Letters to the Editor

Effect of Delay in Imaging

TO THE EDITOR: The recent article by Rothendler and his co-workers (*1*) makes the important point that excessive delay may reduce the sensitivity of Thallium-201 (^{201}Tl) scintigraphy, but it is also susceptible to overinterpretation. The optimal time for imaging occurs when the ratio of activity in normally perfused myocardium to that in hypoperfused muscle is maximal, after clearance of the radiotracer from the blood is sufficient to yield an acceptable target to background ratio. This ideal time reflects an interplay between the attainment of peak activity in normal myocardium and the clearance (or delayed uptake) rates in normal and ischemic regions and obviously will vary among individuals.

Several experimental studies have indicated that peak myocardial activity occurs from 10-40 min after injection (*2,3*). The blood-pool ^{201}Tl concentration reaches a relatively stable nadir after 5-10 min (*3-4*). Clearance rates are determined by the initial tissue radiotracer activity, the subsequent myocardial blood flow, and the time course of ^{201}Tl activity in blood (*2-5*). Important variables which will affect the blood clearance rate and, hence, the optimal imaging time include the level of work performed by skeletal muscle and the interval between the radiotracer injection and the cessation of exercise (*4,6*).

The authors have not provided us with the information necessary to determine the relation between the 2 min-2 hr and 18 min-2-hr reading differences and the duration of exercise or workload achieved or with the timing of the injection relative to the termination of stress. These data might help identify a subset of patients in need of immediate imaging. Most importantly, this study did not examine the sensitivity of scintigraphy performed 10 min postexercise, an interval that our experience and that of others (*7*) suggests is satisfactory and also permits safe monitoring in an exercise laboratory in the vicinity of the imaging suite. Furthermore, the use of the more usual 3-4-hr interval before the delayed images may have minimized the differences between the two initial imaging times. These types of information are essential before the need for immediate postexercise imaging, which would necessitate a combined scintigraphic-exercise suite with attendant additional cost and inconvenience in many institutions, can be assessed.

Rothendler's findings raise one additional point which is not discussed in the manuscript but is relevant whatever the optimal imaging time may be. The dynamic pattern of regional ^{201}Tl distribution in the early post-exercise period may profoundly affect single photon emission computed tomography images, since the reconstruction algorithms assume a stable target. This is an important area for future investigation.

References

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Barry Massie
University of California
San Francisco, California

Wangden Carson
Nigel Soper
John Radcliffe Hospital
University of Oxford
Oxford, UK

REPLY: We thank Drs. Massie, Carson, and Soper for their interest in our article. We agree that the relationship between activity in normal compared with ischemic myocardium and the target to background ratio are complex functions of time and differ from patient to patient. We disagree, however, with some of the conclusions concerning early imaging which were presented in the letter.

Due to the high thallium extraction fraction of the myocardium and other organs, the level of thallium-201 (^{201}Tl) in the blood falls very quickly after injection. Investigations in animals at rest have shown that activity decreases to a value of ~10–15% of its peak within 3 min after injection (*1,2*), with some additional fall to 5–10% of peak at 5-10 min. Due to a shorter circulation time, blood levels following injection at peak exercise might be expected to fall even more rapidly.

While "peak" myocardial ^{201}Tl activity has been found to occur in normal zones 10-40 min after injection (*3*), more than 90% of this peak occurs by the end of the first minute. Again, these experiments were in anesthetized animals at rest, and thallium activity would be likely to peak more quickly with exercise, as suggested by studies during reactive hyperemia (*1*) and norepinephrine infusion (*4*). In the latter study, peak myocardial ^{201}Tl occurred 1–2 min after injection.

Since, as indicated in the article, the ^{201}Tl was injected ~60 sec prior to cessation of exercise, the "2-minute" set of images was begun 3 min after injection. Based on ^{201}Tl kinetics in animal models, we felt that this would not be "too early," especially since the data collection for each view extends over 6 min, ending 9 min after injection for the first view. The empiric observation that there was a significant gain in sensi-

tivity for transient defects without any loss of specificity supports the hypotheses that beginning imaging 2 min after exercise (3 min after ^{201}Tl injection) allows adequate myocardial uptake for accurate definition of normal from ischemic zones without undue interference from background blood activity.

It would be desirable to be able to identify a subset of patients who would benefit most by early imaging. However, we could find no significant differences between the group positive for transient defects using both the 2 min–2 hr and 18 min–2 hr set of images and the group positive on the 2 min–2 hr images alone. As indicated in the article, we compared a number of parameters between the two groups, including peak exercise double product, and found no significant differences. As we discussed, this may be due to a variety of factors.

We would expect that commencing imaging at 10 min compared to 18 min postexercise would offer some advantage. However, since redistribution may begin within several minutes after injection, there is likely to be a continuum in the loss of sensitivity for transient defects the longer imaging is delayed. Further, if three views are obtained beginning at 10 min, the second and third views would not start until ~18–20 min and 26–30 min, respectively, after exercise, assuming 6–8 min/view and 2 min between views. Thus, any excess delay in obtaining the first view may adversely affect subsequent views to a greater degree than the initial view itself.

Delayed imaging at 3 to 4 hr instead of 2 hr may have increased the degree of redistribution to some degree. However, both the 2-min and 18-min sets of images were compared with the same 2-hr delayed image for each patient. Therefore, an advantage for earlier imaging should still exist.

We concur that since single photon emission computed tomography images are often acquired over a 20–30 min interval, ongoing redistribution during the first 30 min after injection could affect the sensitivity of the technique. It may be, however, that the improved spatial contrast between normal and abnormal regions offsets some of this potential disadvantage.

We are cognizant of the physical and cost contraints which limit the availability of combined scintigraphic-exercise laboratories as well as the need to closely monitor certain patients for a period of time after exercise. In light of the results from our study, we would recommend that unnecessary delays between exercise and imaging be reduced as much as is practical given the particular circumstances in which the test is performed. In those laboratories in which it is feasible, commencing imaging several minutes after exercise appears advantageous.

References

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James A. Rothendler
University Hospital
Boston, Massachusetts

Robert D. Okada
Massachusetts General Hospital
Boston, Massachusetts

Attenuation Correction and Lag Period in Gastric Emptying Studies

TO THE EDITOR: It is unfortunate that the recent paper by Moore et al. (*1*) did not refer to our paper (*2*), that was published some time before their manuscript was received. This paper and our previous work (*3*) addressed the areas covered in their article: namely the effect of tissue attenuation and the measurement of the lag period for digestible solid food emptying in radionuclide gastric emptying techniques.

Attenuation Correction

We are in full agreement with the authors with regard to their comments on tissue attenuation correction. Our studies, using a similar meal composition, demonstrated that significant errors in the measurement of gastric emptying rate will occur, particularly with solid meals, if no correction is made for tissue attenuation. In our study of solid emptying using the geometric mean of counts from two cameras (*2*), we found that a single anterior dectector overestimated the 50% emptying time by an average of 15% (range 5–18%) while the posterior detector underestimated this parameter by 15% (range 4–22%). Large differences in the distances of the proximal and distal stomach from the detector surface were demonstrated by measurements from a lateral image of the stomach (mean difference = 5.7 cm). As the half value thickness for 140 keV photons from technetium-99m is 4.95 cm, these measured differences account for the errors in gastric emptying rate that were obtained.

In the large number of studies that we have performed over the past few years (in excess of 1,000 studies) we have observed considerable variation in stomach shape, as seen in the lateral projection. In some patients the effect of tissue attenuation was negligible, while in others the error was well in excess of 30%. Therefore, correction for this error is of the utmost importance for the accurate delineation of patient subgroups. The use of a lateral image of the stomach to derive correction factors (*3*) is an acceptable alternative to the use of geometric mean counts (*2*).

Lag Period

It is obvious that there is a period of time during which ingested food passes from proximal to distal stomach before it enters the duodenum. We disagree with Moore et al. (*1*) that the "lag period" is negligible and possibly artifactual. We have shown that this delay period is significant and that it is readily measured by our technique, both on the corrected time-activity curves and by visual inspection of the 2-min serial scintigrams.

The lag period for solid food using our test meal (100 g