renal diseases on the dosimetry of radioiodine-labeled hippurate. While it is appreciated that the short physical half-life would limit the extent of such effects using Tc-99m DTPA, it is suggested that the value of the MIRD Dose Estimate Report No. 12 could have been increased if a distinction had been made between normal and diseased states, as has been the practice with some of the previous MIRD dose estimate reports.

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Reply

The patients whose data constituted the basis for MIRD Dose Estimate Report No. 12 (*1*) were under study for hypertension. They are the same group who were reported by Klopper et al. (*2*). The total-body data in MIRD Dose Estimate Report No. 12 indicate two components with fractional distributions of 0.579 and 0.421, and biological rate constants of 0.690/hr and 0.075/hr respectively. These values compare fairly well with those reported by Klopper et al., where the fractional distributions were 0.695 and 0.266, and the rate constants were 0.401/h and 0.075/h. The differences arise because in the paper by Klopper et al. the results were obtained by pooling the original data, whereas in the MIRD Dose Estimate Report the results are derived from the mean of the individual data.

The disappearance constants for plasma are very different from those for total-body retention. In the paper by Klopper et al. the plasma disappearance rates are 2.70/hr and 0.329/hr for the two components, neglecting a much shorter mixing component. Calculation of glomerular filtration rate (GFR) from the plasma disappearance rates in each individual gave values of 87.9 ± 24.3 ml/min for Tc-99m DTPA and 98.8 ± 23.0 ml/min for I-125 iothalamate. These values are reasonably normal.

The difference between glomerular filtration rates as calculated from plasma disappearance rates and from total-body retention is difficult to explain. There may be some delay in equilibration of the concentration of the GFR agents throughout the extracellular space.

Dr. Smith is correct in his concern over doses incurred when organ function is not normal, and also that in this case the short physical half-life of Tc-99m DTPA would limit any major effect. Actually, if renal function is absent, the bladder dose, (representing the highest dose in our calculations) would be reduced, and other tissues would be little changed. For example, assuming uniform total-body distribution, the dose estimate for the total body would be 0.017 rad/mCi instead of the 0.0075 rad/mCi in MIRD Dose Estimate No. 12, and all other organs would receive the same dose as the total body.

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Uniformity Correction and Quality Control in Scintillation Cameras

Most of the scintillation cameras currently on the market have

some form of on-line correction device for energy and linearity. There are in use, however, many cameras that are fitted with less sophisticated uniformity-correction modules that depend, at least partially, on a stored count-correction matrix. The incoming data are compared with the count-correction matrix and counts are either added to or subtracted from the image to compensate for nonuniformities on a basis of count density rather than count position.

It may be argued that these count-adding or count-skimming methods do not correct the real cause of nonuniformity, which is nonlinearity or inaccurate mapping of events from the detecting crystal onto the display screen. That, however, is not the subject of this communication, and we recognize that, to a first approximation, these devices do work and do help to overcome some of the deficiencies inherent in scintillation-camera design. Rather, our concerns are directed at the manufacturers' specifications for these cameras and the manner in which quality control is being performed.

With respect to the first problem of manufacturers' specifications, we have repeatedly discovered that manufacturers refuse to divulge the uniformity specifications for their product without count correction in action (assuming that it can, in fact, be disabled). It may well be that such specifications do not exist, for we have heard statements such as "20% sounds about right" or "15% is in the right ball park." Some manufacturers do suggest that if the imaging time is extended by 15% (i.e., 15% of counts are being skimmed) or decreased by 20% (i.e., 20% of the counts are generated by the correction module), then the camera should be retuned. These approximations are poor indicators of the type and extent of nonuniformity compared with NEMA specifications. They fail to reflect the true degree of nonuniformity that exists before count correction, because the correction counts may be fairly evenly distributed over the face of the detector or, alternatively, may be concentrated into one small area. Manufacturers who market scintillation cameras that depend on a count-correction matrix should be encouraged to quote a specification for the uniformity of their cameras without count-correction in action. Only in this way can the user determine whether the camera is subsequently within specifications; otherwise the count-correction module can hide a mishmash of ills. Although NEMA measurements may, in some respects, have some deficiencies, they do at least represent a standardized and traceable approach.

The second problem that we have perceived is a direct result of the first. Some users seem to feel that complete quality-control requirements are fulfilled if images are acquired after count correction. Thus, with a scintillation camera grossly out of tune, a count-correction matrix is acquired and stored; then a second flood study is acquired and corrected by the first to yield what is regarded as a quality-controlled image. This procedure defeats the whole purpose of the exercise and fails to reveal nonuniformities that may have developed.

One of us recently experienced a situation where two cameras were grossly out of tune. One had a uniformity of 71%, the other 65%, but these had not become evident because all of the quality-control images had been acquired with the count-correction circuit in action (Fig. 1). It later became evident that two photomultiplier tubes in each camera were defunct and that 50% of the observed counts were actually being generated by the camera (these systems use count addition). This experience serves to emphasize the need to understand what quality control is all about and why it needs to be performed with a full understanding of the parameters under surveillance, rather than by rote "because it should be done."

Some of the more recent uniformity-correction modules that correct for nonlinearity are preset by the manufacturer and cannot be adjusted by the user. These systems do not use a locally generated flood-field correction matrix, and should a drift in performance occur, it will manifest itself in a routine quality-control flood image. It is with those systems where the user generates a count-correction matrix that we feel particular care must be exercised. Ideally the user should collect a quality-control flood image with the uniformity circuits first disabled and then active. Apart from the images obtained, a record of the count rate under these two conditions will provide a measure of the percentage of counts being either skimmed or added, and will indicate possible uniformity problems.

Another cause for alarm is the fact that some scintillation cameras now being marketed include count correction as a final cosmetic process that cannot be disabled by the operator. The consequence is that the quality control of the device is removed from the responsibility of the operator and placed in the hands of the company's service engineer. It is quite impossible to determine whether a detector head is drifting out of tune if, every time a uniformity flood is collected, it must be done with count correction in action and the flood image is thus automatically corrected to guarantee that it is indeed "uniform."

With the growing interest in single photon emission tomography, which places such exacting demands on uniformity, the two issues that we have raised are of increasing significance, and our own experiences and observations suggest that they deserve to be reemphasized. The quality of scintiphotos is directly dependent on the camera uniformity, and if numerical data are to be extracted from images, it is even more important that the effects of count

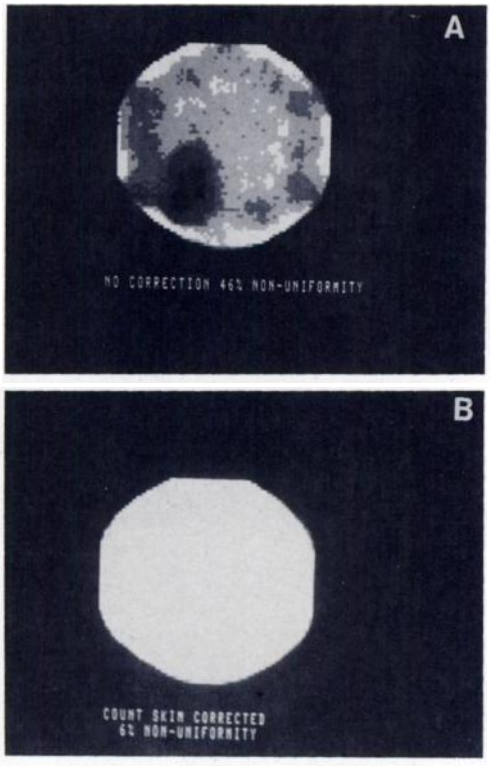

FIG. 1. Two flood images obtained from one scintillation camera. This camera differs from those to which reference is made in text in that it uses count subtraction for uniformity correction. One photomultiplier in camera was deliberately detuned, thereby resulting in integral uniformity of 46% with count-correction circuit disabled (top) and integral uniformity of 6% when count correction was in action (bottom). Observed count rate for two conditions was such that lower took some 50% longer to acquire than upper.

skimming or count addition should not modify those numerical results. Gross modulation of the images by count-correction circuits can only lead to less confidence in numerical analysis of those images.

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Ureterovaginal Fistula Detected by Tc-99m DTPA Scintigraphy

A 33-year-old woman underwent a hysterectomy for a cervical laceration and atonic bleeding.

In her 7th postoperative week, she complained of a watery vaginal discharge. She could also pass urine by urethra. Speculum examination revealed urine issuing from the vaginal vault. After intravenous injection of indigo carmine, no blue stain was observed on vaginal gauze. Intravenous pyelography revealed a left hydronephrosis, delayed visualization of the mid portion of the left ureter but no visualization of its lower portion (Fig. 1, left). The right kidney and ureter were normal, and no extravasation was demonstrated. Retrograde ureterography showed complete obstruction of the left ureter without extravasation (Fig. 1, right).

Renal scintigraphy following 10 mCi administered i.v. of technetium-99m diethylenetriaminepentacetic acid (DTPA) revealed abnormal radioactivity near the lower portion of the left ureter, suggesting extravasation (Fig. 2). Radioactivity on the gauze placed in the vagina was about 200 times background. To rule out extravasation from the urinary bladder, 200 ml water containing 10 mCi Tc-99m human serum albumin (HSA) was instilled into it through a Foley catheter, which was clamped for 2 hr. A scintigram of the bladder after release of the clamp showed no urinary extravasation (Fig. 3).

The incidence of ureteric fistula is extremely low (*1*). It usually occurs by accident, most often following injury to the urinary tract during pelvic surgery for gynecological conditions (*1-3*), or because of necrosis resulting from an impaired blood supply (*1*). The diagnosis of ureterovaginal fistula is generally confirmed by demonstrating urinary extravasation and/or a fistula by excretory or retrograde urography (*1,4*). A dye test can also confirm the diagnosis (*1*). A radionuclide study may be helpful in searching for the urinary extravasation, and Tc-99m DTPA is the preferred radiopharmaceutical to assess glomerular filtration (*5*) because of its ideal physical properties and the simplicity of DTPA labeling. As in this case, when other methods fail to demonstrate the ureterovaginal fistula, renal scintigraphy using Tc-99m DTPA should be performed.

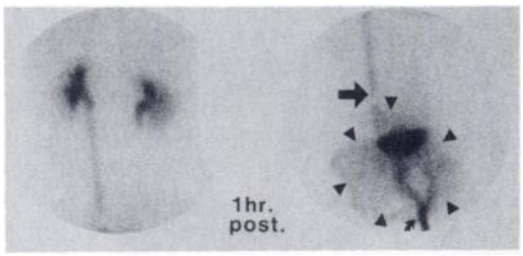

FIG. 2. Posterior views of Tc-99m DTPA study show extravasation of labeled urine into true pelvis (arrowheads) from distal end of dilated left ureter (arrow). Radioactivity is also present in Foley catheter (curved arrow).

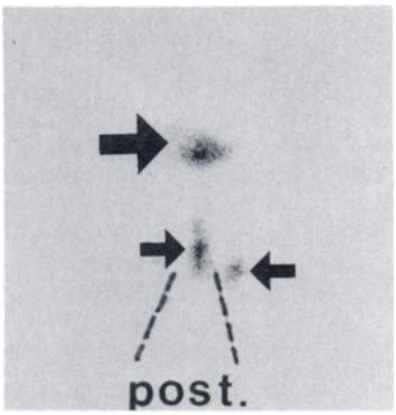

FIG. 3. Scintigram of urinary bladder after retrograde administration of Tc-99m HSA shows no extravasation of labeled urine. Large arrow indicates urinary bladder; small arrows, contamination.

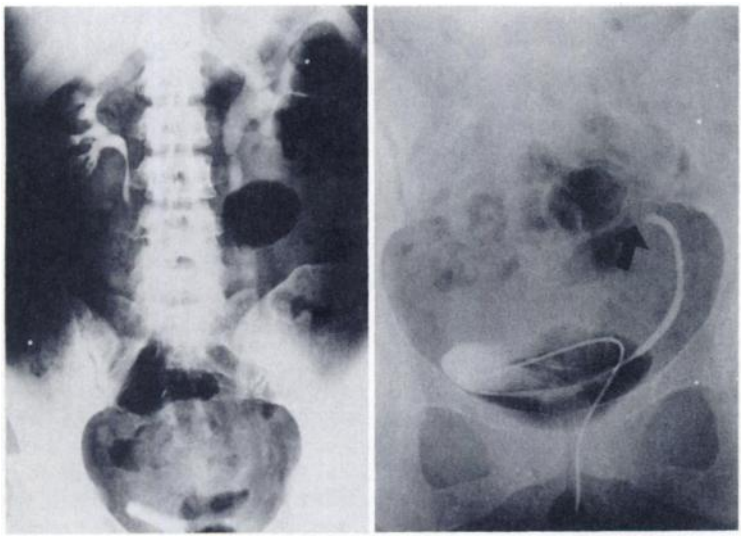

FIG. 1. Excretory urogram 210 min after i.v. injection of contrast medium shows left hydronephrosis and distended left ureter as far as the stenosis in lower portion of ureter, but without extravasation (left). Retrograde ureterogram shows complete obstruction of lower portion of left ureter (arrow), without extravasation (right).