The Technical Maturation of Cardiovascular Nuclear Medicine: An Art Becoming a Science

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Perhaps more that any other nuclear imaging study, myocardial perfusion SPECT requires great attention to technical detail by both the technologist and physician. Moreover, considerable experience, dedication and insight are required on the part of the physician to master the art of image interpretation. Of course, the level of expertise among technologists and physicians and the time they are willing and able to devote to mastering this art will vary greatly. Consequently, there is considerable variability in confidence and diagnostic accuracy in reporting myocardial perfusion SPECT. For this reason, many laboratories maintain only a tenuous hold on perfusion imaging. We are frequently challenged by interlopers who criticize results and, despite minimal training and no official certification, convince both hospital administrators and referring physicians that they can achieve better diagnostic results. In fact, many of these "four-month wonders," intent on providing better service to patients and referring physicians, do pay greater attention to technical and interpretive detail and achieve superior diagnostic accuracy. Also, because of the great variability in expertise of those of us who practice the art of cardiovascular nuclear medicine, we are threatened even more seriously by an entirely different modality, stress echocardiography, which ironically is even more operator-dependent and subjective. Therefore, for all of us to maintain a stronghold on perfusion imaging and to allow it to thrive in a highly cost-competitive health care environment, we must objectify the technology and standardize interpretive criteria in order to achieve a uniformly high degree of diagnostic accuracy. The art of myocardial perfusion SPECT must mature to become a science.

Several articles appearing in this issue of the *Journal* address important sources of subjectivity and variability in interpreting myocardial perfusion SPECT images. The authors introduce innovative, highly accurate and reproducible techniques which should help to objectify processing and interpretation of studies, resulting in fewer artifacts and improved interobserver reproducibility.

One of the most frequent sources of error in processing myocardial perfusion tomograms is incorrect and imprecise selection of the long-axis of the left ventricle from transaxial and vertical long-axis slices. In patients with no discrete apical "dimple," in those with exaggerated shortening of the septal myocardium due to a prominent membranous septum, in those in whom there is poor visualization of the base of the heart due to attenuation and in those with unusually configured hearts due to cardiomyopathy or regional scarring, selection of these axes can be quite difficult. If axes are assigned incorrectly, myocardial walls will become foreshortened, creating apparent perfusion defects. Moreover, if the axes for stress and rest studies are chosen differently, the stress and rest tomograms will be misaligned and artifactual reversible perfusion defects may appear [see Figure 2, p. 1109, Germano et al. (*1*)].

Although physicians interpreting studies can review quickly the axes selected for tomographic slice selection with commercially available software, this is seldom done in actual clinical practice. Therefore, physicians blindly rely on the technologist's selection of axes, seldom considering the possibility of axis misalignment as a source of artifact. In this issue of the *Journal*, Germano et al. (*1*) describe a totally automated, highly accurate and reproducible technique for long-axis selection, which can improve the reproducibility of tomograms in even a large, prestigious academic institution. If implemented and disseminated commercially, this method should provide a means to significantly reduce or eliminate artifacts due to axis selection error. Also in this issue, Slomka et al. (*2*) describe a highly reproducible method to align and conform stress and rest SPECT perfusion scans to a normal three-dimensional template. Although not discussed specifically by these authors, if such a method were coupled to Germano's automated axis selection technique, it could conceivably make axis selection even more precise in patients with dilated and deformed ventricles, factors which particularly confound axis selection. Moreover, in patients undergoing serial perfusion scans in whom there has been a significant change in ventricular geometry (pre/postinfarction, pre/postrevascularization, pre/postvalve surgery, etc.), configuring the ventricle to a standard three-dimen-

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sional template and precise, reproducible axis selection should allow for more reliable assessment and quantification of changes in regional perfusion.

In this issue, Segal et al. (*3*) demonstrate considerable variability in normal coronary anatomy and associated difficulties in accurately predicting the location of coronary artery stenoses. Although they consider such anatomic variability, it is doubtful whether perfusion SPECT will ever precisely predict the location of stenoses. More stringent standardization of SPECT image processing and display by automated and three-dimensional techniques such as those described by Germano et al. and Slomka et al. should certainly decrease interobserver variability in predicting the location of coronary stenoses and the vascular territories involved.

No one interpreting myocardial perfusion SPECT studies is unaware that attenuation artifacts are a major source of false-positive scans and decreased test specificity. If one limitation of cardiovascular nuclear medicine were to be blamed for loss of turf battles, it would be false-positive perfusion scans, as they frustrate both patients and referring physicians. Our coping mechanisms for dealing with artifacts caused by soft-tissue attenuation have evolved and include development of gender-specific normal files, recording detailed information regarding the patient's body habitus, inspection of planar projection images to determine the location and density of soft-tissue attenuators (an exercise sometimes likened to reading tea leaves), performing prone or upright SPECT to minimize diaphragmmatic attenuation, evaluating wall thickening to indirectly differentiate artifact from scar, and lastly, formulating elaborate reports which hedge around the problem of attenuation artifacts. Investigators have been developing methods for several years to eliminate soft-tissue artifacts, including body scatter and/or attenuation maps. These techniques are nicely summarized in the article by Ficaro et al. (*4*). Scatter correction, however, fails to fully compensate for variability in the density of various tissues in the thorax. Transmission mapping has been limited by truncation artifacts, the additional time required to acquire a separate transmission scan and the potential error of misregistration of the transmission scan and the subsequent emission scan. These authors describe a promising new method whereby a three-detector SPECT camera equipped with a scanning ^{241}Am line source and fanbeam collimator performs simultaneous transmission/emission ^{201}Tl tomography. Their results demonstrate accurate identification of perfusion defects due to coronary disease with a remarkable decrease in attenuation artifacts. The configuration of the system they describe appears to avoid truncation artifacts in patients with at least above-average chest dimensions. The method they describe, however, does, as they state, require further clinical validation. It is doubtful whether their method will "render obsolete many of the rules adopted to compensate for attenuation artifacts." Nonetheless, the attenuation correction scheme they describe, or one similar to it, should very likely have a major impact in improving the specificity and interobserver reproducibility of myocardial perfusion SPECT.

Thus, as myocardial perfusion SPECT technology matures and methods are developed whereby studies are acquired and processed more accurately and reproducibly so as to yield images that are free of artifacts, we will all stand on equal footing as scientists (and businessmen) with a cost-effective, foolproof product of unequalled value in the competitive health care marketplace. The years of art imitating science have long exceeded their allowable length of stay.

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