Long-term Prognostic Value of Dobutamine Stress ^{99m}Tc-Sestamibi SPECT: Single-Center Experience with 8-year Follow-up[1]

Arend F. L. Schinkel, MD
Abdou Elhendy, MD
Ron T. van Domburg, PhD
Jeroen J. Bax, MD
Roelf Valkema, MD
Jos R. T. C. Roelandt, MD
Don Poldermans, MD

Index terms:
Heart, abnormalities, 51.771
Heart, SPECT, 51.12119

Published online before print
10.1148/radiol.2253020053
Radiology 2002; 225:701–706

Abbreviations:
ECG = electrocardiography
MI = myocardial infarction
SSS = summed stress score

[1] From the Departments of Cardiology (A.F.L.S., A.E. R.T.v.D., J.R.T.C.R., D.P.) and Nuclear Medicine (R.V.), Erasmus Medical Center Rotterdam, Dr Molewaterplein 40, Thoraxcenter Rm Ba 300, 3015 GD Rotterdam, the Netherlands, and the Department of Cardiology, Leiden University Medical Center, the Netherlands (J.J.B.). Received February 14, 2002; revision requested March 7; revision received May 6; accepted June 25. **Address correspondence to** D.P. (e-mail: *poldermans@hlkd.azr.nl*).

Author contributions:
Guarantors of integrity of entire study, A.F.L.S., J.R.T.C.R., D.P.; study concepts, all authors; study design, A.F.L.S., A.E., R.T.v.D., J.R.T.C.R., D.P., R.V.; literature research, A.F.L.S., A.E.; clinical studies, A.F.L.S., A.E., D.P., R.V.; data acquisition, R.T.v.D., R.V.; data analysis/interpretation, A.F.L.S., A.E., R.T.v.D., D.P., R.V.; statistical analysis, R.T.v.D.; manuscript preparation, A.F.L.S., A.E., D.P.; manuscript definition of intellectual content, all authors; manuscript editing, J.R.T.C.R., D.P., A.E., R.V.; manuscript revision/review, A.E., J.J.B., J.R.T.C.R., D.P., R.V.; manuscript final version approval, all authors.

PURPOSE: To determine the long-term prognostic value of dobutamine stress technetium 99m (^{99m}Tc)-labeled sestamibi single photon emission computed tomography (SPECT) in patients with limited exercise capacity.

MATERIALS AND METHODS: Clinical data and SPECT results were analyzed in 531 consecutive patients. Follow-up was successful in 528 (99.4%) patients; 55 underwent early revascularization and were excluded. Normal or abnormal findings were considered in the absence or presence of fixed and/or reversible perfusion defects. A summed stress score was calculated to estimate the extent and severity of perfusion defects. Univariate and multivariate Cox proportional hazards regression models were used to identify independent predictors of late cardiac events. The incremental value of myocardial perfusion scintigraphy over clinical variables in predicting events was determined according to two models. The probability of survival was calculated by using the Kaplan-Meier method.

RESULTS: Findings were abnormal in 312 patients. During 8.0 years ± 1.5 of follow-up (range, 4.5–10.6 years), cardiac death occurred in 67 patients (total deaths, 165); nonfatal myocardial infarction, in 34; and late revascularization, in 49. The annual rates for cardiac death, cardiac death or infarction, and all events were 0.9%, 1.2%, and 1.5%, respectively, after normal findings and 2.7%, 3.4%, and 4.4%, respectively, after abnormal findings ($P < .05$). In a multivariable Cox proportional hazards model, not only an abnormal finding but also the summed stress score provided incremental prognostic information in addition to clinical data. The hazard ratio for cardiac death was 1.09 (95% CI: 1.01, 1.18) per 1-unit increment of the summed stress score.

CONCLUSION: The incremental prognostic value of dobutamine stress ^{99m}Tc-sestamibi SPECT over clinical data was maintained over an 8-year follow-up in patients with limited exercise capacity.

The primary goal of risk stratification in patients suspected of having or known to have coronary arterial disease is to distinguish patients at high risk of the disease who may benefit from further invasive strategies from low-risk patients who do not require further invasive evaluation. Myocardial perfusion imaging with administration of technetium 99m (^{99m}Tc)-labeled sestamibi during dobutamine-induced patient stress provides useful information for risk stratification and determination of optimal clinical management (1–3). The investigators in multiple studies (4–7) have reported the prognostic value of ^{99m}Tc-sestamibi myocardial perfusion imaging in various patient subsets at short- to intermediate-term follow-up. To overcome reduced exercise capacity and therefore insufficient testing, various types of non–exercise-dependent pharmacologic stressors, such as adenosine and dobutamine, were developed in conjunction with myocardial perfusion imaging.

However, it is important to note that to our knowledge, no findings of long-term prognostic studies involving ^{99m}Tc-sestamibi myocardial perfusion imaging are currently available (1–7). The purpose of our study was to determine the long-term prognostic value of dobutamine stress ^{99m}Tc-sestamibi SPECT findings in patients with limited exercise capacity.

MATERIALS AND METHODS

Study Population

The study population comprised 531 consecutive patients with limited exercise capacity who were referred between 1990 and 1995 for dobutamine stress ^{99m}Tc-sestamibi SPECT for the evaluation of suspected or known coronary arterial disease. Follow-up was successful in 528 (99.4%) of 531 patients. Fifty-five patients underwent early coronary revascularization (35 with coronary arterial bypass graft placement and 20 with percutaneous transluminal coronary angioplasty) 60 days after scintigraphy and were excluded from analysis. In these patients, the decision to revascularize had already been made, and the test was performed as part of a research protocol. As a result, prognostic data reported are based on 473 patients. All patients gave informed consent before testing. The local medical ethics committee approved the study protocol.

In all patients, a structured interview was performed and a clinical history obtained, including assessment of cardiac risk factors, prior to dobutamine stress testing. Hypertension was defined as blood pressure of 140/90 mm Hg or greater or treatment with antihypertensive medication. Diabetes mellitus was defined as a fasting glucose level of 7.8 mmol/L or higher or the need for insulin or oral hypoglycemic agents. Hypercholesterolemia was defined as a total cholesterol level of 6.4 mmol/L or higher or as treatment with lipid-lowering medication.

Dobutamine Stress Protocol

Stress testing after dobutamine administration was performed as described previously (8). Dobutamine hydrochloride (Dobutamine; Centrafarm Services, Eten-Leur, the Netherlands) was injected intravenously, first at a dose of 10 μg per kilogram of body weight per minute for 3 minutes; the dose was then increased by 10 μg/kg/min every 3 minutes up to a maximum dose of 40 μg/kg/min. If the test end point was not reached at a dobutamine dose of 40 μg/kg/min, up to 1 mg of atropine sulfate (Atropine; Centrafarm Services) was administered intravenously. Blood pressure, heart rate, and electrocardiographic (ECG) findings were continuously monitored. Test end points were achievement of target heart rate (85% of maximum age and sex-predicted heart rate); horizontal or downsloping ST segment depression of more than 2 mm at an interval of 80 msec after the J point, as compared with the baseline measurement; ST segment elevation greater than 1 mm in patients without previous myocardial infarction (MI); severe angina; systolic blood pressure decrease greater than 40 mm Hg, as compared with the baseline measurement; blood pressure higher than 240/120 mm Hg; or clinically important cardiac arrhythmias. Intravenously administered metoprolol tartrate (Metoprolol, Selokeen IV; AstraZeneca, Zoetermeer, the Netherlands) was available to reverse the side effects of dobutamine, and atropine was used if the effects did not revert spontaneously after termination of dobutamine infusion. Side effects were registered, and the relationship between cardiac arrhythmias during testing and subsequent cardiac events was evaluated.

SPECT Image Acquisition and Interpretation

A dose of 370 MBq of ^{99m}Tc-sestamibi (Cardiolite; Bristol-Myers Squibb Pharma Belgium, Brussels, Belgium) was administered intravenously approximately 1 minute prior to termination of the stress test. For studies performed with the patient at rest, 370 MBq of sestamibi was injected at least 24 hours after the stress test. Images were acquired with a Gammasonics single-head Rota camera (Orbiter; Siemens, Iselin, NJ) without attenuation or scatter correction, by using a low-energy all-purpose collimator. Thirty-two projections were obtained over a 180° arc, from left posterior oblique to right anterior oblique, with an acquisition time of 45 seconds per projection. Data were collected in a 64 × 64 matrix (word mode), and images were reconstructed by using a filtered backprojection algorithm and a ramp reconstruction filter. Transverse images were reconstructed by using a software package (SPETS; Nuclear Diagnostics, Hägersten, Sweden). From the three-dimensional data, oblique (short-axis) and sagittal (vertical long-axis) images obtained perpendicular and parallel to the long axis, respectively, were reconstructed. For each study, six oblique sections were defined from the apex to the base, and three sagittal sections were defined. Each of the six short-axis sections was divided into eight equal segments. The septal part of the two basal sections was excluded from analysis because this region corresponds to the fibrous portion of the interventricular septum and normally exhibits reduced uptake. Therefore, a total of 47 segments were identified (three long axis and 44 short axis). Scans were semiquantitatively interpreted by using visual analysis assisted by circumferential profile analysis. Profile curves 2.5 SDs below normal perfusion were considered abnormal.

Images obtained at stress and rest were reviewed side by side at a computer display with consensus reading by two experienced observers who were unaware of the patients' clinical data. In case of disagreement, a majority decision was achieved by consulting a third observer. In this study, the original interpretations of the images were used. A reversible perfusion defect was defined as a perfusion defect on stress images that partially or completely resolved at rest on two or more contiguous segments or sections in the 47-segment model. A fixed perfusion defect was defined as a perfusion defect on stress images on two or more contiguous segments or sections that persisted on rest images in the 47-segment model. Findings were designated as abnormal in the presence of a fixed and/or reversible perfusion defect.

To assess the severity of perfusion abnormalities, the left ventricular myocardium was divided into six segments: anterior, inferior, septal anterior, septal posterior, posterolateral, and apical. Each of the six major left ventricular segments was assigned a score by using a four-point system: 0, normal (100% ≥ tracer activity > 75%); 1, slightly reduced (75% ≥ tracer activity > 50%); 2, moderately reduced (50% ≥ tracer activity > 25%); or 3, severely reduced or absent uptake (25% ≥ tracer activity ≥ 0%). A summed stress score (SSS) was obtained by adding the scores of the six myocardial segments during stress. The SSS incorporates the extent and severity of a perfusion defect.

Follow-up

Follow-up data were collected in 2001. One author (A.F.L.S.) contacted patients' general practitioners and/or reviewed hospital records. This author was blinded to scanning results. The date of the last examination or consultation was used to determine follow-up. The mean follow-up was 8.0 years ± 1.4 (range, 4.5–10.6 years). End points were overall deaths (death from all

TABLE 1
Characteristics of Study Population

Characteristic	No. of Patients (n = 473)
Male sex	273 (58)
Hypertension	214 (45)
Diabetes mellitus	69 (15)
Smoking	122 (26)
Hypercholesterolemia	116 (25)
Congestive heart failure	84 (18)
Beta-blocker use	185 (39)
Prior MI	210 (44)
Prior revascularization	
Surgical	92 (19)
Percutaneous	75 (16)

Note.—The mean patient age was 61 years ± 12. Numbers in parentheses are percentages.

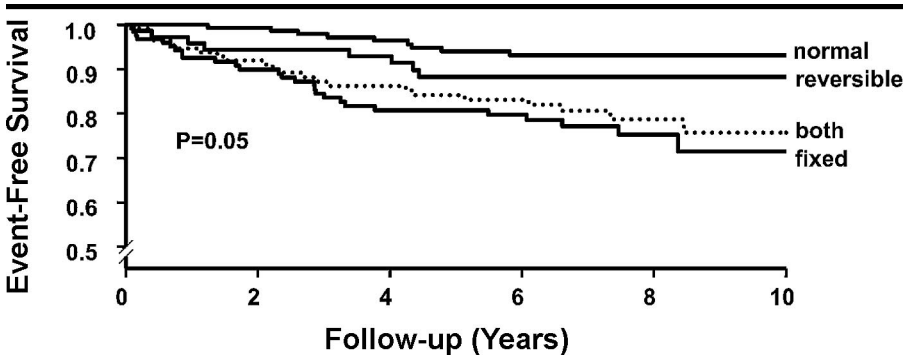

Figure 1. Kaplan-Meier survival curves for cardiac death according to results of dobutamine stress ^{99m}Tc-sestamibi SPECT. The curves indicate that patients with normal stress images maintained a low event rate up to 8 years after stress testing.

causes), cardiac death, nonfatal MI, or late (>60 days) coronary revascularization. Cardiac death was defined as death caused by acute MI, clinically important cardiac arrhythmias, or refractory congestive heart failure, together with ECG and autopsy results, when available. Sudden death occurring without another explanation was included as cardiac death. Cardiac enzyme levels and ECG changes were used to define nonfatal MI. Patients were censored at the time of late coronary revascularization.

Statistical Analysis

Values were expressed as means ± SDs or numbers and were compared by using the Student t test or χ^2 test. Univariate and multivariate Cox proportional hazards regression models (BMDP Statistical Software, Los Angeles, Calif) were used to identify independent predictors of late cardiac events (9). Variables were selected in a stepwise forward selection manner, with entry and retention set with a P value of .05 considered to indicate a significant difference. A variable's risk was expressed as a hazard ratio with a corresponding 95% CI. The incremental value of myocardial perfusion scintigraphy over the clinical variables in the prediction of events was calculated according to two models. In model 1, the only scanning variable entered was an abnormal finding. In model 2, scanning variables, including SSS and the presence of a fixed or reversible defect, were entered. The probability of survival was calculated by using the Kaplan-Meier method, and survival curves were compared by using the log-rank test. A P value less than .05 was considered to indicate a statistically significant difference.

RESULTS

Patient Demographics and Stress Testing Results

The characteristics of the 473 patients (273 men; mean age, 61 years ± 12 [SD]) are presented in Table 1. There was a significant increase in heart rate (70 beats per minute ± 14 to 136 beats per minute ± 17, $P < .001$) and systolic blood pressure (140 mm Hg ± 23 to 146 mm Hg ± 31, $P < .001$) during dobutamine stress testing. The highest dobutamine dose was 10 $\mu g \cdot kg^{-1} \cdot min^{-1}$ in three (1%) patients, 20 $\mu g \cdot kg^{-1} \cdot min^{-1}$ in 15 (3%), 30 $\mu g \cdot kg^{-1} \cdot min^{-1}$ in 66 (14%), and 40 $\mu g \cdot kg^{-1} \cdot min^{-1}$ in 389 (82%). In 196 (41%) patients, atropine was added. Patients who were receiving beta blockers (120 [65%] of 185) more frequently received atropine than those who were not receiving beta blockers (76 [26%] of 288, $P < .001$). Test findings were inconclusive (failure to achieve target heart rate in the absence of perfusion abnormalities) in 43 (9%) patients. Prognostic data reported were based on 473 patients, including the 43 who did not achieve the target heart rate. No patient experienced MI or ventricular fibrillation. Side effects were atrial fibrillation in five (1%) patients, short ventricular tachycardia (<10 complexes) in 19 (4%), severe hypotension (decrease in systolic blood pressure > 40 mm Hg) in three (0.6%), and severe hypertension (blood pressure > 240/130 mm Hg) in three (0.6%). Minor side effects included nausea in 18 (4%), chills in 22 (5%), and headache in 29 (6%). No relationship was observed between cardiac arrhythmias during the test and subsequent cardiac events; the hazard ratio was 1.3 (range, 0.8–2.0).

SPECT and Follow-up Results

SPECT images were abnormal in 312 (66%) of 473 patients. Perfusion abnormalities were reversible in 72 (15%), fixed in 126 (27%), and both fixed and reversible (or partially reversible) in 114 (24%) patients. During follow-up, 165 (35%) deaths occurred, of which 67 (41%) were due to cardiac causes. Nonfatal MI occurred in 34 (7%) patients. Forty-nine (10%) patients underwent late (>60 days) coronary revascularization (coronary arterial bypass graft placement, 28 patients; percutaneous transluminal coronary angioplasty, 21 patients). All 49 patients had abnormal SPECT findings, and 43 (88%) of the 49 had reversible perfusion defects.

Predictive Value of Clinical Data and Test Results

Univariate and multivariate predictors of cardiac events are presented in Tables 2 and 3. The annual event rates for cardiac death, cardiac death or nonfatal MI, and all events were 0.9%, 1.2%, and 1.5%, respectively, for patients with normal findings and 2.7%, 3.4%, and 4.4% for patients with abnormal findings. Kaplan-Meier survival curves are presented in Figures 1–3. The survival curves indicate that patients with normal sestamibi SPECT findings after induced stress maintained a low event rate up to 8 years after stress testing. Figure 4 demonstrates the incremental prognostic value of dobutamine stress sestamibi SPECT findings over clinical data. An abnormal perfusion pattern, as well as the SSS, provided additional incremental prognostic information. The hazard ratio for cardiac death was 1.09 (range, 1.01–1.18) per 1-unit increment of the SSS. There was no further

TABLE 2
Predictors of Cardiac Death at Univariate and Multivariate Analysis

Predictors	Univariate Analysis	Multivariate Analysis		
		Clinical Data	Model 1	Model 2
Clinical characteristics				
Age*	1.03 (1.01, 1.06)	1.03 (1.01, 1.05)	1.02 (1.01, 1.04)	1.03 (1.01, 1.05)
Male sex	2.4 (1.4, 4.1)	2.5 (1.6, 3.9)	2.1 (1.3, 3.3)	2.3 (1.4, 3.6)
Prior MI	2.0 (1.2, 3.3)	NS	NS	NS
Diabetes mellitus	2.3 (1.3, 4.0)	1.8 (1.1, 2.8)	1.7 (1.1, 2.7)	1.7 (1.1, 2.8)
Hypertension	0.7 (0.4, 1.2)	NS	NS	NS
Hypercholesterolemia	0.9 (0.5, 1.5)	NS	NS	NS
Typical angina	1.1 (0.6, 1.9)	NS	NS	NS
Smoking	1.6 (0.9, 2.6)	NS	NS	NS
Congestive heart failure	4.7 (2.9, 7.6)	2.1 (1.4, 3.2)	1.9 (1.2, 2.8)	1.7 (1.1, 2.7)
Stress test results				
Typical angina	1.0 (0.6, 1.7)	NA	NS	NS
ST segment changes	1.5 (0.9, 2.5)	NA	NS	NS
Scanning parameters				
Abnormal scan	3.4 (1.7, 6.8)	NA	2.1 (1.2, 3.7)	NA
SSS*	1.22 (1.13, 1.32)	NA	NA	1.09 (1.01, 1.18)
Fixed defect	1.8 (1.1, 2.9)	NA	NA	NS
Reversible defect	1.2 (0.8, 2.0)	NA	NA	NS

Note.—Values are Cox proportional hazards ratios; numbers in parentheses are 95% CIs. In model 1, the only scanning variable entered was the presence of an abnormal scan. In model 2, the SSS and the presence of a fixed or reversible defect were included. NA = not applicable, NS = not significant.

* Per 1-unit increment; indicates variable excluded.

TABLE 3
Predictors of Cardiac Events (cardiac death, nonfatal MI, or revascularization) at Univariate and Multivariate Analysis

Predictors	Univariate Analysis	Multivariate Analysis		
		Clinical Data	Model 1	Model 2
Clinical characteristics				
Age*	1.02 (1.00, 1.04)	1.03 (1.01, 1.05)	1.02 (1.01, 1.04)	1.03 (1.01, 1.05)
Male sex	2.5 (1.6, 3.8)	2.5 (1.6, 3.9)	2.1 (1.3, 3.3)	2.3 (1.4, 3.6)
Prior MI	2.2 (1.5, 3.2)	NS	NS	NS
Diabetes mellitus	1.9 (1.2, 3.0)	1.8 (1.1, 2.8)	1.7 (1.1, 2.7)	1.7 (1.1, 2.8)
Hypertension	0.7 (0.5, 1.1)	NS	NS	NS
Hypercholesterolemia	1.1 (0.7, 1.7)	NS	NS	NS
Typical angina	1.1 (0.7, 1.7)	NS	NS	NS
Smoking	1.2 (0.8, 1.9)	NS	NS	NS
Congestive heart failure	2.7 (1.8, 4.1)	2.1 (1.4, 3.2)	1.9 (1.2, 2.8)	1.7 (1.1, 2.7)
Stress test results				
Typical angina	1.1 (0.7, 1.6)	NA	NS	NS
ST segment changes	1.6 (0.8, 1.8)	NA	NS	NS
Scanning parameters				
Abnormal scan	3.2 (1.9, 5.4)	NA	2.1 (1.2, 3.7)	NA
SSS*	1.17 (1.10, 1.25)	NA	NA	1.09 (1.01, 1.18)
Fixed defect	1.4 (1.0, 2.1)	NA	NA	NS
Reversible defect	1.4 (1.0, 2.1)	NA	NA	NS

Note.—Values are expressed as Cox proportional hazards ratios and 95% CIs. In model 1, the only scanning variable entered was the presence of an abnormal scan. In model 2, the SSS and the presence of a fixed or reversible defect were included. NA = not applicable, NS = not significant.

* Per 1-unit increment, indicates variable excluded.

increase of the hazard ratio if the SSS was greater than 9.

DISCUSSION

Risk stratification in patients known to have or suspected of having coronary arterial disease is essential for optimal clinical decision making (10). The prognostic value of imaging during stress and after administration of technetium has been reported in various patient subsets at short-to intermediate-term follow-up (2-7). The mean follow-up in the current study was 8.0 years ± 1.4, as compared with an average follow-up of 0.8–3.6 years after exercise and 0.8–2.3 years after myocardial perfusion imaging with sestamibi during pharmacologic stress among previous studies (2–7). The main finding from the current study was that the prognostic value of dobutamine stress ^{99m}Tc-sestamibi SPECT was maintained at long-term follow-up. Univariate and multivariate Cox proportional regression analysis demonstrated that sestamibi SPECT provided incremental prognostic information in addition to clinical and stress test parameters through a nearly complete 8-year follow-up period. Patients with normal examination find-

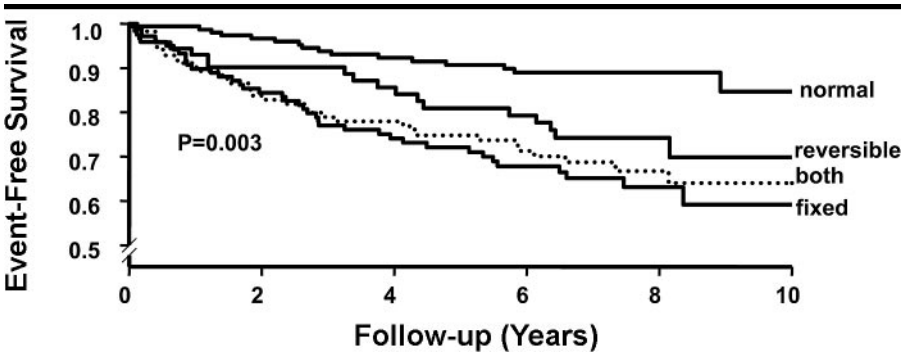

Figure 2. Kaplan-Meier survival curves for cardiac events (cardiac death, nonfatal MI, or revascularization), according to results of dobutamine stress ^{99m}Tc-sestamibi SPECT. The annual cardiac event rate was significantly lower in patients with normal perfusion.

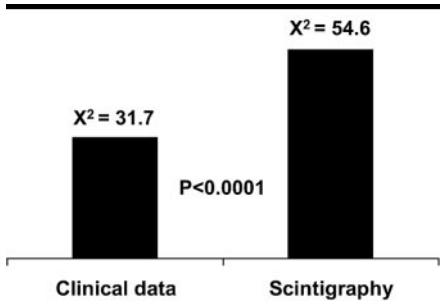

Figure 3. Bar graph shows incremental prognostic value of dobutamine stress ^{99m}Tc-sestamibi SPECT over clinical data. Dobutamine stress ^{99m}Tc-sestamibi SPECT provided significant prognostic information in addition to clinical data alone.

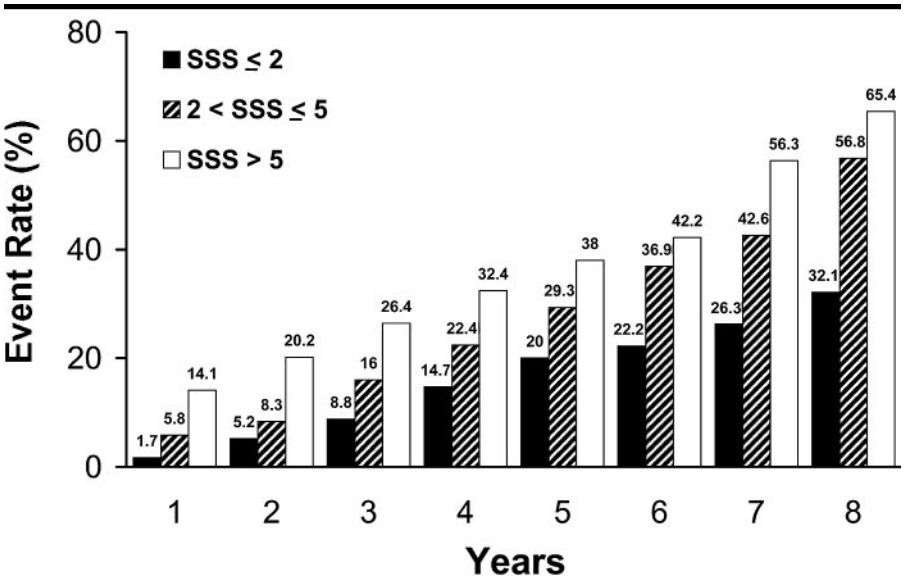

Figure 4. Bar graph shows cumulative cardiac event (cardiac death, nonfatal MI, or revascularization) rates per year according to SSS. An abnormal perfusion pattern, as well as the SSS, provided additional incremental prognostic information.

ings had a good long-term prognosis, and in contrast, patients with abnormal findings had an increased risk of future cardiac events. An abnormal perfusion pattern, as well as SSS, provided additional incremental prognostic information.

Long-term Prognostic Value

Although the findings of long-term prognostic studies are currently not available, the medium-term prognostic value of dobutamine stress sestamibi SPECT has been reported in several studies (4–7). Geleijnse et al (4) examined 392 patients, with a median follow-up of 22 months ± 13. Twenty-seven (7%) patients died of cardiac-related causes during follow-up, 17 (4%) had nonfatal MIs, and 34 (9%) underwent late coronary revascularization. The hard cardiac event (cardiac death or nonfatal MI) rates were 0.8% per year in patients with normal examination findings and 9.2% per year in those with abnormal dobutamine stress sestamibi SPECT scintigraphic findings.

The medium-term prognosis of women with chest pain and normal dobutamine stress sestamibi SPECT images is excellent (5). None of the study population of 80 women died or had a nonfatal MI during the follow-up of 23 months ± 13. Senior et al (6) followed up 61 patients undergoing coronary angiography and dobutamine stress sestamibi SPECT for 19 months ± 11. There were two (3%) deaths, two (3%) nonfatal MIs, 13 (21%) cases of unstable angina, and three (5%) cases of congestive heart failure during follow-up. The event rate was 3% in patients with normal results and 44% in patients with abnormal results. Recently, Calnon et al (7) studied 308 patients at high risk for cardiac events who underwent dobutamine stress sestamibi SPECT. During an average follow-up of 1.9 years ± 1.1, 15 patients died of cardiac causes and 18 had MIs. Event rates were 10.0% in patients with abnormal SPECT images and 2.3% in those with normal results.

The findings of the present study extend the conclusions drawn from the four medium-term prognostic studies (4–7). In the current study population of 473 patients, the prognostic value of dobutamine stress sestamibi SPECT imaging was maintained over an 8-year period. The event rates for cardiac death, cardiac death or nonfatal MI, and all events were, respectively, 0.9%, 1.2%, and 1.5% per year for patients with normal results and 2.7%, 3.4%, and 4.4% per year for those with abnormal results. Moreover, Kaplan-Meier survival curves continued to diverge over time, whereas the curve for patients with normal SPECT findings showed favorable event-free survival, indicating that the prognostic value was maintained during the entire follow-up period. This is particularly relevant, since some investigators have recently suggested that the "warranty" period for normal findings of sestamibi imaging after stress appears to be 2 years (2). In contrast, findings of the present study indicate that patients with normal findings of sestamibi imaging after stress have a durable good prognosis up to 8 years after index stress testing. The annual event rate for cardiac death

or nonfatal MI in patients with normal scintigraphic results was comparable with the event rate in the general population. Hence, patients with normal SPECT images can be spared further invasive evaluation of their coronary anatomy. However, the clinical value and optimal intervals of periodic stress testing in these patients deserve further investigation.

Incremental Prognostic Value

In this study, a multivariate Cox regression model demonstrated that dobutamine stress sestamibi SPECT had an incremental prognostic value in addition to prognostic information from clinical data and stress testing. This is in agreement with the findings obtained in long-term follow-up studies in which thallium 201 SPECT was used to stratify patients (10–14). Independent clinical predictors of cardiac events were age, male sex, diabetes mellitus, and congestive heart failure. Typical angina was not independently predictive of events, perhaps because of diminished physical activity in a population with a limited exercise capacity. The incremental value of myocardial perfusion scintigraphy over the clinical variables in the prediction of events was determined according to two models: In the first model, abnormal findings were a powerful independent scintigraphic predictor of future cardiac events. The second model demonstrated that the SSS was additive to clinical parameters and to hemodynamic and ECG parameters. This indicates that the long-term prognosis is related not only to the presence but also to the extent and severity of perfusion defects on dobutamine stress sestamibi SPECT scans.

Limitations

The diagnostic value of dobutamine stress sestamibi SPECT was high; however, 9% of patients had inconclusive findings (failure to achieve the target heart rate or to demonstrate a perfusion abnormality). Therefore, the diagnostic and perhaps the prognostic value could have been even higher if beta-blocker medication had been routinely withheld before stress testing.

In conclusion, the incremental prognostic value of dobutamine stress ^{99m}Tc-sestamibi SPECT findings over clinical data is maintained at long-term follow-up. Patients with normal test results have a good long-term prognosis and thus may not require further invasive evaluation.

References

1. Beller GA, Zaret BL. Contributions of nuclear cardiology to diagnosis and prognosis of patients with coronary artery disease. Circulation 2000; 101:1465–1478.
2. Iskander S, Iskandrian AE. Risk assessment using single-photon emission computed tomographic technetium-99m sestamibi imaging. J Am Coll Cardiol 1995; 26:639–647.
3. Geleijnse ML, Elhendy A, Fioretti PM, Roelandt JRTC. Dobutamine stress myocardial perfusion imaging. J Am Coll Cardiol 2000; 36:2017–2027.
4. Geleijnse ML, Elhendy A, Van Domburg RT, et al. Prognostic value of dobutamine-atropine stress technetium-99m sestamibi perfusion scintigraphy in patients with chest pain. J Am Coll Cardiol 1996; 28: 447–454.
5. Geleijnse ML, Elhendy A, Van Domburg RT, Cornel JH, Reijs AEM, Fioretti PM. Prognostic significance of normal dobutamine-atropine stress sestamibi scintigraphy in women with chest pain. Am J Cardiol 1996; 77:1057–1061.
6. Senior R, Raval U, Lahiri A. Prognostic value of stress dobutamine technetium-99m sestamibi single-photon emission computed tomography (SPECT) in patients with suspected coronary disease. Am J Cardiol 1996; 78:1092–1096.
7. Calnon DA, McGrath PD, Doss AL, Harrell FE, Watson DD, Beller GA. Prognostic value of dobutamine stress technetium-99m-sestamibi single-photon emission computed tomography myocardial perfusion imaging: stratification of a high-risk population. J Am Coll Cardiol 2001; 38: 1511–1517.
8. Elhendy A, Valkema R, van Domburg RT, et al. Safety of dobutamine-atropine stress myocardial perfusion scintigraphy. J Nucl Med 1998; 39:1662–1666.
9. Cox DR. Regression models and life-tables. J R Stat Soc B 1972; 34:187–202.
10. Brown KA. Prognostic value of thallium-201 myocardial perfusion imaging: a diagnostic tool comes of age. Circulation 1991; 83:363–381.
11. Vanzetto G, Ormezzano O, Fagret D, Comet M, Denis B, Machecourt J. Long-term additive prognostic value of thallium-201 myocardial perfusion imaging over clinical and exercise stress test in low to intermediate risk patients: study in 1137 patients with 6-year follow-up. Circulation 1999; 100:1521–1527.
12. Pavin D, Delonca J, Siegenthaler M, Doat M, Rutishauser W, Righetti A. Long-term (10 years) prognostic value of a normal thallium-201 myocardial exercise scintigraphy in patients with coronary artery disease documented by angiography. Eur Heart J 1997; 18:69–77.
13. Steinberg EH, Koss JH, Lee M, Grunwald AM, Bodenheimer MM. Prognostic significance from 10-year follow-up of a qualitatively normal planar exercise thallium test in suspected coronary artery disease. Am J Cardiol 1993; 71:1270–1273.
14. Marie PY, Danchin N, Durand JF, et al. Long-term prediction of major ischemic events by exercise thallium-201 single-photon emission computed tomography: incremental prognostic value compared with clinical, exercise testing, catheterization and radionuclide angiographic data. J Am Coll Cardiol 1995; 26:879–886.