Editorial Comment

SPECT Thallium Imaging in the Diagnosis of Myocardial Ischemia*

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Diamond (1) and Gould (2) raise independently interesting points concerning our recent study (3). Their thoughtful comments addressed Bayes' theorem, selection bias, specificity, normalcy and observed versus corrected test results, and we concur with the analysis and major conclusions by Diamond. Regrettably however, their comments did not address the major conclusion of our study: the effect of level of exercise on results of single photon emission computed tomography (SPECT) with thallium-201. Our results clearly demonstrated improved sensitivity in patients with adequate exercise end points compared with those with submaximal exercise performance. These results, which were derived from a large cohort of patients, have important clinical implications, given the availability of alternative techniques of stress testing such as thallium imaging during dipyridamole- or adenosine-induced coronary hyperemia.

The group of patients with a low pretest likelihood of coronary artery disease and a normalcy rate of 93% were selected on the basis of the Duke algorithm described by Pryor et al. (4). The specificity of 62% in the patients with normal coronary angiograms is similar to that reported by other experienced investigators (2) in this field. The conclusion by Gould (2) that positron emission tomography with its greater accuracy will prevent unnecessary catheterization procedures due to false positive results is not entirely valid even if cost consideration is not an issue. Similarly, the conclusion by Diamond (1) that clinicians should view as suspect any sensitivity and specificity derived for reports that do not include the frequency and number of positive test responses in the larger group of nonangiographic responses appears to deserve a few additional comments.

Positive versus false positive diagnoses of myocardial ischemia. There is as yet no diagnostic test that is 100% sensitive and 100% specific for detecting myocardial ischemia—not even coronary angiography! Myocardial ischemia may occur in patients with normal coronary angiograms (or those with insignificant stenosis) and, alternatively, ischemia may not be evoked in patients with apparently significant stenosis by coronary angiography. Functional measurements have repeatedly shown the limitations of anatomic descriptors of coronary stenosis. For that reason, positive thallium results in the absence of coronary stenosis may not always be false positive (5). Further, in a given patient, knowledge that a specificity is 80% and not 60% has a limited usefulness. An analogy can be made, for example, with surgical mortality results. Whereas a 2% mortality rate in a group of 100 patients undergoing surgery is low and acceptable, for the 2 patients who died, the mortality rate is 100%—too high and unacceptable! Also, with experience we have learned to recognize causes of false positive results such as motion, artifact, creep and attenuation artifact. Finally, the newer imaging agents such as technetium-99m-labeled methoxyisobutyl isonitrile (MIBI) or technetium-99m tetroxide may pose less attenuation artifact and, hence, decrease the rate of false positive results.

Positron emission tomography versus SPECT. The study by Tamaki et al. (6) failed to reveal any advantage of positron emission tomography over SPECT thallium imaging in diagnosing coronary artery disease or in identifying individual diseased vessels. Several recent preliminary reports have also shown substantial false positive rates with positron emission tomography. For example, Go et al. (7) reported a specificity of 84% with rubidium-82 and 77% with SPECT thallium-201 imaging. The only real advantage of positron emission tomography appears to be in assessing myocardial viability. The use of the reinjection technique with thallium-201 and the use of newer imaging agents may decrease, but will not eliminate, the need for positron emission tomography in assessment of myocardial viability.

Advantages of SPECT imaging. The sensitivity of SPECT thallium imaging in our experience and that of others (8) has been uniformly better than that of planar imaging. As shown in our report (3), false negative results were often seen in patients with one vessel disease, mild disease or inadequate stress. We and others have shown that the prognosis of patients with normal exercise thallium images is benign, and hence, the prognostic information of thallium imaging in these patients is of great help in patient management. In our opinion (9), patients with normal exercise thallium images do not require revascularization procedures.

A clear advantage of SPECT imaging is in the determination of the extent of ischemia and the size of the jeopardized myocardium. Such information is extremely useful in patient

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prognosis and is not readily available by clinical evaluation or by treadmill exercise testing alone. Assessment of the presence and extent of ischemia may be especially important in patients with previous myocardial infarction.

A major shift in our utilization of nuclear imaging techniques in patients with ischemic heart disease has been the assessment of the functional consequences of coronary artery disease. Considerable variability in the size and extent of perfusion abnormality exists in relation to the anatomic severity of coronary disease (10). It is possible now to quantitate these data using polar maps, an approach that may even be more suitable with the newer technetium imaging agents.

**Conclusions.** Regrettably, the traditional method of reporting nuclear imaging data as sensitivity and specificity do not take into consideration the variability in the severity and the extent of the perfusion abnormality. These quantitative data are difficult to present in the framework of Bayes' theorem, which defines a test result as either normal or abnormal. The challenge for the future is to incorporate the functional data as a continuous distribution in computer programs. Such a model based on radionuclide angiographic test results has been shown (11) to increase the diagnostic and prognostic information for individual patients with symptoms suggestive of coronary artery disease.

**References**