LETTERS TO THE EDITOR

Accidental Ingestion of Tc-99m in Breast Milk by a 10-Week-Old Child

Rumble et al. (*1*) have estimated radiation dosage to various organs in a 10-week-old baby who was breast-fed by the mother a few hours after a [^{99m}Tc] pertechnetate brain scan. The authors have not emphasized two factors that may have introduced errors in the dosimetry calculations for this patient.

First, they assume that 50% of the orally ingested pertechnetate was absorbed, and they have referenced that inference to work of Hays (*2*). In her article, Hays does not give firm numerical data regarding absorption of orally administered pertechnetate. In fact, she makes the point that plasma levels of pertechnetate after oral administration are extremely erratic, varying from patient to patient and even from session to session in some patients.

The second point is only a conjecture but probably a logical one. The mother of the patient had a pertechnetate brain scan, so she must have received sodium or potassium perchlorate just before the study. Since it is known that iodide and pertechnetate are secreted in milk during lactation, it is probably safe to assume that perchlorate also is. The level of perchlorate will alter the organ distribution of pertechnetate considerably, with less of it getting to the thyroid gland (3).

The whole-body counting measured the total radioactivity present in the baby, but the above-mentioned factors suggest that the radiation dose to the thyroid gland was probably overestimated and to the gastrointestinal tract underestimated.

The case report emphasizes that a patient's history and physical examination are an essential part of the services we offer as nuclear medicine consultants. In the two institutions that I have been associated with, no patient is injected with any radiopharmaceutical before a nuclear-medical physician has examined the patient and/or gone through his hospital records. I suggest one more precaution to join the three mentioned in the report. No woman in the child-bearing age should receive iodine-131 therapy without a pregnancy test.

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Reply

We have received the comments regarding our article, and greatly appreciate the re-emphasis of the difficulties inherent in dosimetry calculations for a small child, as noted in the text. Human dosimetry calculations involve many variables, some of which require biologic data that are either unavailable or limited. Because of these uncertainties, it is necessary to select conservative best estimates (those that maximize the calculated radiation doses) wherever a choice of values exists.

Although it is true that the range of plasma values reported by Hays (*1*) is highly variable, we were able to derive an absorption number from her data. Hays reported plasma values after oral administration that ranged from a few percent to nearly 140% of those after i.v. administration. Our estimate of 50% was derived by correcting Hays' average plasma ratio value of 0.75 by taking as 100% absorption her maximum value of nearly 1.4 on the assumption that absorption could not exceed 100%.

The point about perchlorate's altering the tissue distribution of pertechnetate is certainly a reasonable conjecture. In this case, however, the patient was scanned without perchlorate in order to visualize pertechnetate localization in the region of the nose (*2*).

In light of the above discussion, we believe that the dose estimates in our article are reasonable within the limitations of the biologic information available.

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Single-Slice Contrasted with Multiple-slice Positron Tomographs

A recent discussion of the factors that relate to the single-slice contrasted with multiple-slice design choice (*1*) is both misleading and incomplete. The authors support their choice of a single-slice system by comparing it with a hypothetical multislice device with a sensitivity per slice only 20% of that of a single-slice system. It is unreasonable to postulate, a priori, that the sensitivity per slice of a five-slice system would be one-fifth that of a one-slice system. For example, if five sets of detectors were placed side by side in the ORTEC ECAT configuration, it would be illogical to assume that the sensitivity of each slice would automatically decrease to one-fifth of the original value. Of course, there are many factors that influence the sensitivity of a multislice system, but it has been our experience that a properly designed system should yield much higher overall sensitivity than would a comparable single-slice system. Thus the example presented of a five-slice system and a single-slice system that have the same overall sensitivity is an extreme case, and is misleading.

The cost of a multislice system compared with a single-slice system may be discussed ad infinitum. It has been our experience with PETT III and PETT IV that a multislice system has been constructed for approximately 30% increase in cost over a single-slice system. The major differences in cost arise from the detectors and the front-end electronics, since the cost of the gantry, computer, and related peripherals remains essentially the same for the two systems.

It has also been our experience that the multislice system is far superior in its clinical applications because of its higher sensitivity and simultaneous acquisition of multiple slices over the organ of interest. It yields several slices in physiologic synchrony, thus permitting a better and easier comparison of information from slice to slice. These factors also facilitate the reordering of the reconstructed images into sagittal and coronal planes. Fast multislice tomographic systems will permit dynamic studies in the clinical situation, whereas a single-slice system would require multiple administration of tracers if more than one slice of the organ is to be studied.

We agree with the authors that a tomographic system should have maximum circumferential efficiency for detection of positrons. However, to achieve this goal we have found that a circular array of detectors exhibits a higher detection efficiency than a hexagonal array for comparable detectors. The hexagonal array offered an easy approach to positron emission tomography, but there is abundant evidence (*2-6*) to indicate that a circular arrangement represents the state of the art in positron tomography. The circular system also offers the physical capability of collecting the data in a shorter period of time than a translate-rotate system. This is an important consideration in a system that may be used for fast dynamic studies, and in minimizing artifacts from patient motion. Redundant sampling in a ring geometry is easily attained and user-controlled by overscanning in the rotation direction.

It is our opinion that successful clinical application of positron emission tomography will be carried out with multislice devices and most likely with circular geometry.

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Reply

The statements in our article (*1*) were not a condemnation of the concept of multislice systems per se. They explain our decision to concentrate on delivery of the best possible images per slice. In order that no one is "mislead," we present here a more complete discussion of the topic by considering each of the points in the preceding letter.

"Hypothetical" five-slice system. This example was given to point out a factor that is particular to computed tomography (CT). In CT, each image is formed by solving an interdependent set of linear equations, and this imposes certain constraints that are not common in medical imaging systems. Any inconsistencies in these interdependent data sets results in a removal of information or addition of artifacts by the reconstruction algorithm. Thus, in the evaluation of different design alternatives for CT, in which there are interdependent data (i.e., data within a plane for each image) and independent data sets (i.e., data for images from one plane to the next), one should try to complete the collection of the interdependent data as quickly as possible. This lessens the probability of errors caused by movement of activity, organ, or patient, or other time-dependent sources of error.

We tried to provide an example in which this point is important, with a five-slice system that had 1/5 the efficiency, per slice, of a single-slice system. With these "hypothetical" systems one could collect five images in the same time. However, if motion or some other disturbance should occur at some time during the study, it would affect only the plane being examined at that time with the single-plane system, but would affect all the planes of the five-plane system. This is a fundamental issue in CT design but it applies, of course, only if the single-plane system is more efficient than *each* plane of a multiplane system. The obvious example cited in the above letter—that of multiple ECAT detector planes compared with a single-detector-plane ECAT—does not apply since it doesn't meet the criteria of the example.

There are many factors involved in CT system design, with different strategies for choosing one set of design criteria over another. This has resulted in a number of different types of positron-emission CT (PCT) systems of which a number are multislice (*2-4*). These multislice systems, when used in a transaxial CT format, were all considered to be similar to the example of the hypothetical five-plane system above when compared with the ECAT i.e., they all have considerably less efficiency per plane than the ECAT. For example, since we feel the PETT IV (*2*) has the highest efficiency per plane among present multiplane devices, it can be chosen as a basis for comparison. We measured the efficiency and resolution of a single pair of PETT IV detectors (ignoring losses caused by position logic of PETT IV) and estimated the efficiency of one plane. Our estimate showed the ECAT to be 4.7 times as efficient as one PETT IV plane. Subsequently Ter-Pogossian et al. (*2*) published the PETT IV efficiency, and the ECAT is now seen to have 5.3 times the efficiency per plane as the PETT IV at comparable resolutions. Thus we do not feel our example was as hypothetical as it was made out to be in the above letter.

Cost. It is very difficult to do true cost accounting in a university setting. We agree that a 30% increase in cost for materials—between, say, the PETT III and PETT IV—may be realistic. However, cost of the added complexity in terms of labor, overhead, service requirements, and maintenance is less well defined in this setting. Yet they are all part of the final product in commercial equipment. Thus we are not in a position to be very confident in final cost estimates.

Clinical applications. In regard to the authors' statement that in clinical applications the multi-slice system is far superior to the single-slice systems, it is our turn to state that this is presented in a fashion both "misleading and incomplete." There are several aspects about the geometry of the PETT IV that the authors have failed to mention. The image planes in the PETT IV are not contiguous. There is about a 3.8-cm gap between detector planes, and therefore in the four-plane configuration the patient had to be moved twice for planes to be contiguous, or moved once in the seven-plane version. This appears to us to limit their point of "physiologic synchrony." The *total* system