A Comparison Between Conventional Scintigraphy and Emission Tomography with Thallium-201 in the Detection of Myocardial Infarction: Concise Communication

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We have compared emission tomography and conventional scintigraphy with thallium-201 in a series including 15 normal subjects and 64 patients showing transmural myocardial necrosis in various locations, fully documented by clinical, electrocardiographic, and enzymatic evidence. The reconstruction was derived from 32 projection images collected around the left side of the patient's chest by a rotating scintillation camera. The conventional views and the transverse, frontal, and sagittal sections were interpreted independently by two observers. The final calculated sensitivity was 89% with conventional scintigraphy and 98% with emission tomography, and the specificity was 93% in the two cases. Thus, emission tomography provides a better sensitivity and also a better interobserver agreement than conventional scintigraphy in the detection of transmural myocardial necrosis with thallium-201.

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Since its introduction into nuclear medicine in 1973 by Lebowitz et al. (*1*), thallium-201 has been extensively used in the detection of myocardial infarction (*2,3*) as well as of coronary artery stenosis (*3–5*). In both conditions it was found that the sensitivity and specificity of this procedure were satisfactory, but no real progress was noticed in recent years, mainly because of limitations due to the imaging technique and to the biological behavior of the tracer.

However, the introduction of emission tomography has recently provided new possibilities in the technique of imaging. With the first generation of tomographs, it was possible only to obtain independent slices that were acquired one by one so that they were generally transversely oriented and not adjacent. Some interesting clinical results have been described with such devices (*6–8*). A second generation is now commercially available; it provides simultaneously several adjacent transverse, sagittal, and frontal sections, allowing the study of the complete tridimensional distribution of the tracer.

Experimental studies have been performed with phantoms (*9*), and some preliminary clinical results in the study of the liver (*10*) and myocardium (*11*) have been described, but no data are available concerning large series of patients.

We present here a comparison between conventional scintigraphy and the tomographic views obtained in a series including normal subjects and patients presenting a proven myocardial infarct.

MATERIAL AND METHODS

Sixty-four patients were selected for having presented both clinical and laboratory (EKG and enzyme) proofs of transmural myocardial necrosis. ECG proof required a QS wave or a Q wave lasting more than 0.04 sec and with an amplitude of more than a third of the following R wave, associated with ST-segment elevation; enzymatic proof required >300 IU/ml CPK and >12 IU/ml

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TABLE 1. INTERPRETATIONS OF THE PLANAR IMAGES AND OF THE TOMOGRAPHIC SECTIONS IN 15 NORMAL SUBJECTS

	Abnormal	Normal and doubtful
Planar scintigraphy	1 posteroinferior	11 normal
		1 anterior
		1 anteroapical
		1 inferior
Emission tomography	1 apical	11 normal
		3 apical

TABLE 2. INTERPRETATIONS OF THE PLANAR IMAGES IN 64 PATIENTS WITH MYOCARDIAL INFARCTION

	Before consensus	After consensus
Normal for both observers	2	2
Doubtful for both observers	1	2
Abnormal for both observers	54	57
Disagreement between observers	7	3

of the MB fraction. Infarct ages ranged between 4 days and 13 yr. Their locations were anterior, apical, or septal in 37 cases, and diaphragmatic, posterobasal, or posterolateral in 27 cases. For comparison, 15 subjects with no known myocardial history were studied. These people belonged to another study in which a reference myocardial examination was required at its beginning; they were controlled by ECG and echocardiography so that the risk of previously unknown myocardial infarction was minimized, even though none of them had undergone contrast coronary angiography.

Each patient received, at rest and standing if possible, 2 mCi of thallium-201. Ten minutes later the imaging was begun, using a 40-cm large-field rotating scintillation camera* equipped with a high-resolution parallel-hole collimator. The detection was centered on the 69–83-keV x-ray emission of the mercury daughter with a 25% window, and simultaneously on the 167-keV gamma peak with a 12.5% window. Three zoomed views (anterior, 45° left anterior oblique, and left lateral) or 300,000 counts each were collected in 64 × 64 matrices and stored on the memory disk of a computer,† to be displayed later on radiographic film for interpretation. The tomographic acquisition was then promptly undertaken, the patient lying on a bed with his left arm over his left side, in 32 equal steps. Each step acquired counts through 30 sec; usually there were about 60,000 counts per image.

From these 64 × 64 matrices the computer could reconstruct transverse sections between the upper and the lower limits chosen by the operator. A maximum of 64 sections could be obtained so that the planes could be centered every 6.25 mm. Other authors working with the same material (*12*) have measured an intrinsic resolution (FWHM) of 5.5 ± 0.5 mm for the same camera; they found a spatial resolution of 18 mm in water at 20 cm from the collimator, and the same value occurred at the center of a transverse section with a radius of rotation of 20 cm. In myocardial tomography, 10 to 20 transverse images were generally sufficient to include the whole of the left-ventricular muscle. The algorithm for reconstruction used backprojection. Filtering was performed in the space domain by the convolution technique and a pure ramp filter, leading to a more practical resolution than filtering in the frequency domain (*13*). The arithmetic recombination of the 180-deg opposing views was chosen, with the virtual views set to zero; no attenuation correction coefficient was used. It took about 30 sec for reconstruction and normalization of each transverse section, after which the frontal and sagittal views could be rapidly reconstructed between the anteroposterior and left-right limits chosen by the operator. The three series of sections were independently processed by a previously described smoothing algorithm (*14*) that takes into account the values of the pixels surrounding each processed pixel, in tridimensional space. Finally, a background subtraction was performed, using the mean activity inside a posterior peripheral region of interest drawn by the operator, followed by interpolative zooming. The resulting views were then displayed in black and white on radiographic film. The interpretation was done by two independent observers who graded the examination as normal, doubtful, or abnormal, and a consensus was reached if necessary; if doubtful or abnormal, the location of the defect or pseudodefect was recorded.

A chi-square test was used for comparison of the results.

RESULTS

Results concerning the normal patients are shown in Table 1. It appears that the specificity is 93% with both techniques. All the doubtful interpretations of the sections involved the apex.

Table 2 exhibits the results of the planar scintigrams in the patients with a myocardial necrosis. Note that the number of definitely abnormal cases was increased after consensus, whereas the number of patients considered normal remained constant. The corresponding final sensitivity was 89%. Table 3 presents the changes of the sensitivity when the patients are divided into three groups with different infarct ages. A significant difference was found ($p < 0.02$). With emission tomography, 63 of the 64 patients with a necrosis were classified as definitely abnormal, and this remained unchanged after consensus;

TABLE 3. INTERPRETATIONS OF THE PLANAR IMAGES IN THREE GROUPS OF PATIENTS WITH MYOCARDIAL INFARCTS OF VARIOUS AGES

Age of infarct	Abnormal	Normal and doubtful	Sensitivity
Less than 1 mo	49	3	94
Between 1 and 6 mo	3	1	75
More than 6 mo	5	3	63

thus, the sensitivity was 98% for tomography. This value differs significantly from the results of planar scintigraphy ($p < 0.05$).

In most of the patients, the defect on the sections showed a higher contrast in comparison with normal tissue than on the conventional views. Anterior infarcts (Fig. 1) were detected as well as inferior ones (Fig. 2). Among the seven patients for whom interobserver disagreement occurred before consensus with the planar images, five presented an infarct located in the anterior, apical, or septal wall; after consensus, three of these remained unclassified. Among the remaining seven cases in which both observers found no pathological conventional images, they agreed in four cases to rate the defect seen on the tomographic views as a large one. An example is shown in Fig. 3. In one patient, both explorations were concordantly considered normal; this patient was a 63-yr-old man who had presented a proven history of infarction 4 yr before, but who showed no persistent electrical abnormalities at the time of the scintigraphic exploration.

Globally, there was complete agreement on the location of the abnormalities considered to be either anterior or inferior when detected by ECG, planar scintigraphy, and tomography. However, differences between ECG and tomography occurred regarding the qualitative size of the defect: at the level of the apex the ECG underestimated the extent of the damage. Moreover, an inferior extension of the lateral infarcts was often observed with tomography.

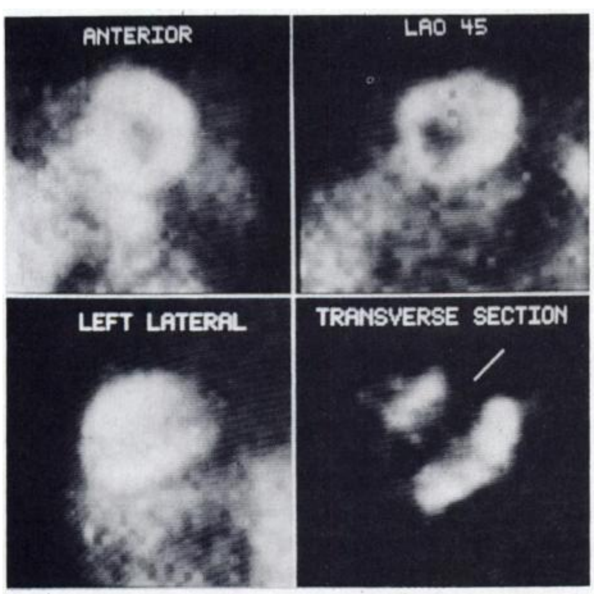

FIG. 1. Planar images and a transverse section, at mid level, of left ventricle in patient with an anterior necrosis.

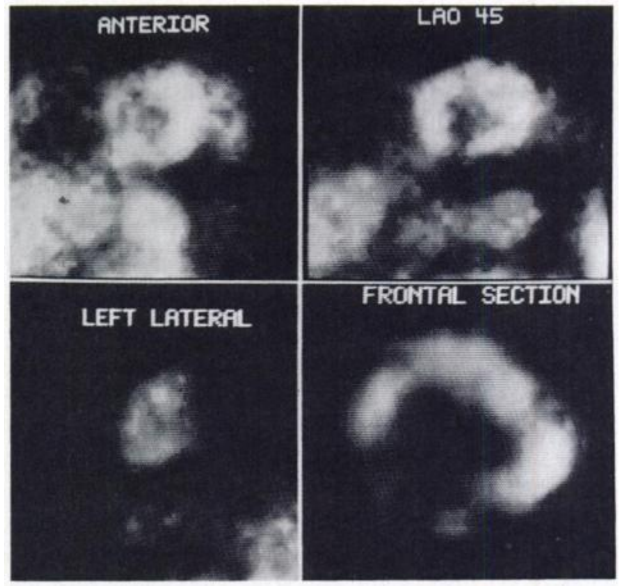

FIG. 2. Planar images and frontal section, at mid depth, of left ventricle in patient with a posteroinferior infarct.

DISCUSSION

This study shows that emission tomography using multiple orthogonal sections allows a dramatic improvement in the detection of transmural myocardial infarction.

Our results with conventional scintigraphy are in good agreement with those of other authors. Wackers et al. (*2*) reported a sensitivity of 90% in a series of patients studied 24 to 48 hr after acute myocardial infarction. The sensitivity was 85% in the series of Ritchie et al. (*3*), which included 145 patients with acute or old necrosis. More recently Niess et al. (*15*) found a sensitivity of 95% in patients with electrocardiographic proof of necrosis, and Tiefenbrum et al. (*16*) obtained sensitivities of 94 and 91% for two observers in a series of 32 patients. Moreover, we have found a decreasing sensitivity accompanying an increase in infarct age. It also appears that the subjective intervention of the observer is reduced to a very low level when the tomographic views are used. Moreover, not only did the sections allow us to detect and locate precisely some small defects, but it also was the only way to visualize some anterior or inferior defects corresponding to doubtful conventional scintigraphic images; in all these patients, it could be admitted retrospectively that a large and clear left-ventricular cavity

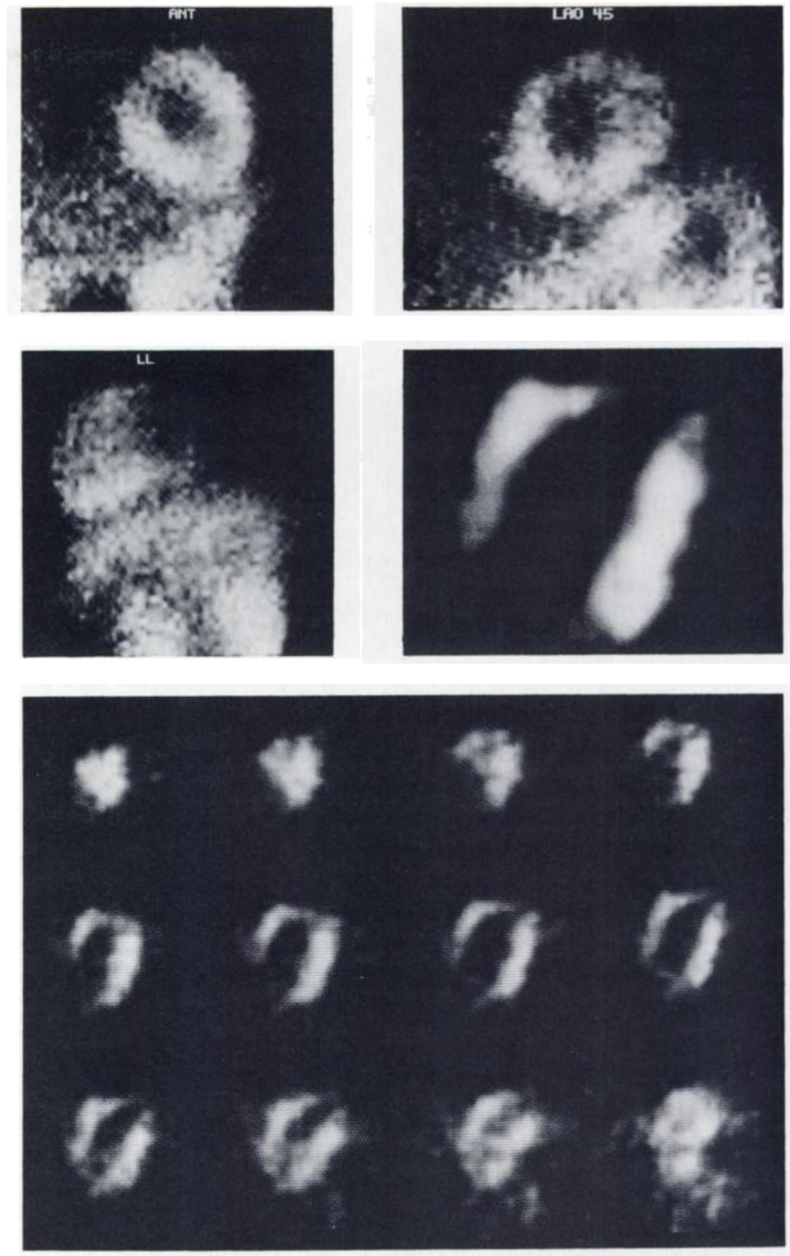

FIG. 3. Subnormal planar images (ANT, LAO 45, LL) with one of the transverse sections clearly showing a transmural defect. Center right illustration is an enlargement of eighth section (bottom).

seemed to be present and could explain the misinterpretation.

This overall improvement is probably related both to the tridimensional visualization of the thallium-201 distribution, which decreases the likelihood of superimposition of a defect with a normal wall, and to the significant increase of the myocardium-to-background ratio that we have demonstrated in a previous study (*11*). However, there seems to exist a concomitant increase in the number of falsely positive findings at the level of the apex that appeared in our population of normal patients. This is compensated, however, by a decrease of the falsely positive results in other territories.

Finally, emission tomography now seems able to show almost all the confirmed transmural myocardial necroses—or, at least, to detect more true abnormalities than conventional scintigraphy, and this without a loss in specificity.

FOOTNOTES

* General Electric 400T.

† Informatek Simis 3.

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