Comparison Between Thallium-201, Technetium-99m-Sestamibi and Technetium-99m-Teboroxime Planar Myocardial Perfusion Imaging in Detection of Coronary Artery Disease

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Technetium-99m-sestamibi (MIBI) and ^{99m}Tc-teboroxime (TEBO) are two new myocardial perfusion imaging agents. The purpose of this prospective study was to compare MIBI and TEBO to ^{201}Tl planar imaging. Eighteen patients with significant coronary artery disease on coronary angiogram were submitted to three treadmill stress tests performed within 3 mo and were imaged with the three radiopharmaceuticals as follows.

1. Tl: 2.2 mCi, immediate and delayed views (4 hr later, 8 min/view).
2. TEBO: 15–20 mCi at stress (1 min/view) and a second injection was repeated 4 hr later at rest (20–25 mCi).
3. MIBI: 15–18 mCi at stress (8 min/view) and 1–4 days later, 15–18 mCi at rest.

Patients achieved similar levels of exercise. A blinded reading was performed by three observers. The left ventricle was divided into three segments/view and ischemic/normal wall ratios were also determined. Segmental comparison showed an agreement in 85% (138/162) of the segments between Tl and TEBO, in 92% (149/162) between Tl and MIBI and in 84% (136/162) between MIBI and TEBO. Abnormal Tl, MIBI and TEBO studies were seen in 16 (89%), 16 (89%) and 15 (83%) patients, respectively, detecting 77, 75 and 65 abnormal segments. Ischemic-to-normal wall ratios were 0.75 ± 0.06, 0.73 ± 0.08 and 0.78 ± 0.08 for Tl, MIBI and TEBO, respectively. In conclusion, although the biologic characteristics of these agents are different, this study showed a good correlation between them in detection of significant coronary artery disease (high pretest likelihood population).

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During the past fifteen years, ^{201}Tl myocardial perfusion imaging has been widely accepted for establishing the diagnosis and prognosis of coronary artery disease and evaluating the hemodynamic significance of documented coronary stenoses (*1–3*). Although [^{201}Tl]thallous chloride shows excellent physiologic characteristics for imaging myocardial perfusion and viability, its physical characteristics are suboptimal for dosimetry and scintillation camera imaging. During the last decade, research has focused on development of myocardial perfusion agents labeled with ^{99m}Tc. Different ^{99m}Tc-labeled agents have been synthesized and have demonstrated interesting myocardial uptake and clearance properties. Technetium-99m-labeled isonitrile compounds (*4*) and boronic acid adducts of ^{99m}Tc dioxime (BATO) compounds (*5,6*) are two classes of radiopharmaceuticals that have been more extensively evaluated in humans. Two new ^{99m}Tc-labeled myocardial perfusion imaging agents are now available for clinical use: ^{99m}Tc-sestamibi (Cardiolite from DuPont) and ^{99m}Tc-teboroxime (Cardiotec from Squibb). Many studies comparing ^{99m}Tc-sestamibi to ^{201}Tl planar and SPECT imaging have been previously reported (*7–15*). Clinical experience with ^{99m}Tc-teboroxime and comparison to ^{201}Tl is more limited (*16–18*). So far, ^{99m}Tc-teboroxime has not been directly compared to ^{99m}Tc-sestamibi and no studies have reported the results of ^{201}Tl, ^{99m}Tc-sestamibi and ^{99m}Tc-teboroxime imaging performed in the same patient population. The purpose of this preliminary prospective study is to compare planar myocardial perfusion imaging performed with the three radiopharmaceuticals in patients referred for coronary angiography and to evaluate their relative sensitivity and agreement to detect coronary artery disease.

METHODS

Patient Population

Eighteen patients (16 males, 2 females, ranging in age from 44 to 76 yr, mean age, 59 yr) referred for chest pain evaluation and/or coronary angiography were prospectively studied. Within 14 wk, all patients underwent coronary angiography and three tread-

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mill stress tests with ^{201}Tl, ^{99m}Tc-sestamibi and ^{99m}Tc-teboroxime injection for planar myocardial perfusion imaging. The sequence of radiopharmaceuticals injections was randomly assigned.

A written, informed consent approved by the ethics committee of our institution was obtained from each patient. Patients with unstable angina, severe arrhythmias, recent myocardial infarction (less than 6 wk), overt congestive heart failure, significant valvular heart disease or patients unable to achieve an adequate level of exercise or with known left main disease were excluded from the study.

Preparation of the patients was identical for the ^{201}Tl, ^{99m}Tc-sestamibi and ^{99m}Tc-teboroxime studies. Patients were instructed to fast after midnight and, whenever possible, cardiovascular drugs were discontinued 24–48 hr prior to the study. The exercise protocol (standard Bruce protocol) was similar for each patient who exercised to the same level (heart rate and blood pressure) for each of the three stress tests. An intravenous line with NaCl 0.9% solution was installed with a no. 20 gauge plastic cannula in an antecubital vein before the stress test and radionuclide injection. Patients were exercised on the treadmill until they reached 85% of the age-predicted maximal heart rate or developed angina, shortness of breath, hypotension or arrhythmias. Thirty to 60 sec before the end of the stress test, the radiopharmaceutical was injected as a compact bolus.

Radiochemical purity was assessed by thin-layer chromatography for both ^{99m}Tc-sestamibi and ^{99m}Tc-teboroxime before each injection. A labeling efficiency of more than 90% was necessary for the intravenous injection of the radiopharmaceuticals.

Thallium-201 Myocardial Imaging

A standard stress-redistribution ^{201}Tl imaging protocol was used. One minute before the end of exercise, 2.2–2.5 mCi of ^{201}Tl were injected into the cannula and immediately flushed with 10 ml of normal saline solution. Myocardial planar imaging was started 5 min after ^{201}Tl injection with a small field of view scintillation camera using a low-energy, all-purpose, parallel-hole collimator. The gamma camera was interfaced to a computer. Digital images were recorded using a 128 × 128 matrix. The first image acquired was a 45° left anterior oblique (LAO) view (best septal view) followed by the anterior and a left lateral view using an acquisition time of 8 min for each view with the photopeak set at 80 keV with a 20% symmetrical window. In all cases, redistribution images were obtained 3–5 hr later. The same imaging parameters were used for the redistribution phase.

Technetium-99m-Sestamibi Myocardial Imaging

At least three days after the ^{201}Tl or ^{99m}Tc-teboroxime study, patients were submitted to another exercise study in the same manner and to the same level achieved during the first stress test. A separate-day injection protocol was used with an initial injection of 15–18 mCi of ^{99m}Tc-sestamibi performed 1 min before the end of the exercise. Myocardial planar imaging began 60–75 min later in the same views (reproduction of camera angles) obtained with ^{201}Tl. Three 8-min images were acquired (45° LAO, anterior and left lateral views) with the photopeak set at 140 keV with a 20% symmetrical window. Digital acquisition was the same as for ^{201}Tl imaging. However, a high-resolution collimator was used instead of an all-purpose collimator (which was used for ^{201}Tl and ^{99m}Tc-teboroxime studies). Because there is no significant myocardial redistribution of ^{99m}Tc-sestamibi, a second injection of 15–18 mCi was given at least 24 hr later with the patient at rest. Three planar images were again obtained 75–90 min after injection with the same acquisition parameters used in the exercise study. The mean interval between the stress and rest ^{99m}Tc-sestamibi injections was 2 days (1–4 days).

Technetium-99m-Teboroxime Myocardial Imaging

A same-day stress-rest injection protocol was used for ^{99m}Tc-teboroxime imaging. Patients were submitted to a stress test similar to the two previous with ^{201}Tl and ^{99m}Tc-sestamibi imaging. A dose of 15–20 mCi of ^{99m}Tc-teboroxime was injected 30–60 sec before the end of exercise. Planar imaging was started approximately 90–120 sec after injection with the same gamma camera and collimator used in the ^{201}Tl study. The first two planar images (supine anterior and 45° LAO views) were acquired for 60 sec/view and the last view (left lateral, patient sitting with his left side close to the camera) lasted 90 sec. Approximately 4 hr later (215 ± 60 min), a second injection of 20–25 mCi of ^{99m}Tc-teboroxime was given at rest. Two minutes later, planar imaging was repeated in the same three standard views according to acquisition parameters used in the stress study.

Cardiac Catheterization

All patients underwent coronary angiography and left ventriculography using the Judkin's technique with multiple views of the right and left coronary arteries. Coronary angiograms were interpreted by two independent observers without knowledge of the ^{201}Tl, ^{99m}Tc-sestamibi or ^{99m}Tc-teboroxime study results. Significant coronary artery stenosis was defined as a 70% or greater reduction in luminal diameter of one or more major coronary arteries.

Data Analysis

All myocardial scintigraphic studies were analyzed by three experienced observers without prior knowledge of the patient's history, results of the stress electrocardiograms or coronary anatomy. Disagreements in interpretation were resolved by consensus. The reading of ^{201}Tl, ^{99m}Tc-sestamibi and ^{99m}Tc-teboroxime studies was performed independently.

Interpretation of the three myocardial scans was based primarily on analog and digital displays using a semiquantitative analysis with segmental activity profiles of opposing myocardial walls for each view on digital images (images with a 10% standard uniform background subtraction were also available for the three studies). This display was used for both stress and rest (or redistribution) studies. A semiquantitative analysis was also used to assess the relative severity of ischemia. Ischemic-to-normal wall ratios were determined for the three studies. Three regions of interest were chosen for each patient with ischemic defects (on either ^{201}Tl, ^{99m}Tc-sestamibi or ^{99m}Tc-teboroxime studies) on the same views for both stress and rest (or redistribution) imaging. The regions had the same location and size in each study for a given patient. The regions of interest were placed over a normally perfused myocardial wall, on the ischemic wall and over the left lung. The latter region was used as a background value for subtraction.

The left ventricle was arbritrarily divided into three segments in each view for segmental comparison between ^{201}Tl, ^{99m}Tc-sestamibi and ^{99m}Tc-teboroxime. Each segment was characterized as being normal, reversible or fixed. For each study, nine segments (three segments for each view) per patient were evaluated for a total of 162 segments for the 18 patients. The observers were asked to determine the final diagnosis for each patient according to the scan results, allowing for a diagnostic comparison between

TABLE 1
Hemodynamic Parameters

	^{201}Tl	^{99m}Tc-sestamibi	^{99m}Tc-teboroxime
1. Heart rate (beats/min)	129 ± 26	125 ± 20	126 ± 17
2. %MPHR	81 ± 9	78 ± 10	78 ± 11
3. Blood pressure	152 ± 26	155 ± 27	159 ± 29
4. Double product (bpm-mmHg)	20000 ± 5300	19500 ± 5200	21100 ± 4900

the three modalities. Each final diagnosis was characterized as being normal, ischemic or scar.

The results of the ^{201}Tl, ^{99m}Tc-sestamibi and ^{99m}Tc-teboroxime studies were correlated with those of coronary angiography. For this purpose, the perfusion defects identified on myocardial scans were related to a specific major coronary territory (left anterior descending, left circumflex and right coronary arteries).

Statistical Analysis

All results were expressed as mean ± one standard deviation. The sensitivity of scintigraphic studies in detecting coronary artery disease was defined as: true-positive × 100 divided by the sum of true-positive plus false-negative tests. Serial changes in heart rate, peak systolic blood pressure and double product (maximal heart rate × peak systolic blood pressure) were evaluated with an analysis of variance. Agreement of the three agents (segment and diagnosis) was evaluated using a kappa (Cohen) analysis.

RESULTS

Patient Population

Four of the 18 patients had evidence of prior myocardial infarction. The mean time interval between ^{201}Tl and ^{99m}Tc-sestamibi studies was 17 ± 10 days and 6 ± 3 days between ^{201}Tl and ^{99m}Tc-teboroxime. The patient's condition and medication remained the same throughout the study period. Coronary angiography was performed either before the first radionuclide study, between the first and

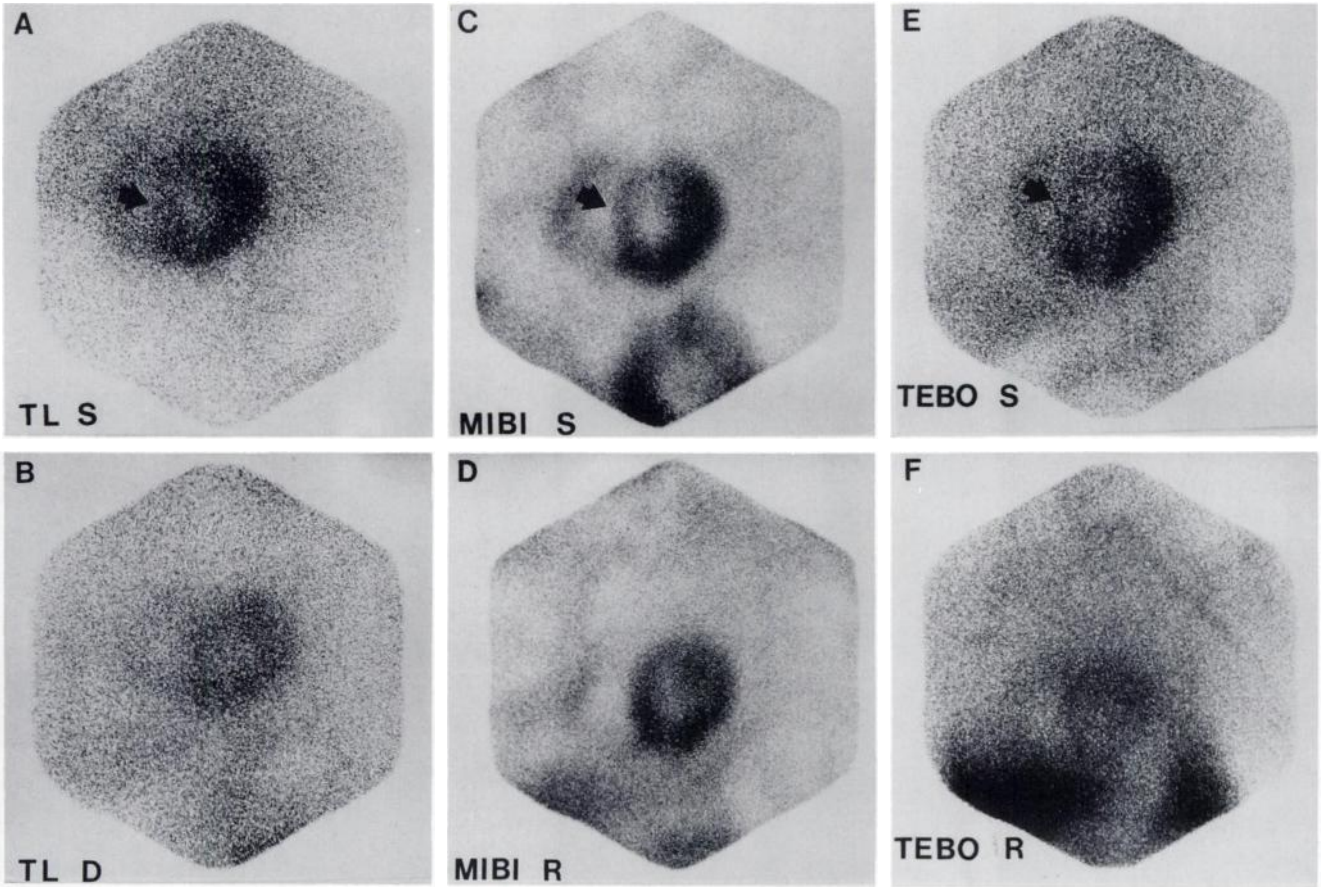

FIGURE 1. Myocardial perfusion imaging (45° LAO view) in a patient with a 95% stenosis of the left anterior descending artery. A reversible anteroseptal defect (arrow) is seen with the three radiopharmaceuticals (Tl = ^{201}Tl, MIBI = ^{99m}Tc-sestamibi, TEBO = ^{99m}Tc-teboroxime, S = stress, R = rest, D = delayed).

third or after the last radionuclide study. Seven patients had single-vessel disease, six had double-vessel disease and five had triple-vessel disease. None showed normal coronary anatomy or left main coronary artery disease.

The level of exercise achieved was comparable for the ^{201}Tl, ^{99m}Tc-sestamibi and ^{99m}Tc-teboroxime stress tests (p = ns). Table 1 summarizes the hemodynamic parameters at peak stress for the three studies. The reasons for stopping the exercise and the electrocardiographic changes for each patient were similar in the three studies. Except for one patient, the results of the stress tests were clinically and electrically similar for the three studies (both clinically and electrically positive for ischemia in eight patients, clinically and electrically negative in two, clinically negative and electrically positive in six and clinically positive and electrically negative in one patient). In the last patient, the three tests were clinically positive, but electrically positive only during the stress test with ^{201}Tl. No serious complications such as severe arrhythmia, worsening of angina or myocardial infarction occurred during or after stress testing. A transient metallic or bitter taste was noted by a few patients within 1 min of the stress and/or rest ^{99m}Tc-sestamibi injection.

Segmental Analysis

Comparison Between ^{201}Tl and ^{99m}Tc-Sestamibi (Figs. 1-4). Analysis of the ^{201}Tl and ^{99m}Tc-sestamibi results in 162 left ventricle segments (Table 2) showed an overall agreement in 149/162 (92%) segments (k = 0.85). Fifty percent of all segments were normal on both ^{201}Tl and ^{99m}Tc-sestamibi. The total number of reversible segments determined by both agents is similar, 69 (42.6%) for ^{99m}Tc-sestamibi and 71 (43.8%) for ^{201}Tl, as well as the number of segments that were normal with one agent and reversible with the other, five with ^{201}Tl and three with ^{99m}Tc-sestamibi.

Comparison Between ^{201}Tl and ^{99m}Tc-teboroxime. Table 3 summarizes the segmental comparison between ^{201}Tl and ^{99m}Tc-teboroxime. The overall segmental agreement between the two agents was 85% (138 out of 162 segments). Seventy-one segments (43.8%) were reversible on the ^{201}Tl studies and 57 (35.2%) on ^{99m}Tc-teboroxime imaging (k = 0.72). Thirteen segments were reversible on ^{201}Tl and normal on ^{99m}Tc-teboroxime, while the inverse was seen in one segment.

Comparison Between ^{99m}Tc-Sestamibi and ^{99m}Tc-Teboroxime. Segmental analysis of ^{99m}Tc-sestamibi and ^{99m}Tc-

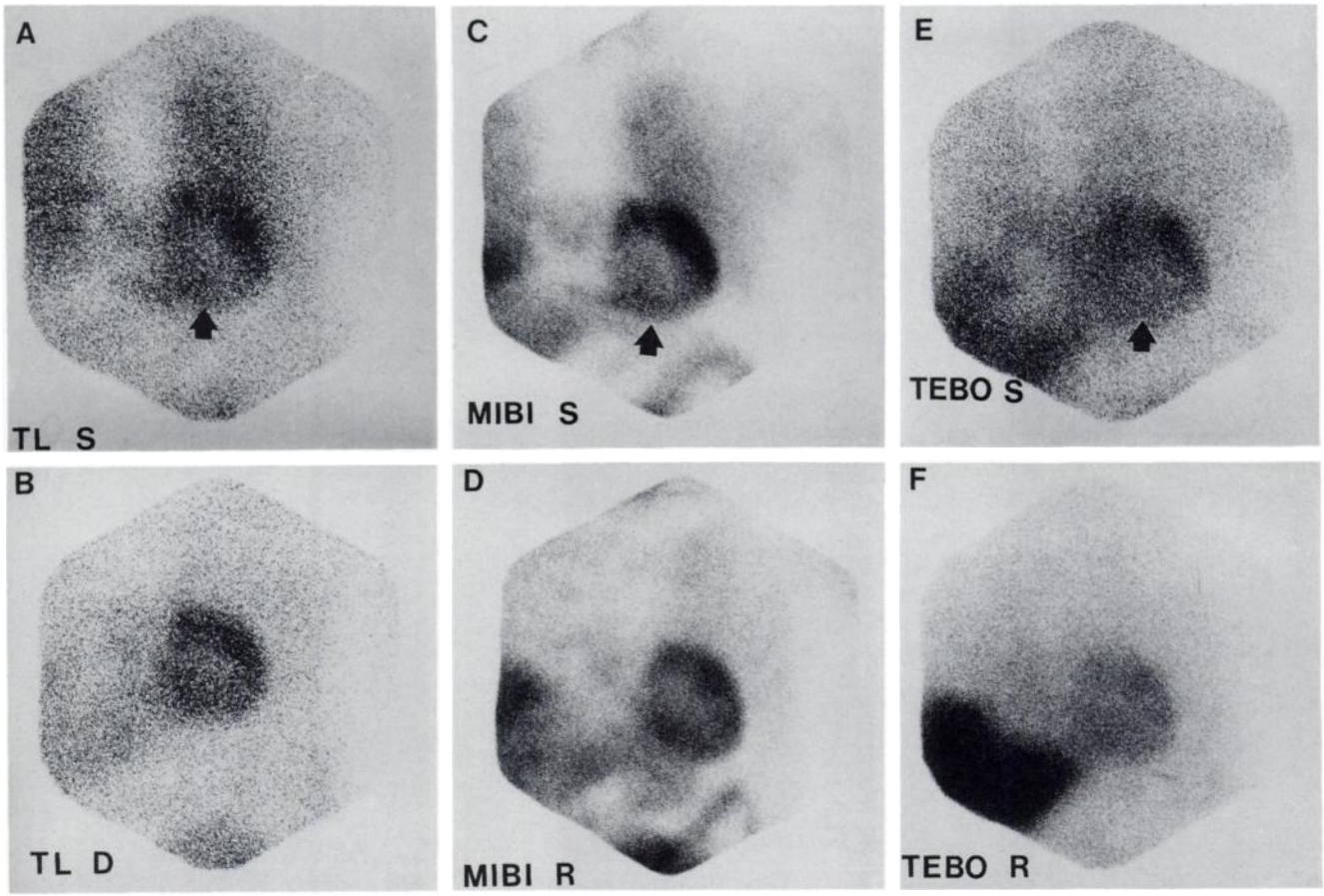

FIGURE 2. Planar imaging performed in the anterior view in a patient with a 90% stenosis of the right coronary artery and the left circumflex. There is an increased radiotracer lung uptake (Tl and MIBI) and a reversible perfusion defect (arrow) of the inferior wall (Tl = ^{201}Tl, MIBI = ^{99m}Tc-sestamibi, TEBO = ^{99m}Tc-teboroxime, S = stress, R = rest, D = delayed).

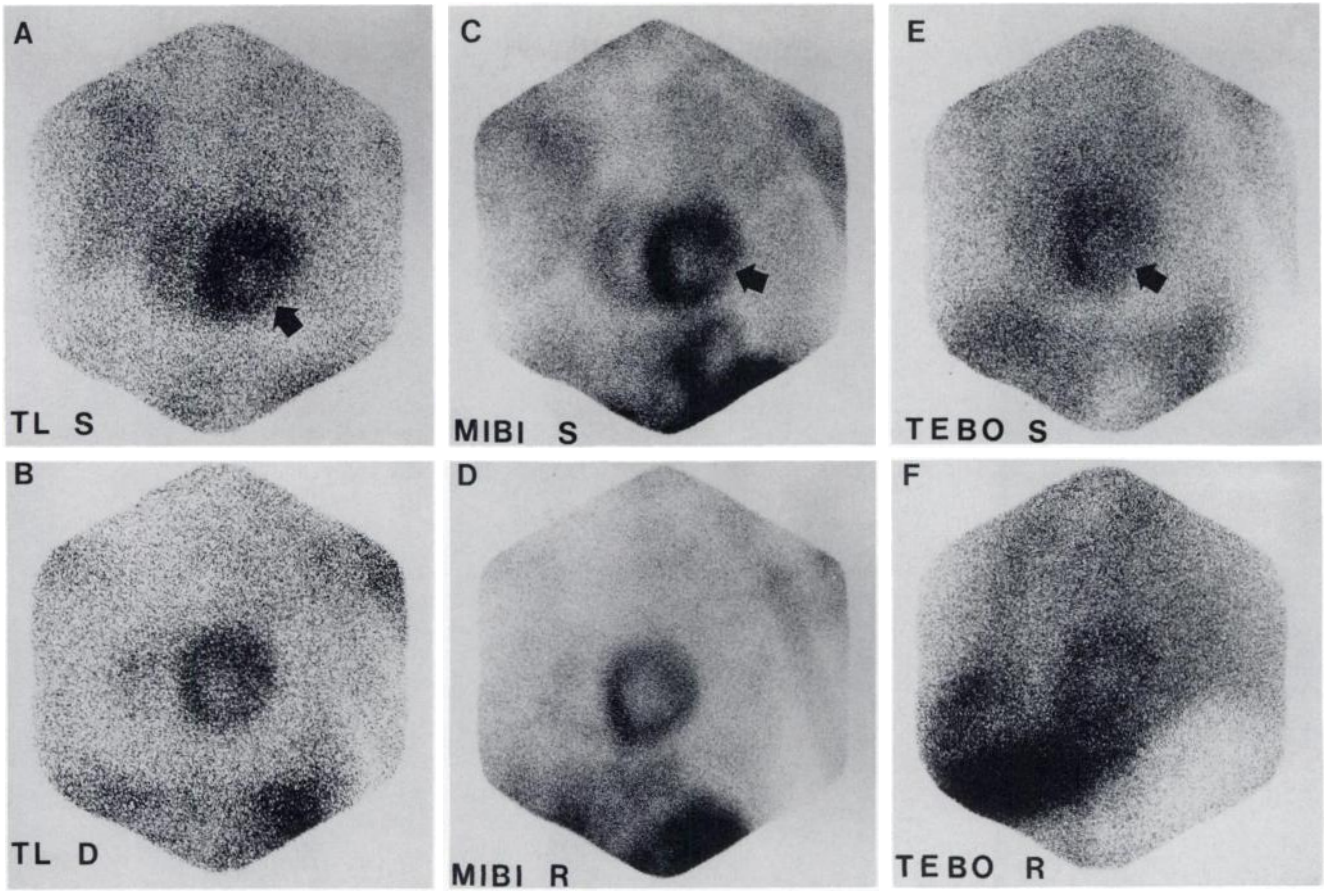

FIGURE 3. Patient with a 95% stenosis of the left circumflex. On these 45° LAO views, there is a reversible perfusion defect (arrow), involving the lateral wall of the left ventricle (Tl = ^{201}Tl, MIBI = ^{99m}Tc-sestamibi, TEBO = ^{99m}Tc-teboroxime, S = stress, R = rest, D = delayed).

teboroxime (Table 4) showed an overall agreement in 136/162 segments (84%). Technetium-99m-sestamibi detected 88, 69 and 5 segments that were normal, reversible and fixed, respectively, while ^{99m}Tc-teboroxime detected 97, 57 and 8 segments, respectively (k = 0.69).

Global Correlation

Thallium-201, ^{99m}Tc-sestamibi and ^{99m}Tc-teboroxime studies detected 77, 75 and 64 abnormal segments, respectively. Thallium-201 and ^{99m}Tc-sestamibi studies were abnormal in 16 patients (89%), and ^{99m}Tc-teboroxime studies were abnormal in 15 patients (83%) (p = ns). The ischemic-to-normal wall ratios were 0.75 ± 0.06, 0.73 ± 0.08 and 0.78 ± 0.08 for ^{201}Tl, ^{99m}Tc-sestamibi and ^{99m}Tc-teboroxime imaging, respectively (p = ns).

Correlation with Coronary Angiography

Coronary angiography was performed in all patients. The angiogram showed significant stenosis in 34 major coronary arteries. The distribution of coronary stenosis was: left anterior descending artery in 12 patients, left circumflex in 8 and the right coronary artery in 14. Table 5 summarizes the sensitivity of ^{201}Tl, ^{99m}Tc-sestamibi and ^{99m}Tc-teboroxime in the detection of territories supplied by stenotic coronary arteries. Thallium-201 and ^{99m}Tc-sestamibi detected 24 of 34 (70.6%) coronary stenoses, while ^{99m}Tc-teboroxime showed abnormalities in 23 (67.6%). There is no significant statistical difference between these values. The ^{99m}Tc-teboroxime study failed to detect a lesion involving the right coronary artery in one patient.

DISCUSSION

Over the past 15 yr, the clinical usefulness of ^{201}Tl myocardial perfusion imaging in the investigation of patients with coronary artery disease has become well established. However, the physical characteristics of [^{201}Tl]thallous chloride are suboptimal for imaging and dosimetry. The development of a myocardial perfusion imaging agent labeled with ^{99m}Tc was an attractive means to circumventing the limitations of ^{201}Tl. Technetium-99m-labeled isonitrile compounds were the first class of agents to be successfully used for clinical imaging. Technetium-99m-tertiary butyl isonitrile (TBI), ^{99m}Tc-carboxyisopropyl isonitrile (CPI) and ^{99m}Tc-methoxyisobutyl isonitrile (MIBI or sestamibi) were successively used in clinical research (*19–21*). Because of its more favorable biologic characteristics for myocardial perfusion imaging (minimal

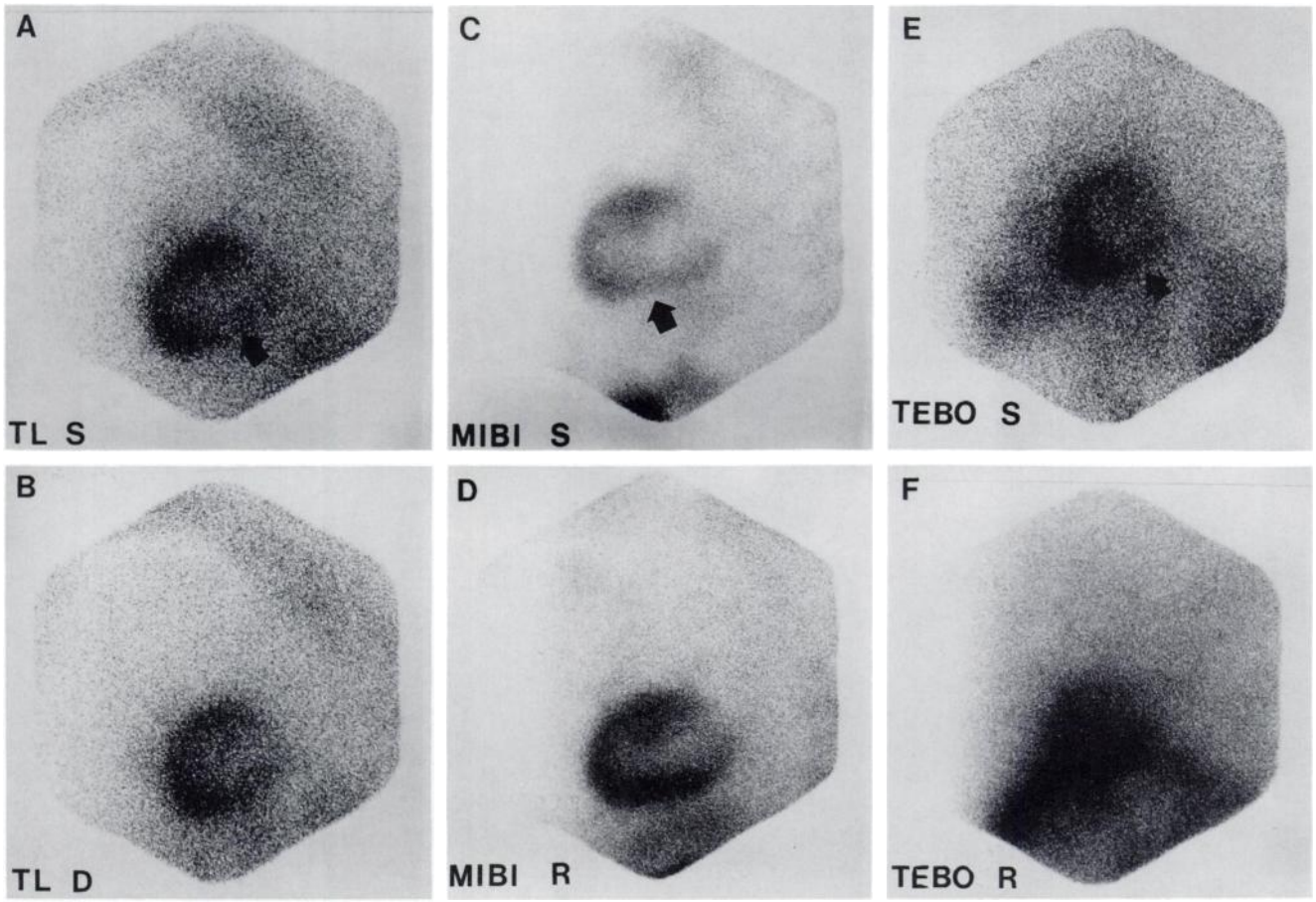

FIGURE 4. Patient with a 95% stenosis of the right coronary artery. On these left lateral views, a reversible defect (arrow) of the inferior wall is seen. However, the inferior wall is masked on the ^{99m}Tc-teboroxime study performed at rest by the scattered activity from the liver uptake (Tl = ^{201}Tl, MIBI = ^{99m}Tc-sestamibi, TEBO = ^{99m}Tc-teboroxime, S = stress, R = rest, D = delayed).

lung uptake and transient liver uptake), ^{99m}Tc-sestamibi was selected for commercial development. Another class of ^{99m}Tc-labeled agents, the boronic acid adducts of ^{99m}Tc-dioxime or BATO compounds, was also introduced. Technetium-99m-teboroxime was the radiopharmaceutical of this class that has been developed commercially.

Although the biologic characteristics of ^{201}Tl, ^{99m}Tc-sestamibi and ^{99m}Tc-teboroxime are quite different, the results of this study, performed on a small number of patients with significant coronary artery disease, showed a similar detection rate with the three radiopharmaceuticals. Previous studies (*9–11,14–15*) comparing ^{201}Tl and ^{99m}Tc-sestamibi have reported a similar concordance (92% in this study), both on a segmental and on a diagnostic basis. Recent data (*16*) also showed the same overall segmental agreement between ^{201}Tl and ^{99m}Tc-teboroxime (85% in this study) with planar imaging. To date, there are no currently available data on direct comparison between ^{99m}Tc-sestamibi and ^{99m}Tc-teboroxime (segmental agreement was 84% in this study).

Although there was no significant statistical difference between the three agents for ischemic-to-normal wall ratios, segmental and diagnostic comparison and correlation with coronary angiography, some technical differences

TABLE 2
Comparison Between ^{201}Tl and ^{99m}Tc-Sestamibi Segmental Analysis

		^{201}Tl		
		Normal	Reversible	Fixed
^{99m}Tc-sestamibi	Normal	82	5	1
	Reversible	3	64	2
	Fixed	0	2	3

Segmental agreement: 92% (149/162)

TABLE 3
Comparison Between ^{201}Tl and ^{99m}Tc-Teboroxime Segmental Analysis

		^{201}Tl		
		Normal	Reversible	Fixed
^{99m}Tc-teboroxime	Normal	82	13	2
	Reversible	1	54	2
	Fixed	2	4	2

Segmental agreement: 85% (138/162)

TABLE 4
Comparison Between ^{99m}Tc-Teboroxime and ^{99m}Tc-Sestamibi Segmental Analysis

		^{99m}Tc-teboroxime		
		Normal	Reversible	Fixed
^{99m}Tc-sestamibi	Normal	83	4	1
	Reversible	13	51	5
	Fixed	1	2	2
	Segmental agreement: 84% (136/162)			

were observed. Since data on ^{201}Tl have been gathered for over 15 yr, the imaging parameters are well known. The image quality of ^{201}Tl planar studies is usually good with a relatively satisfactory count rate. However, imaging must start relatively rapidly because of the possibility of early redistribution (*22*). The high photon flux of ^{99m}Tc-sestamibi results in high count density images. Although soft-tissue attenuation and scattering are also seen on ^{99m}Tc-sestamibi scans, their effect on imaging is less significant than with ^{201}Tl. Furthermore, since there is only minimal myocardial redistribution, imaging can be repeated if necessary or the acquisition time can be increased (in order to improve image quality). Technetium-99m-teboroxime acquisition on the other hand is technically more demanding. Due to its very rapid myocardial washout, imaging must be completed in less than 6–8 min after injection. This clearance requires the treadmill to be close to the imaging device. Image interpretation can also sometimes be complicated by significant liver uptake.

Limitations of the Study

The patient population of this study was highly selected since all subjects underwent coronary angiography either before or after the three radionuclide studies. Furthermore, the coronary anatomy was abnormal in all patients, indicating a high prevalence of coronary artery disease in this study group. Thus, the reported statistics may not reflect the sensitivity of these tests performed in the general population.

Imaging parameters are related to the physical and biologic characteristics of the radiopharmaceutical used. These parameters are known for ^{201}Tl and ^{99m}Tc-sestamibi. However, clinical experience with ^{99m}Tc-teboroxime is more limited. Optimal imaging parameters with ^{99m}Tc-teboroxime are not yet well established. Its very rapid myocardial clearance and the possibility of an early myocardial redistribution make teboroxime imaging technically more difficult than imaging with ^{201}Tl or ^{99m}Tc-sestamibi, mainly with stress test imaging.

TABLE 5
Correlation with Coronary Angiography

	^{201}Tl	^{99m}Tc-sestamibi	^{99m}Tc-teboroxime
LAD (n = 12)	9 (75%)	9 (75%)	9 (75%)
RCA (n = 14)	10 (71.4%)	10 (71.4%)	9 (64.3%)
CX (n = 8)	5 (62.5%)	5 (62.5%)	5 (62.5%)
Total (n = 34)	24 (70.6%)	24 (70.6%)	23 (67.6%)

SPECT is now widely used for myocardial perfusion imaging. Planar acquisition has been chosen in this study because of the limitations related to ^{99m}Tc-teboroxime SPECT imaging, mainly with a single detector gamma camera. A multidetector system was not available in our institution to perform ^{99m}Tc-teboroxime tomographic studies. The ^{99m}Tc-teboroxime image acquisition protocol used in this study started with the best septal view followed by the anterior and left lateral views. Technetium-99m-teboroxime liver uptake is more important and persistent than that with ^{99m}Tc-sestamibi. Liver uptake becomes more significant after the second ^{99m}Tc-teboroxime injection, even when performed 2–4 hr after the initial injection. Scattered activity into the inferior wall of the left ventricle (especially on the left lateral view, when performed last or on the second study) from anatomic overlap and early hepatic uptake can interfere with visualization of inferior wall perfusion (as seen in Fig. 4). It might be valuable to start imaging with the left lateral view first, followed by the best septal and anterior views, since on these latter views liver uptake does not usually represent a significant imaging limitation. Studies recorded with the patient upright, a position that can lower the liver, may also improve the diagnostic quality of the images by better delineating the inferior wall. Although a same-day ^{99m}Tc-sestamibi imaging protocol is clinically useful (*23,24*), the optimal two-day protocol was chosen because of the slow radiotracer myocardial washout. As with ^{99m}Tc-sestamibi, a separate-day protocol can be used with ^{99m}Tc-teboroxime, but the advantage of very rapid ^{99m}Tc-teboroxime myocardial washout is lost. Ideally, it would have been interesting to use separate rest and stress studies for ^{201}Tl, ^{99m}Tc-sestamibi and ^{99m}Tc-teboroxime for a real comparison. However, our standard clinical imaging protocols, with 4-hr redistribution images were used.

Interpretation of the three types of scintigraphic studies was primarily based on analog images and, if necessary, a digital display with a uniform background subtraction. Since the best method for quantitative assessment of ^{99m}Tc-teboroxime and ^{99m}Tc-sestamibi planar imaging has not yet been established, no specific quantitative analysis was applied.

In conclusion, despite significant differences in biologic characteristics of ^{201}Tl, ^{99m}Tc-sestamibi and ^{99m}Tc-teboroxime, myocardial perfusion imaging with the three radiopharmaceuticals showed similar results for the detection of coronary artery disease. Their respective clinical role will partially depend on imaging and logistic considerations.

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REFERENCES

1. Pohost GM, Zir LM, Moore RM, McKusick KA, Guiney TE, Beller GA. Differentiation of transiently ischemic from infarcted myocardium by serial 2imaging after a single dose of thallium-201. *Circulation* 1979;55: 294–302.
2. Gibson RS, Watson DD, Craddock GB, et al. Prediction of cardiac events after uncomplicated myocardial infarction: a prospective study comparing predischarge exercise thallium-201 scintigraphy and coronary angiography. *Circulation* 1983;68:321–326.
3. Brown KA, Boucher CA, Okada RD, et al. Prognostic value of exercise thallium-201 imaging in patients presenting for evaluation of chest pain. *J Am Coll Cardiol* 1983;4:994–1001.
4. Jones AG, Abrams MJ, Davison A, et al. Biological studies of a new class of technetium complexes: the hexakis (alkylisonitrile) technetium (II) cations. *Int J Nucl Med Biol* 1984;11:225–234.
5. Stewart RE, Schwaiger M, Hutchins GD, et al. Myocardial clearance kinetics of technetium-99m-SQ 30217: a marker of regional myocardial blood flow. *J Nucl Med* 1990;31:1183–1190.
6. Narra RK, Kuczynski BL, Feld T, Nunn AD, Eckelman WC. A comparison of the pharmacokinetics of a new technetium-99m-labeled myocardial imaging agent, SQ-32014 and SQ-30217. *Nuklearmedizin* 1988;24: 731–734.
7. Buell V, Dupont F, Vebis R, et al. Tc-99m-methoxy-isobutyl-isonitrile SPECT to evaluate a perfusion index from regional myocardial uptake after exercise and at rest. Results of a four hour protocol in patients with coronary heart disease and controls. *Nucl Med Comm* 1990;11:77–94.
8. Hassan IM, Mohammad MMJ, Constantinides C, et al. Segmental analysis of SPECT ^{99m}Tc-methoxy isobutyl isonitrile and ^{201}Tl myocardial imaging in ischemic disease. *Eur J Nucl Med* 1990;16:705–711.
9. Iskandrian A, Heo J, Kong B, Lyons E, Marsh S. Use of technetium-99m isonitrile (RP-30A) in assessing left ventricular perfusion and function at rest and during exercise in coronary artery disease and comparison with coronary arteriography and exercise thallium-201 SPECT imaging. *Am J Cardiol* 1989;64:270–275.
10. Kahn J, McGhie I, Akers M, et al. Quantitative rotational tomography with ^{201}Tl and ^{99m}Tc-2-methoxy-isobutyl isonitrile: a direct comparison in normal individuals and patients with coronary artery disease. *Circulation* 1989;79:1282–1293.
11. Kiat H, Maddahi J, Roy L, et al. Comparison of technetium-99m methoxy-isobutyl isonitrile and thallium-201 for evaluation of coronary artery disease by planar and tomographic methods. *Am Heart J* 1989;117:1–11.
12. Najm YC, Maisey MN, Clarke SM, Fogelman I, Curry PVL, Sowton P. Exercise myocardial perfusion scintigraphy with technetium-99m-methoxy isobutyl isonitrile: a comparative study with thallium-201. *Int J Cardiol* 1990;26:93–102.
13. Sinusas AJ, Beller GA, Smith WH, Vinson EL, Brookeman V, Watson DA. Quantitative planar imaging with technetium-99m methoxyisobutyl isonitrile: comparison of uptake patterns with thallium-201. *J Nucl Med* 1989;30:1456–1463.
14. Taillefer R, Dupras G, Sporn V, et al. Myocardial perfusion imaging with a new radiotracer, technetium-99m-hexamibi (methoxy isobutyl isonitrile): comparison with thallium-201 imaging. *Clin Nucl Med* 1989;14:89–96.
15. Taillefer R, Lambert R, Dupras G, et al. Clinical comparison between thallium-201 and Tc-99m-methoxy isobutyl isonitrile (hexamibi) myocardial perfusion imaging for detection of coronary artery disease. *Eur J Nucl Med* 1989;15:280–286.
16. Hendel RC, McSherry B, Karimeddini M, Leppo JA. Diagnostic value of a new myocardial perfusion agent, teboroxime (SQ-30217), utilizing an rapid planar imaging protocol: preliminary results. *J Am Coll Cardiol* 1990; 16:855–861.
17. Seldin DW, Johnson LL, Blood DK, et al. Myocardial perfusion imaging with technetium-99m-SQ-30217: comparison with thallium-201 and coronary anatomy. *J Nucl Med* 1989;30:312–319.
18. Fleming RM, Kirkeeide RL, Taegtmeyer H, Adyanthaya A, Cassidy DB, Goldstein RA. Comparison of technetium-99m teboroxime tomography with automated quantitative coronary arteriography and thallium-201 tomographic imaging. *J Am Coll Cardiol* 1991;17:1297–1307.
19. Holman BL, Jones AG, Lister-James J, et al. A new Tc-99m-labeled myocardial imaging agent, hexakis (T-butyl-isonitrile), technetium (I) (Tc-99m TBI): initial experience in the human. *J Nucl Med* 1984;25: 1350–1355.
20. Holman BL, Sporn V, Jones AG, et al. Myocardial imaging with technetium-99m CPI: initial experience in the human. *J Nucl Med* 1987;28: 13–18.
21. Sia STB, Holman BL, Campbell S, et al. The utilization of technetium-99m CPI as a myocardial perfusion imaging agent in exercise studies. *Clin Nucl Med* 1987;12:681–687.
22. Rothendler JA, Okada RD, Wilson RA. Effect of a delay in commencing imaging on the ability to detect transient thallium defects. *J Nucl Med* 1985;26:880–883.
23. Taillefer R, Laflamme L, Dupras G, Picard M, Phaneuf DC, Léveillé J. Myocardial perfusion with ^{99m}Tc-methoxy-isobutyl-isonitrile (MIBI): comparison of short- and long-time intervals between rest and stress injections. *Eur J Nucl Med* 1988;13:515–522.
24. Taillefer R. Technetium-99m sestamibi myocardial imaging: same-day rest-stress studies and dipyridamole. *Am J Cardiol* 1990;66:80–84.