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Adenosine Coronary Vasodilation in Coronary Artery Disease: Technetium-99m Tetrofosmin Myocardial Tomography Versus Echocardiography

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This study compared the results of adenosine ^{99m}Tc-tetrofosmin cardiac tomography with those of adenosine echocardiography in identifying patients with coronary artery disease (CAD) and in localizing individual stenosed coronary vessels. **Methods:** Twenty-six consecutive patients with suspected or known CAD had simultaneous adenosine (140 μg/Kg/min intravenously) ^{99m}Tc-tetrofosmin tomography and two-dimensional echocardiography. All patients had coronary angiography within 4 wk from imaging studies. Regional ^{99m}Tc-tetrofosmin activity was quantitatively measured in 78 coronary vascular territories and echocardiographic left ventricular function was assessed in corresponding regions. **Results:** At coronary angiography one patient had normal coronary vessels, 12 patients one-vessel and 13 had multivessel disease (≥50% luminal stenosis). Among the 25 patients with CAD, 22 showed perfusion defects at adenosine ^{99m}Tc-tetrofosmin tomography (sensitivity 88%) and 17 had abnormal echocardiographic study (sensitivity 68%, $p < 0.05$ versus ^{99m}Tc-tetrofosmin). Agreement for the identification of patients with CAD between adenosine ^{99m}Tc-tetrofosmin tomography and echocardiography was observed in 21 (81%) of the total 26 patients, with a kappa value of 0.45. Overall sensitivity, specificity and diagnostic accuracy for detection of individual stenosed vessels were 79%, 88% and 83% for ^{99m}Tc tetrofosmin and 57%, 68% and 61% (all $p < 0.05$ versus ^{99m}Tc-tetrofosmin) for echocardiography. Concordance between adenosine ^{99m}Tc-tetrofosmin tomography and echocardiography in the detection of individual stenosed coronary vessels was observed in 57 (73%) of the 78 vascular territories, with a kappa value of 0.36. **Conclusion:** Adenosine-induced coronary vasodilation associated with quantitative ^{99m}Tc-tetrofosmin tomography is more accurate than adenosine echocardiography in identifying patients with CAD and in detecting individual stenosed coronary vessels.

Key Words: myocardial perfusion; left ventricular function; pharmacologic stress test

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Although myocardial perfusion imaging and two-dimensional echocardiography associated with dynamic exercise test have been widely used in the noninvasive evaluation of patients with coronary artery disease (CAD) (*1–5*), these procedures may be not accurate in patients unable to perform an adequate maximal test (*3,6*). It also has been demonstrated that approximately 30% of echocardiographic studies are technically suboptimal because of the difficulties due to the rapid and deep respiratory movements during dynamic physical exercise (*6*). Therefore, pharmacological stress testing has been proposed as an alternative to exercise test in evaluating patients with CAD.

Previous studies demonstrated that maximal pharmacological coronary vasodilation induced by adenosine administration combined with ^{201}Tl imaging is a useful noninvasive approach for the diagnosis of CAD showing good agreement with exercise myocardial scintigraphy (*7–10*). However, ^{201}Tl presents some physical and biological limitations as myocardial perfusion agent and, therefore, it is not ideal for cardiac imaging (*11*). Technetium-99m-labeled compounds have been introduced for myocardial perfusion imaging to overcome some of these limitations. In particular, ^{99m}Tc-sestamibi has been used for clinical purposes showing good agreement with ^{201}Tl in detecting CAD (*12–14*). Recent studies suggest that the adenosine test associated with ^{99m}Tc-sestamibi imaging or echocardiography has good diagnostic accuracy for detecting CAD (*15–19*). Technetium-99m-tetrofosmin has been introduced recently for myocardial perfusion imaging (*20–23*) and a good correlation between adenosine and dynamic exercise ^{99m}Tc-tetrofosmin cardiac imaging also has been demonstrated (*24*). However, no data are available comparing adenosine ^{99m}Tc-tetrofosmin tomography with adenosine echocardiography in the same patients. This study was designed to compare the results of adenosine ^{99m}Tc-tetrofosmin cardiac tomography with those of adenosine echocardiography in identifying patients with CAD and in localizing individual stenosed coronary vessels.

TABLE 1
Clinical Data and Comparison of Technetium-99m-Tetrofosmin Cardiac Tomography and Echocardiography During Adenosine Test in 26 Patients

Patient no.	Age (yr)	Sex	HxMI	Coronary artery stenosis (≥50%)	Adenosine ^{99m}Tc-tetrofosmin		Adenosine echocardiography	
					AbnSeg	RevSeg	AbnSeg	RevSeg
1	64	M	−	LAD, PDA	−	−	−	−
2	43	M	−	LAD, LCx	+	+	−	−
3	55	F	−	LAD, PDA, LCx	+	+	−	−
4	60	M	+	LAD	+	−	+	−
5	55	M	−	PDA	+	−	+	+
6	57	M	−	LAD, PDA, LCx	+	+	+	+
7	48	M	+	LAD	+	+	+	+
8	53	M	−	LAD, LCx	+	+	+	+
9	53	M	+	LAD, PDA, LCx	+	+	+	+
10	43	M	−	PDA	+	+	+	+
11	55	M	−	PDA, LCx	+	+	+	−
12	60	M	+	LAD	+	−	+	−
13	52	M	+	LAD, PDA, LCx	+	+	+	+
14	59	M	−	LAD	+	+	+	+
15	49	M	−	LAD	+	+	+	+
16	51	M	−	LAD, LCx	+	+	+	+
17	41	M	−	LAD	+	+	−	−
18	53	M	−	LAD, PDA, LCx	+	+	+	+
19	53	M	−	None	−	−	−	−
20	42	M	−	LAD	+	+	+	+
21	46	M	+	LAD	+	+	+	+
22	57	M	−	LAD	+	+	+	+
23	51	M	−	PDA, LCx	−	−	−	−
24	61	M	−	LAD, PDA, LCx	+	+	−	−
25	50	F	−	LAD, LCx	+	−	−	−
26	51	M	−	LAD	−	−	−	−

HxMI = history of myocardial infarction; LAD = left anterior descending artery; LCx = left circumflex artery; PDA = posterior descending artery; AbnSeg = abnormal myocardial segments; RevSeg = reversible myocardial segments.

MATERIALS AND METHODS

Patients

Twenty-six consecutive patients (24 men, 2 women, mean age 52 ± 10 yr) who had undergone coronary angiography were prospectively studied. Demographics and the individual clinical data of the patients are illustrated in Table 1. Seven of these patients have been reported previously, as part of a different protocol performed in our laboratory (*24*). None of the patients had previous coronary revascularization. Six patients (23%) had prior myocardial infarction documented on electrocardiography by pathologic Q-waves in appropriate leads. In all patients, antianginal medications (long-acting nitrates and calcium antagonists) were discontinued at least 72 hr before imaging studies. At the time of the study, 15 patients were symptomatic (stable angina in 14 patients and unstable angina in one patient). Exclusion criteria for the protocol were severe hypertension (systolic blood pressure >200 mmHg and/or diastolic blood pressure >110 mmHg), hypotension (systolic blood pressure <90 mmHg), history of asthma or severe chronic obstructive pulmonary disease, severe congestive heart failure (New York Heart Association Class III or IV), second- or third-degree atrioventricular block. All patients gave informed consent as part of protocol approved by the Institutional Ethical Committee.

Study Protocol

All patients had adenosine infusion as described previously (*15,16*). Caffeine ingestion and medications containing methylxanthine were not allowed for at least 24 hr preceding the study. Adenosine was infused through a peripheral vein by using an infusion pump at a rate of 140 μg/kg per min for 6 min with the patients in the supine position. After 4 min, ^{99m}Tc-tetrofosmin (740 MBq) was injected as a bolus into an intravenous line and flushed with 10 ml of NaCl 0.9% solution into the opposite arm and the adenosine infusion continued for additional 2 min. Technetium-99m tetrofosmin tomography at rest was performed on a separate day. Images were acquired with the patients in the supine position 30 min after ^{99m}Tc-tetrofosmin injection for both studies. In all patients two-dimensional echocardiographic images of the left ventricle (LV) were continuously monitored in all standard views before, during and up to 3 and 6 min after adenosine administration. Heart rate and rhythm, blood pressure and symptoms were continuously monitored. A twelve-lead electrocardiogram was recorded before and every 2 min during the infusion, and 3 and 6 min after its withdrawal. All patients had had coronary angiography within 4 wk from imaging studies. No patient had a change in clinical status between the coronary angiography and the adenosine study.

Coronary Angiography. Coronary angiography was performed by Judkin's technique. It was reported by two independent, experienced observers. Stenoses of coronary vessels were coded according to American Heart Association criteria (*25*). Angiographic demonstration ≥50% stenosis of any one of the epicardial coronary arteries was considered abnormal. A luminal coronary stenosis ≥50% to 75% was considered moderate, while a luminal coronary stenosis >75% was considered severe.

Technetium-99m-Tetrofosmin Tomography. SPECT was performed as described previously (*22–24*), using a rotating large field-of-view gamma camera (Elscint SP4HR, Haifa, Israel) equipped with a low-energy, all purpose, parallel-hole collimator

TABLE 2
Hemodynamic Parameters Recorded Under Control Conditions and During Adenosine Infusion

	Adenosine test	
	Baseline	Peak
Heart rate (bpm)	73 ± 12	91 ± 18†
Systolic blood pressure (mmHg)	130 ± 18	129 ± 19
Diastolic blood pressure (mmHg)	81 ± 11	75 ± 11*
Rate-pressure product ($\times 10^3$)	9.6 ± 2.3	11.7 ± 3.0**
Side effects during test	17 (65%)	
ECG ischemic changes during test	3 (11%)	

ECG = electrocardiographic. **$p < 0.05$ and $p < 0.001$ vs. baseline, respectively.

and connected with a dedicated computer system. Briefly, 32 projections (40 sec/projection) were obtained over a semicircular 180° arch, which extended from the 30° right anterior oblique to the left posterior oblique position. A 20% symmetric energy window centered on the 140-keV peak was used. Filtered back-projection was then performed with a low-resolution Butterworth filter with a cutoff frequency of 0.5 cycles/pixel, order 5.0. No attenuation or scatter correction was applied.

Echocardiography. Echocardiographic studies were performed using a wide-angle, two-dimensional, phased-array sector scanner (Hewlett-Packard 77020AC, Andover, MA) equipped with a 2.5-MHz transducer. All studies were videotaped on a 3/4-inch videocassette recorder SVHS. The video frame rate of the system was 60 frames per second.

Data Analysis

Technetium-99m-Tetrofosmin Tomography. In each patient, corresponding adenosine and resting ^{99m}Tc-tetrofosmin images were evaluated by two observers unaware of clinical, echocardiographic and angiographic results. Regional ^{99m}Tc-tetrofosmin activity was measured on the three short-axis (apical, midventricular and basal) tomograms and on the two horizontal and vertical long-axis tomograms using a semiautomatic circumferential profile method, as described previously (*22–24*). Briefly, an operator-defined ROI was drawn around the left ventricular activity of the short-axis and long-axis tomograms. Each short-axis tomogram was then divided into six sectors of equal arc, representing the anterolateral, lateral, inferior, posteroseptal, septal and anterior myocardium. To measure apical ^{99m}Tc-tetrofosmin uptake, vertical and horizontal long-axis tomograms were also divided into six sectors, but only the apical segments were considered for the analysis. In each tomogram, the myocardial sector with the maximum counts was used as the normal reference region. Tracer uptake in all other myocardial sectors was then expressed as a percentage of the activity measured in the reference region. Each myocardial segment was assigned to one of the major vascular territories, as described previously (*15,16,22*). Briefly, the left anterior descending artery territory included the anterior wall, septum and apical wall. The posterior descending artery was assigned the inferior wall. The left circumflex artery was assigned the lateral wall. In each of these segments, perfusion data were directly compared with the functional data derived from the echocardiographic analysis, as described below. A myocardial segment was considered abnormal if ^{99m}Tc-tetrofosmin uptake was >2 s.d. below the mean observed in the same region for normal volunteers (*23,24*). A segment with reduced activity on adenosine ^{99m}Tc-tetrofosmin images was considered reversible if the activity increased at least 10% on resting images. Alternatively, a segment with reduced activity on adenosine ^{99m}Tc-tetrofosmin images was considered irreversible if the activity did not increase more than 10% on resting images.

Echocardiography. All studies were performed by the same investigator and were analyzed independently by two experts unaware of clinical, radionuclide and angiographic findings. A third investigator blindly reviewed the echocardiograms when the first two observers were not in agreement. Regional LV function was assessed according to the recommendations of the American Society of Echocardiography (*26*). Segmental LV wall motion was graded semiquantitatively on rest and adenosine echocardiographic images using a scoring system where 1 indicated normal, 2 hypokinesia, 3 akinesia and 4 dyskinesia. Adenosine echocardiographic images were considered positive when new or worsening of pre-existing wall motion abnormality was observed. Thus, a normal response was defined by homogeneous contraction at rest and with pharmacologic stress. Ischemia was characterized by adenosine-induced wall motion abnormality or worsening of a resting abnormality. A fixed alteration was indicated by a resting wall motion abnormality that remained unchanged with adenosine test. To directly compare the results of two-dimensional echocardiography with those of ^{99m}Tc-tetrofosmin tomography, each ventricular segment was assigned to one of the major coronary vascular territories, as described previously (*4*). In particular, the anterior, anterolateral, proximal and distal septal wall were assigned to the left anterior descending artery, the posterolateral wall to the left circumflex artery and the posterior and inferior wall to the posterior descending artery. The assignment of the LV apex was variable and based on the presence of adjacent wall motion abnormalities. However, some error in the correlation between regional echocardiographic wall motion and regional quantitative perfusion secondary to miss registration could not be completely excluded.

Statistical Analysis

Data are expressed as mean ± 1 s.d. Differences in the mean values were assessed by Student's t-test for paired or unpaired data, as appropriate. Frequency data were compared by McNamar's test or Fisher exact test, as appropriate. Probability values <0.05 were considered statistically significant. Sensitivity was defined as the number of true-positive divided by the sum of true-positive and false-negatives ×100. Specificity was defined as the number of true-negatives divided by the sum of true-negatives and false-positive ×100. Diagnostic accuracy was defined as the sum of true-positive and true-negatives divided by the total ×100. The kappa statistic and its s.e. were used as a measure of agreement between adenosine echocardiography and ^{99m}Tc-tetrofosmin tomography. A value of 1 denotes perfect agreement, and 0 indicates no agreement beyond change (*27*). In general, kappa values of 0.6 or greater are considered indicative of good agreement.

RESULTS

Coronary Angiography

The results of coronary angiography are reported in Table 1. Of the 26 patients studied, 25 (96%) had 50% or greater luminal diameter stenosis in at least one major coronary vessel. Twelve patients had single-vessel disease, seven patients had two-vessel disease and the remaining six patients had three-vessel disease. One patient had normal coronary arteries. Individual vessel analysis showed 13 coronary arteries with moderate (≥ 50% to 75%) luminal stenosis in 11 patients and 31 coronary arteries with severe (>75%) luminal stenosis in 22 patients.

Hemodynamic Parameters and Electrocardiographic Changes

The hemodynamic parameters recorded under control conditions and during adenosine infusion are reported in Table 2.

TABLE 3
Sensitivity, Specificity and Diagnostic Accuracy of Adenosine Technetium-99m-Tetrofosmin Tomography and Echocardiography in the Detection of Individual Stenosed Vessels

	^{99m}Tc-tetrofosmin				Echocardiography			
	LAD	LCx	PDA	All	LAD	LCx	PDA	All
Sensitivity (%)	81	83	73	79	57*	50*	64	57*
Specificity (%)	100	86	87	88	80	64	67*	68*
Accuracy (%)	85	85	81	83	61*	58*	65	61*

LAD = left anterior descending artery; LCx = left circumflex artery; PDA = posterior descending artery. * indicates $p < 0.05$ vs. ^{99m}Tc-tetrofosmin tomography.

Adenosine administration induced a significant increase of heart rate and rate-pressure product (both $p < 0.001$) and a slight, but statistically significant, decrease of diastolic blood pressure ($p < 0.05$) as compared to control conditions. Electrocardiographic changes indicative of myocardial ischemia during adenosine administration occurred in 3 (11%) patients. During adenosine infusion, 9 (35%) patients did not report side effects. The remaining 17 (65%) patients experienced mild and transient symptoms. In these patients the most common side effects were chest pain (36%), flushing (30%), light-headedness or dizziness (10%) and dyspnea (6%). All symptoms resolved spontaneously within 2 min after adenosine infusion was discontinued, and side effects did not require premature interuption of adenosine administration or interventions in any patient.

Identification of Patients with Coronary Artery Disease

Echocardiographic images and ^{99m}Tc-tetrofosmin studies were adequate for analysis in all patients. Among the 25 patients with significant stenosis of at least one major coronary artery, 22 showed perfusion defects at adenosine ^{99m}Tc-tetrofosmin tomography (sensitivity 88%) and 17 had abnormal adenosine echocardiography (sensitivity 68%, $p < 0.05$ versus ^{99m}Tc-tetrofosmin) (Table 1). The only patient (Patient 19 in Table 1) without significant CAD showed normal findings on both cardiac tomography and echocardiographic imaging. Agreement for the identification of patients with CAD between ^{99m}Tc-tetrofosmin imaging and echocardiography was observed in 21 (81%) of the total 26 patients, with a kappa value of 0.45 (s.e. = 0.18).

Localization of Individual Stenosed Coronary Vessels

A total of 78 vascular territories was analyzed. Overall sensitivity, specificity and diagnostic accuracy in the detection of individual stenosed coronary vessels were significantly higher (all $p < 0.05$) for ^{99m}Tc-tetrofosmin tomography as compared to echocardiography (Table 3). Sensitivity, specificity and diagnostic accuracy of ^{99m}Tc-tetrofosmin tomography and echocardiography in the detection of individual stenosed vessels in each of the vascular territories are reported in Table 3. Concordance between ^{99m}Tc-tetrofosmin tomography and echocardiography in the detection of individual stenosed coronary vessels was observed in 57 (73%) of the total 78 vascular territories, with a kappa value of 0.36 (s.e. = 0.09).

Diagnostic Accuracy in Patients with Single-Vessel and Multivessel Disease

A separate analysis was performed dividing the patients with single-vessel disease (n = 12) from those with stenoses of two or more coronary arteries (n = 13). In patients with single-vessel disease (Fig. 1, left), overall sensitivity in the identification of individual stenosed vessels was not significantly different between ^{99m}Tc-tetrofosmin imaging (83%) and echocardiography (75%). Overall specificity and diagnostic accuracy were significantly higher for ^{99m}Tc-tetrofosmin imaging (87% and 86%, respectively) as compared to echocardiography (62% and 67%, respectively, both $p < 0.05$ versus ^{99m}Tc-tetrofosmin). Moreover, 67% of patients with single-vessel disease showed a scintigraphic pattern characterized by the presence of perfusion defects in only one coronary artery territory, while echocardiography correctly identified only 33% ($p < 0.01$ versus ^{99m}Tc-tetrofosmin) of these patients. In 42% of the patients with single-vessel disease, there was an echocardiographic pattern characterized by the presence of wall motion abnormalities in two or more coronary artery territories. In the remaining 25% of patients with single-vessel disease, echocardiographic abnormalities were on a single-vessel distribution but in the wrong territory.

In patients with multivessel disease (Fig. 1, right), overall specificity in detecting individual stenosed coronary vessels was not significantly different between ^{99m}Tc-tetrofosmin tomography (86%) and echocardiography (71%). Sensitivity and diagnostic accuracy in the identification of individual stenosed coronary arteries were significantly higher for ^{99m}Tc- tetrofosmin imaging (78% and 79%, respectively) as compared to echocardiography (50% and 54%, respectively, both $p < 0.05$ versus ^{99m}Tc-tetrofosmin). Moreover, 61% of the patients with multivessel disease showed a scintigraphic pattern character-

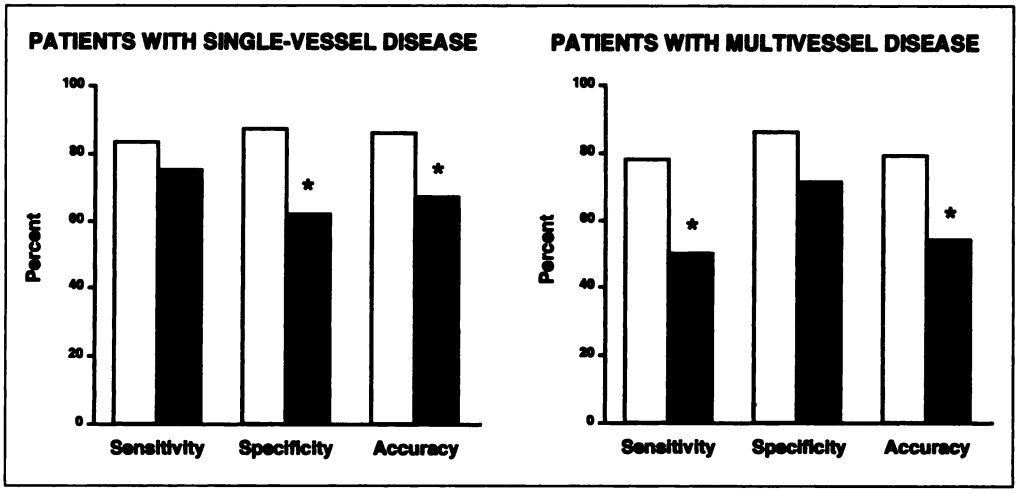

FIGURE 1. Sensitivity, specificity and diagnostic accuracy of adenosine ^{99m}Tc-tetrofosmin cardiac tomography (open bars) and adenosine echocardiography (closed bars) for detecting individual stenosed coronary artery in patients with single-vessel disease (left) and in patients with multivessel disease (right). *$p < 0.05$ versus ^{99m}Tc-tetrofosmin imaging.

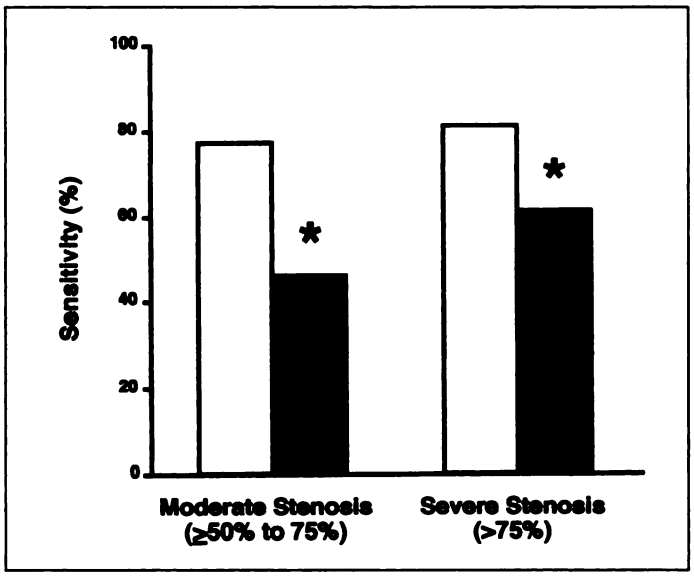

FIGURE 2. Sensitivity of adenosine ^{99m}Tc-tetrofosmin cardiac tomography (open bars) and adenosine echocardiography (closed bars) for identifying diseased vessels in vascular territories supplied by coronary arteries with moderate and severe stenosis. *$p < 0.05$ versus ^{99m}Tc-tetrofosmin imaging.

ized by the presence of perfusion defects in two or more coronary artery territories, while echocardiography correctly recognized only 46% ($p < 0.05$ versus ^{99m}Tc-tetrofosmin) of these patients.

Assessment of Reversibility

Of the 22 patients with regional hypoperfusion detected with adenosine ^{99m}Tc-tetrofosmin tomography, 18 (82%) had reversible defects. Fourteen of 17 (82%) patients with positive adenosine echocardiography had reversible regional wall motion abnormalities. Overall, quantitative analysis of ^{99m}Tc-tetrofosmin imaging in the 26 patients studied identified 29 myocardial regions with reversible hypoperfusion. This compared with 20 regions identified as showing reversible wall motion abnormalities with echocardiography (p = ns). In the 20 patients without a history of myocardial infarction, ^{99m}Tc-tetrofosmin tomography identified 24 reversibly hypoperfused regions in 14 patients compared with 14 regions with echocardiographic reversible wall motion abnormalities in 11 patients (p = ns). In the six patients with prior myocardial infarction, both ^{99m}Tc-tetrofosmin tomography and echocardiography identified five regions with reversible abnormalities in four patients.

Effects of the Severity of Coronary Artery Stenosis

The effect of the severity of stenosis on the detection of lesions is shown in Figure 2. Overall sensitivity in the identification of individual diseased vessels with moderate luminal stenosis was 77% and 46% for ^{99m}Tc-tetrofosmin tomography and echocardiography, respectively ($p < 0.05$). Moreover, overall sensitivity in the detection of individual diseased vessels with severe luminal stenosis was 81% and 61% for ^{99m}Tc-tetrofosmin tomography and echocardiography, respectively ($p < 0.05$). For both ^{99m}Tc-tetrofosmin tomography and echocardiography, sensitivity in the identification of individual diseased vessels with severe luminal stenosis was not significantly different compared with those with moderate luminal stenosis.

DISCUSSION

The results of this study demonstrate that adenosine-induced coronary vasodilation combined with quantitative ^{99m}Tc-tetrofosmin cardiac tomography is more accurate than adenosine echocardiography in the identification of patients with CAD and in the detection of individual stenosed coronary vessels.

Myocardial scintigraphy associated with pharmacological stress has been widely used for the diagnosis of CAD in patients with chest pain unable to perform an adequate dynamic exercise test (*7–10,15,16*). Pharmacological stress echocardiography has emerged as a sensitive noninvasive method for the evaluation of CAD and as a cost-effective alternative to radionuclide myocardial perfusion imaging (*28*). Among the different vasodilator pharmacological agents, adenosine has been recently used because of its short half-life so that patients do not experience prolonged ischemia after infusion, such as with dipyridamole, and because of its more rapid action so that echocardiographic imaging may be performed early after each dose increment (*29*). Previous studies demonstrated good diagnostic accuracy of adenosine test associated with myocardial perfusion imaging in the detection of CAD (*7,9,16*). Good agreement between adenosine and dynamic exercise myocardial perfusion scintigraphy with ^{201}Tl- (*8,10*) and ^{99m}Tc-labeled agents (*15,24*) also has been reported.

Technetium-99m tetrofosmin is a newly developed cationic compound for myocardial perfusion imaging showing several advantages over other available myocardial tracers (*20–24*). Previous studies in animal models and in humans suggested the validity of ^{99m}Tc-tetrofosmin as a myocardial perfusion agent over a wide range of flows produced during pharmacological stimulation (*30–32*). In particular, Sinusas et al. (*30*) demonstrated in a canine model of ischemia the reliability of this tracer, showing increased relative uptake of ^{99m}Tc-tetrofosmin in the low-flow regions resulting from more efficient tissue extraction associated with longer transit time. Dahlberg et al. (*31*) reported that the uptake of ^{99m}Tc-tetrofosmin increased linearly with flow. However, when it is administered at flow rates greater than 2 ml/min/gm, relative ^{99m}Tc-tetrofosmin activity underestimated flow (*30,31*). This property of decreased myocardial extraction at high coronary flow rates is characteristic of all diffusible perfusion tracers (*33*). This is particularly true when pharmacologic vasodilatation is used. However, it should be considered that in clinical imaging ideal conditions do not exist and other factors, such as scatter and attenuation, may influence the image quality. These points may explain why clinical studies show similar accuracy for the detection of CAD between ^{201}Tl and ^{99m}Tc-labeled agents (*13,14*). Finally, comparable myocardial uptake and retention between ^{99m}Tc-tetrofosmin and ^{99m}Tc-sestamibi in humans also were shown (*32*). Thus, ^{99m}Tc-tetrofosmin tomography associated with a powerful vasodilator, such as adenosine, appears to be a suitable tool to assess CAD in patients unable to perform an adequate dynamic exercise test (*24*). In this study we compared in the same group of patients the diagnostic accuracy of adenosine ^{99m}Tc-tetrofosmin tomography and echocardiography in the identification of patients with CAD and in the localization of individual stenosed coronary vessels.

Our data demonstrate that adenosine ^{99m}Tc-tetrofosmin tomography has higher sensitivity than adenosine echocardiography in identifying patients with CAD. These results are concordant with those obtained in previous studies performed with other myocardial perfusion agents and confirm that adenosine cardiac tomography is more accurate than adenosine echocardiography in detecting CAD (*18,19,34*). There are some possible explanations for the better diagnostic capability of adenosine ^{99m}Tc-tetrofosmin tomography as compared to echocardiography. First, myocardial regions supplied by stenosed coronary vessel present less hyperemia than those

supplied by normal arteries, so that perfusion defects may occur early (*28*). On the contrary, the development of more pronounced ischemia is needed to provoke regional wall motion abnormalities detectable by echocardiography (*28*). In addition, the lower diagnostic accuracy of adenosine echocardiography also could be partially due to technical problems, individual expertise and difficulties to evaluate suboptimal images resulting from poor echogenicity that may be present in some patients. Seven of the 26 patients included in this study have been reported previously as part of a different protocol performed in our laboratory (*24*), directly comparing the results of adenosine and bicycle dynamic exercise ^{99m}Tc-tetrofosmin tomography. The findings of that study demonstrated that, despite different hemodynamic effects, adenosine and exercise ^{99m}Tc-tetrofosmin imaging provide similar information in the diagnosis and localization of CAD (*24*).

Overall sensitivity, specificity and diagnostic accuracy of adenosine ^{99m}Tc-tetrofosmin tomography in the detection of individual stenosed coronary vessels were higher than those of adenosine echocardiography in patients with single-vessel involvement and in those with multivessel disease. The prediction of multivessel CAD was significantly higher on the basis of the presence of multiple perfusion defects on adenosine ^{99m}Tc-tetrofosmin tomography as compared to the results of adenosine echocardiography. These findings may have important clinical implications and are in agreement with previous reports showing higher value of radionuclide myocardial perfusion imaging compared to stress echocardiography in the correct identification of patients with multivessel CAD (*28*).

There are some limitations in this study. The first is the lack of computer quantitation of coronary angiography. However, even with quantitative coronary arteriography there may be discordance between physiology and anatomy (*35*). Second, only one patient had a normal coronary angiogram and, because patients with a low likelihood of CAD were not studied, the true normalcy rate was not assessed. Furthermore, because of the selection of study patients from the cardiac catheterization laboratory, 23% of patients had experienced prior infarction and the majority of coronary stenosis were severe. This potentially could lead to an overestimation of sensitivity for these methods compared with their application in more general populations. However, it should be considered that the aim of our study was not to evaluate the true diagnostic potential of these imaging techniques associated with adenosine test but to compare their results directly in the same patients with angiographically documented CAD.

CONCLUSION

This study demonstrates that adenosine-induced maximal coronary vasodilatation associated with quantitative ^{99m}Tc-tetrofosmin cardiac tomography is more accurate than adenosine two-dimensional echocardiography to identify patients with CAD and localize individual stenosed coronary vessels.

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