TEACHING EDITORIAL

Tomographic Imaging of the Heart with Thallium-201: Seven-Pinhole or Rotating Gamma Camera?

In an effort to obtain more information from a thallium-201 cardiac image, several researchers have utilized either seven-pinhole tomography or single-photon emission computed tomography (SPECT), using a rotating Anger camera as the basic detector element. The seven-pinhole concept, as developed by Vogel and Kirch (*1*), utilizes a limited-angle tomography technique in which a reconstructed image is obtained by using seven simultaneous pinhole views of the myocardium from a limited angular distance. The rotating gamma camera system, on the other hand, obtains data from 360° around the patient to reconstruct a cross-sectional slice of the myocardium. Since both tomographic approaches are relatively new, they have not been evaluated sufficiently in a clinical situation to determine which technique is significantly better than the other, or whether both techniques are unquestionably better than planar imaging of the myocardium using thallium-201. Several groups (*2–8*) are now carrying out comparative clinical studies between the seven-pinhole technique and planar imaging to evaluate whether the tomographic technique provides significant improvement in sensitivity and specificity for clinical diagnosis.

In order to understand some of the discussions about the two tomographic methods, it is essential to comprehend the physical concepts of limited-angle and full-view tomography, as well as the basic differences of the two approaches. These two techniques have been analyzed recently by Budinger (*9*). The seven-pinhole system acquires a severely limited amount of information whereas the SPECT system provides a more complete set of information required to effect a cross-sectional reconstruction. Because of the limited amount of information contained with the seven-pinhole tomographic system, there is error propagation, or a residual forward and backward interaction from the tissue underlying and overlying the image plane (*10*), in the reconstructed image planes. To minimize this effect, we can add some *a priori* information, such as the expected shape of the organ of interest and the orientation of the tomographic system to that organ, to the seven-pinhole reconstruction. For the case of the heart, the cylindrical nature of the left ventricle and alignment of the seven-pinhole system with the long axis of the heart aid in the tomographic reconstruction to produce images that are much better than one would obtain with a similar system in the brain. The problem of orientation is quite serious, however, and has been demonstrated by Budinger to cause severe reconstruction artifacts with even a few degrees variation from the long axis of the heart. SPECT, on the other hand, collects all the information around the patient and thus satisfies the data sampling requirements of the reconstruction algorithm. As a result, the image produced by a SPECT system should have relatively fewer reconstruction artifacts; and from a physical point of view, it is definitely a better system than is seven-pinhole tomography for reconstruction of cross-sectional images.

One must then ask why the tomographic systems have not been used universally by nuclear medicine clinicians in the last few years. Jazczack (*11*) points out that there are three major objectives for tomographic imaging in nuclear medicine: detection of a lesion, determination of the size of the lesion, and measurement of the regional concentration of radionuclide within a region. For the first of these objectives, the current article by Tamaki et al. (*8*) shows that the sensitivity and specificity are highest for the SPECT system, but only marginally so. The sensitivity for the seven-pinhole system is higher than the planar system although the specificity is worse. In the evaluation of the results obtained by other researchers on the comparison between the seven-pinhole and planar modes of imaging, we find a fair amount of variation in the reported values of sensitivity and specificity. For example, Vogel et al. reported that the sensitivity of the seven-pinhole system is better than that of planar imaging, whereas Ritchie et al. (*7*) found no significant difference in the sensitivity and specificity between those two modes. To date, none of the clinical studies has shown a dramatic improvement for either tomographic technique compared with a planar system for lesion detection.

A major problem of tomographic systems for myocardial imaging is the great difficulty in absolute quantification of the radionuclide within the myocardium. This problem is caused by the attenuation correction that is required to compensate for the absorption of the gamma radiation by the patient's body. Since the heart is surrounded by irregularly shaped lung tissue and the rib cage, computation of the exact attenuation correction factors in various views for single-photon tomography is not possible at this time. Therefore, as long as this problem exists, the image that is reconstructed for the chest cannot be accurately quantitative. Even with positron tomographic systems where the attenuation can be determined exactly, quantification of the radionuclide concentration in the myocardium is difficult owing to noise amplification of the attenuation correction and the image-reconstruction mathematics. This problem is further complicated for SPECT systems by the low-energy, gamma emission of Tl-201, which undergoes a greater attenuation than the higher-energy gamma radiation from annihilation of positrons.

Thus, SPECT, theoretically, has some significant advantages over seven-pinhole tomography, which, in turn, has some theoretical advantages over planar images. Practically speaking, however, in terms of sensitivity and specificity, there is no measurable or significant improvement of seven-pinhole tomography over planar imaging, and the advantage of SPECT over planar or seven-pinhole tomography is borderline for Tl-201 imaging of the heart. In the chest at least, the problems of attenuation correction are still so great for SPECT that it may be, in essence, only another "improved" but significantly imperfect diagnostic technique, although its sensitivity and specificity need to be confirmed by larger studies in cardiac patients. SPECT incurs major expense and effort. Since nuclear medicine facilities have standard planar imaging facilities for lung scans, gated blood-pool studies, etc., the addition of SPECT with its added expense for restricted applications may be unwarranted in view of the limited improvement in diagnostic sensitivity and specificity apparent to date. If larger studies demonstrate more significant improvement in sensitivity and specificity, however, then SPECT might become a more important clinical tool.

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