Role of Dobutamine Stress Echocardiography in Predicting Outcome in 860 Patients With Known or Suspected Coronary Artery Disease

Seng-Chye Chuah, MD; Patricia A. Pellikka, MD; Veronique L. Roger, MD; Robert B. McCully, MD; James B. Seward, MD

Background—Increasingly, dobutamine stress echocardiography has been used for detection of coronary artery disease. Less information exists regarding the incremental prognostic value of the test, including semiquantitative wall scoring, compared with clinical and rest echocardiographic variables.

Methods and Results—Follow-up information was obtained from 860 patients who underwent dobutamine stress echocardiography over a 2-year period. To determine the value of dobutamine stress echocardiography in predicting cardiac events, including cardiac death and myocardial infarction, clinical and rest and stress echocardiographic data were considered in a stepwise Cox multivariate regression model. During follow-up of up to 52 months, 72 patients underwent coronary revascularization before any cardiac event and were censored. Eighty-six patients had cardiac events, including nonfatal myocardial infarction in 36 and cardiac death in 50. In a multivariate model, a history of congestive heart failure, the percentage of abnormal segments at peak stress, and an abnormal left ventricular end-systolic volume response to stress were independent predictors of cardiac events. The model that best predicted subsequent cardiac events included clinical and stress echocardiographic data.

Conclusions—Dobutamine stress echocardiography with semiquantitative segmental wall scoring provides important incremental information in predicting subsequent cardiac events. (Circulation. 1998;97:1474-1480.)

Key Words: coronary disease ★ echocardiography ★ prognosis ★ stress

Dobutamine stress echocardiography has increasingly been used for the diagnosis of coronary artery disease in patients who are unable to perform exercise testing.1-5 Several recent studies have examined the role of dobutamine stress echocardiography as a predictor of patient outcomes6-11 and as a predictor of cardiac events in patients undergoing major vascular surgery.12,13 Less information exists about the incremental prognostic value of the test compared with clinical and rest echocardiographic variables.

This study was undertaken to assess the role of dobutamine stress echocardiography in predicting cardiac events, including myocardial infarction and cardiac death, in 860 patients with known or suspected coronary artery disease. The incremental value of the results of dobutamine stress echocardiography, after consideration of clinical and rest echocardiographic variables, was assessed.

Methods

Patient Population

From January 1991 through December 1992, 863 patients underwent clinically indicated dobutamine stress echocardiography. Follow-up data were obtained for 860 patients (99.7%). Cardiovascular risk factors and clinical status were recorded at the time of dobutamine stress echocardiography. Prior myocardial infarction was determined from the history or the presence of significant Q waves. Patients were considered to have hypercholesterolemia if their total cholesterol value was $\geq 200 \text{ mg/dL}$ or if they were receiving cholesterol-lowering medication.

Dobutamine Stress Echocardiography

Dobutamine stress echocardiography was performed according to a previously described protocol1; the peak dosage used was 40 $\mu$g · kg$^{-1}$ · min$^{-1}$. Atropine, in doses of 0.25 mg to a total dose of 2 mg, was administered intravenously as needed to augment the heart rate. Ejection fraction was measured with a modification of the method of Quinones et al14 or by visual estimation.15 Wall motion at rest and at peak stress was scored 1 through 5, according to the 16-segment model of the American Society of Echocardiography.16 The development of new or worsening wall motion abnormality, including a deterioration of wall motion after improvement at low-dose dobutamine, was considered indicative of myocardial ischemia. Ischemic threshold, defined as the heart rate at which ischemia was first noted, was recorded. An akinetic segment that never improved but became dyskinetic was classified as a fixed wall motion abnormality indicative of myocardial infarction.17 A wall motion abnormality present at rest and unchanged with stress also was classified as a fixed wall motion abnormality. Dobutamine test results were defined as abnormal if there was ischemia or fixed wall motion abnormality. The percentages of segments that were abnormal at rest and at peak stress were calculated as abnormal segments divided by 16 segments times 100%. The percentage of segments that showed fixed wall motion abnormalities and the percentage of segments that showed ischemia were calculated similarly. The change in end-systolic volume from rest to peak stress was recorded as normal (decrease in left ventricular end-systolic volume) or abnormal (increase in left ventricular
end-systolic volume or absence of a decrease). The stress ECG was positive for ischemia if there was horizontal or downsloping ST-segment depression of ≥1 mm at 80 ms after the J point.

To assess interobserver variability for interpretation of regional wall motion and assessment of left ventricular end-systolic volume response, two independent observers scored regional wall motion at rest and with stress and assessed end-systolic volume response in a sample of 30 studies, randomly selected according to a systematic sampling framework to represent a range of responses. In this sample, a third independent observer measured left ventricular end-systolic volume at rest and with stress using modified biplane Simpson’s method (ImageVue, Nova Microsonics).

**Follow-up**

Follow-up information was obtained by review of medical records, a mailed questionnaire, and telephone interviews. Death certificates were reviewed. End points were defined as cardiac death or myocardial infarction. Patients who underwent revascularization before cardiac events were censored at the time of revascularization.

**Statistical Analysis**

Categorical data were reported as percentages, and continuous data were reported as mean±SD. Patient groups were compared by one-way ANOVA or Student’s t test for continuous variables and the χ² test for categorical variables. Cumulative probability of freedom from cardiac events was calculated by the Kaplan-Meier method and compared between groups by the log-rank test. Univariate predictors of cardiac events were calculated with the Cox proportional hazards model. A value of P<.05 was considered significant. The clinical and rest and stress echocardiography data were entered into various stepwise Cox multiple regression models. To determine the incremental value of dobutamine stress echocardiography, the best model of clinical and rest echocardiography variables alone was compared with the best model including dobutamine stress echocardiography variables.

**Results**

**Study Group**

The study group consisted of 479 men and 381 women; their mean age was 70±10 years. Dobutamine stress echocardiography was performed for diagnosis of suspected coronary artery disease in 470 patients (55%) and for risk stratification of known coronary artery disease in 390 patients (45%). Cardiovascular risk factors included hypertension in 63%, hypercholesterolemia in 62%, family history of premature coronary artery disease in 45%, diabetes mellitus in 26%, and smoking in 20%. Thirty-two percent of the patients had angiographically proven coronary artery disease (≥50% diameter stenosis), 31% had a history of myocardial infarction, 26% had a history of angina, 24% had undergone previous cardiac revascularization, 22% were receiving β-adrenergic blocker therapy, and 17% had a history of congestive heart failure.

**Dobutamine Stress Echocardiography**

Dobutamine was infused to a mean peak dose of 35±9 µg·kg⁻¹·min⁻¹, and 0.6±0.3 mg of atropine was administered to 64 patients (7%). Heart rate increased from 72±13 to 123±20 bpm (P<.0001), and systolic blood pressure decreased from 144±21 to 141±30 mm Hg (P<.0005). Side effects included nausea in 65 patients (8%), headache in 81 (9%), palpitations in 104 (12%), chest pain in 121 (14%), dyspnea in 125 (15%), light-headedness in 42 (5%), and tremor in 97 (11%). The ECG was positive for ischemia in 102 patients (12%). The dobutamine stress echocardiogram was normal at rest and with stress in 302 patients (35%). In 237 patients (28%), there were resting wall motion abnormalities that did not worsen with stress. In 321 patients (37%), new or worsening wall motion abnormalities developed; in 115 of these patients, the studies were normal at rest. An abnormal left ventricular end-systolic volume response at peak stress was noted in 98 patients (11%).

Four hundred sixty-one patients failed to reach target rate; among these, 181 patients had new or worsening wall motion abnormalities. Of the 280 patients (33%) who did not achieve either the end point of target heart rate or new wall motion abnormalities, the test was stopped in 28 because of side effects or hypotension, in 21 because of arrhythmias, and in 231 after a peak dose of 40 µg·kg⁻¹·min⁻¹. Among these patients with submaximal stress, 130 (46%) had resting wall motion abnormalities. Compared with patients who achieved either target heart rate or echocardiographic evidence of ischemia, a greater percentage of these patients were receiving β-adrenergic medications (26% versus 20%, P<.05).

**Interobserver Variability and Volumetrics**

In 30 selected patients, there was complete agreement between the two independent observers in the scoring (1 through 5) of regional wall motion in 461 (96%) of 480 segments at rest (κ, 0.86; 95% CI, 0.80 to 0.93). With stress, there was concordance in 432 (90%) of 480 segments (κ, 0.82; 95% CI, 0.77 to 0.87). There was 100% agreement between the two observers regarding the subjective interpretation of left ventricular end-systolic volume response to stress (normal versus abnormal). Volumetric assessment revealed a decrease in end-systolic volume in all 15 studies that were subjectively classified as normal volume response (range, −5 to −21 mL). The group subjectively thought to have an abnormal volume response had a measured increase in end-systolic volume in 13 of 15 studies (87%). Two patients had a decrease in end-systolic volume (1 mL each). The volumetric assessment for the two groups was significantly different (−14±4 versus 6±5 mL, P<.0001).

**Outcomes**

During follow-up of up to 52 months (mean, 24±10 months), 72 patients underwent revascularization before any cardiac event and were censored. Of these patients, 52 (72%) had ischemia by dobutamine stress echocardiography and 18 (25%) had fixed wall motion abnormalities. These 72 patients had a higher wall motion score index at rest (1.39±0.44 versus 1.27±0.42, P<.05), a greater increase in wall motion score index with stress (0.18±0.26 versus 0.05±0.24, P<.0001), and a greater percentage of segments that were abnormal at peak stress (38±29% versus 21±27%, P<.0001).

Eighty-six patients had cardiac events, including nonfatal myocardial infarction in 36 and cardiac death in 50. The clinical and rest and stress echocardiography characteristics of patients with and without cardiac events are shown in Tables 1 and 2. Among patients with events, the rest ejection fraction was lower, and there were more extensive wall motion abnormalities at rest and with stress.
### TABLE 1. Clinical Characteristics of 860 Patients With and Without Cardiac Events After Dobutamine Stress Echocardiography

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>No Events (n=774)</th>
<th>Events (n=86)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, y*</td>
<td>69±10</td>
<td>72±9</td>
<td>.017</td>
</tr>
<tr>
<td>History of CHF</td>
<td>109 (14%)</td>
<td>36 (42%)</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Previous MI</td>
<td>228 (29%</td>
<td>42 (49%)</td>
<td>.0002</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>193 (25%</td>
<td>32 (37%)</td>
<td>.014</td>
</tr>
<tr>
<td>Smoking</td>
<td>151 (20%)</td>
<td>19 (22%)</td>
<td>NS</td>
</tr>
<tr>
<td>Hypertension</td>
<td>486 (63%)</td>
<td>53 (62%)</td>
<td>.045</td>
</tr>
<tr>
<td>Family history of CAD</td>
<td>349 (45%</td>
<td>42 (49%)</td>
<td>NS</td>
</tr>
<tr>
<td>Hypercholesterolemia</td>
<td>486 (63%)</td>
<td>50 (58%)</td>
<td>NS</td>
</tr>
<tr>
<td>Male</td>
<td>426 (55%)</td>
<td>53 (62%)</td>
<td>NS</td>
</tr>
</tbody>
</table>

*CHF indicates congestive heart failure; MI, myocardial infarction; and CAD, coronary artery disease.
*Age is expressed as mean±SD. For all other characteristics, values are the number and percentage of patients.

### Outcome With Normal Stress Echocardiography

Of the 302 patients with normal results of rest and stress echocardiography, 12 (4%) had cardiac events: 3 had nonfatal myocardial infarction, 5 had fatal myocardial infarction, 1 died of myocarditis, and 3 died of atherosclerotic heart disease. Six of these patients (50%) did not achieve target heart rate during dobutamine stress echocardiography. The nonfatal myocardial infarction and cardiac death rates per patient-year of follow-up were 0.5% and 1.1%, respectively. The event-free probabilities at 1, 2, and 3 years were 98%, 97%, and 96%, respectively. In a multivariate model, the presence of three or more cardiac risk factors (present in 33% of patients) identified a subset of patients with normal dobutamine stress echocardiography who were at a higher risk of cardiac events (hazard ratio, 5.8; 95% CI, 4.5 to 7.1; χ²=6.9; P<.01). Age, sex, percentage of maximal heart rate attained, and positive stress ECG were not predictive.

### Outcome With Ischemia by Stress Echocardiography

Of the 321 patients with new or worsening wall motion abnormality, 44 (14%) had cardiac events: 24 had nonfatal myocardial infarction, 8 died of myocardial infarction, 5 died of congestive heart failure, 3 had sudden cardiac death, and 4 died of atherosclerotic cardiac disease. The cardiac event–free probabilities at 1, 2, and 3 years were 93%, 88%, and 86%, respectively (Figure, left). Compared with a normal study, ischemia was associated with an increased risk of cardiac events (hazard ratio, 3.9: 95% CI, 2.0 to 7.4; χ²=17.3; P<.0001). The heart rate at which ischemia developed was predictive of cardiac events only among the patients who were not receiving β-adrenergic blockers. Among these patients, an ischemic threshold of <120 bpm (hazard ratio, 2.9; 95% CI, 1.1 to 7.7; χ²=4.9; P<.05) or <76% of the age-predicted maximum (hazard ratio, 2.7; 95% CI, 1.1 to 6.4; χ²=4.8; P<.05) was determined to be the best cutoff point. Among patients with an ischemic threshold of <120 bpm, 20 (18%) had cardiac events, whereas 5 (7%) with an ischemic threshold of ≥120 bpm had events.

### Outcome With Fixed Wall Motion Abnormalities

Among the 237 patients with fixed wall motion abnormalities, 30 (13%) had cardiac events: 9 had nonfatal myocardial infarction, 4 had fatal myocardial infarction, 11 died of congestive heart failure, 3 had sudden cardiac death, and 3 had atherosclerotic cardiac death. Twenty-one of these patients (70%) did not achieve target heart rate. Events occurred in 9 of 107 patients (8.4%) in whom target heart rate was...
achieved, compared with 21 of 130 (16.2%) in whom testing was submaximal (\(P = .07\)). Compared with a normal dobutamine stress echocardiogram, fixed wall motion abnormalities were associated with an increased risk of cardiac events (hazard ratio, 3.4; 95% CI, 1.8 to 6.7; \(x^2 = 13.1; P = .0003\)) (Figure, left). The event rate among patients with fixed wall motion abnormalities was not significantly different from the rate in patients with inducible ischemia (6.3% versus 7.2% per patient-year of follow-up, respectively). However, patients with fixed wall motion abnormalities more often had a prior myocardial infarction (49% versus 40%, \(P < .05\)) or history of congestive heart failure (27% versus 19%, \(P < .05\)) and had lower rest ejection fraction (48% versus 53%, \(P < .0001\)), higher rest wall motion score index (1.55 versus 1.35, \(P < .0001\)), and greater percentage of abnormal segments at rest (39% versus 23%, \(P < .0001\)).

Predictors of Cardiac Events

Univariate predictors of cardiac events are shown in Table 3. A history of congestive heart failure, the percentage of abnormal segments at peak stress, and an abnormal left ventricular end-systolic volume response to stress were independent predictors of cardiac events in a multivariate model (Table 4). When the percentage of abnormal segments at peak stress was not included in the model, peak wall motion score index became significant (\(x^2 = 8.2, P < .005\)). An increased extent of abnormal segments at peak stress predicted a higher risk of cardiac events, as shown in the Figure, right. Independent predictors of myocardial infarction (overall \(x^2 = 38, P < .0001\)) included history of congestive heart failure (\(x^2 = 7.5, P < .01\)) and

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Prediction of Cardiac Events</th>
<th>Hazard Ratio</th>
<th>95% CI</th>
<th>(x^2)</th>
<th>(P)</th>
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</thead>
<tbody>
<tr>
<td>Clinical data</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>Age*</td>
<td></td>
<td>1.36</td>
<td>1.08–1.72</td>
<td>6.84</td>
<td>.009</td>
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<tr>
<td>Diabetes mellitus</td>
<td></td>
<td>1.75</td>
<td>1.13–2.72</td>
<td>6.35</td>
<td>.012</td>
</tr>
<tr>
<td>Previous myocardial infarction</td>
<td></td>
<td>2.23</td>
<td>1.46–3.40</td>
<td>13.81</td>
<td>.0002</td>
</tr>
<tr>
<td>History of congestive heart failure</td>
<td></td>
<td>4.26</td>
<td>2.77–6.54</td>
<td>43.68</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Rest echocardiography data</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Ejection fraction†</td>
<td></td>
<td>0.70</td>
<td>0.61–0.81</td>
<td>21.63</td>
<td>&lt;.0001</td>
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<tr>
<td>Rest WMSI‡</td>
<td></td>
<td>1.15</td>
<td>1.09–1.20</td>
<td>32.20</td>
<td>&lt;.0001</td>
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<tr>
<td>Rest % abnormal segments§</td>
<td></td>
<td>1.19</td>
<td>1.12–1.26</td>
<td>33.97</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Stress echocardiography data</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ischemia</td>
<td></td>
<td>3.89</td>
<td>2.05–7.35</td>
<td>17.32</td>
<td>&lt;.0001</td>
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<tr>
<td>Abnormal</td>
<td></td>
<td>3.71</td>
<td>2.01–6.82</td>
<td>17.69</td>
<td>&lt;.0001</td>
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<tr>
<td>Peak WMSI‡</td>
<td></td>
<td>1.18</td>
<td>1.13–1.23</td>
<td>51.33</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Difference WMSI‡</td>
<td></td>
<td>1.18</td>
<td>1.08–1.30</td>
<td>12.27</td>
<td>.0005</td>
</tr>
<tr>
<td>% ischemic segments§</td>
<td></td>
<td>1.30</td>
<td>1.18–1.43</td>
<td>22.50</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>% fixed WM abnormalities†</td>
<td></td>
<td>1.23</td>
<td>1.16–1.31</td>
<td>41.77</td>
<td>&lt;.0001</td>
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<tr>
<td>Peak % abnormal segments§</td>
<td></td>
<td>1.26</td>
<td>1.19–1.33</td>
<td>55.78</td>
<td>&lt;.0001</td>
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<tr>
<td>Abnormal LVESV response</td>
<td></td>
<td>4.48</td>
<td>2.86–7.04</td>
<td>42.42</td>
<td>&lt;.0001</td>
</tr>
</tbody>
</table>

WMSI indicates wall motion score index; WM, wall motion; and LVESV, left ventricular end-systolic volume.

*Per decade.
†Per 10% ejection fraction points.
‡Per 0.125-point (two-segment) change.
§Per 10% ischemic segments.
||Per 10% abnormal segments.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Hazard Ratio</th>
<th>95% CI</th>
<th>(x^2)</th>
<th>(P)</th>
</tr>
</thead>
<tbody>
<tr>
<td>History of congestive heart failure</td>
<td>2.51</td>
<td>1.54–4.07</td>
<td>13.8</td>
<td>.0002</td>
</tr>
<tr>
<td>Peak % abnormal segments‡</td>
<td>1.14</td>
<td>1.05–1.23</td>
<td>10.6</td>
<td>&lt;.0005</td>
</tr>
<tr>
<td>Abnormal LVESV response</td>
<td>1.98</td>
<td>1.14–3.46</td>
<td>5.8</td>
<td>&lt;.05</td>
</tr>
</tbody>
</table>

LVESV indicates left ventricular end-systolic volume.

*Variables that were not significant: age, sex, angina pectoris, diabetes mellitus, hypertension, smoking, family history of coronary artery disease, hypercholesterolemia, previous myocardial infarction, rest ejection fraction, positive dobutamine stress echocardiography, ischemia by dobutamine stress ECG, ischemic threshold, angina during dobutamine stress test, wall motion score index at rest and at peak stress, percentage of abnormal segments at rest, percentage of ischemic segments, and percentage of fixed wall motion abnormalities.

†Overall \(x^2 = 29; P < .0001\).
‡Per 10% abnormal segments.
TABLE 5. Incremental Value of Dobutamine Stress Echocardiography in Predicting Cardiac Events

<table>
<thead>
<tr>
<th>Variables Considered</th>
<th>Model Variables Selected</th>
<th>Partial χ², P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clinical*</td>
<td>49 Previous MI, History of CHF</td>
<td>5.0275, 0.0001</td>
</tr>
<tr>
<td>Clinical + rest echocardiography†</td>
<td>58 History of CHF, Rest % abnormal</td>
<td>21.0001, 0.0007</td>
</tr>
<tr>
<td>Clinical + rest echocardiography + stress echocardiography‡</td>
<td>81 History of CHF, Peak % abnormal</td>
<td>15.0001, 0.0004</td>
</tr>
</tbody>
</table>

*Clinical: age, sex, angina, history of congestive heart failure (CHF), previous myocardial infarction (MI), diabetes.
†Rest echocardiography: rest ejection fraction, rest wall motion score index, rest % abnormal segments.
‡Stress echocardiography: peak wall motion score index, peak % abnormal segments, positive dobutamine stress echocardiography, ischemia by dobutamine stress ECG, angina during dobutamine stress echocardiography, percentage of ischemic segments, percentage of fixed wall motion abnormalities, abnormal left ventricular end-systolic volume (LVESV).

The percentage of ischemic segments (χ²=27, P<.0001). Independent predictors of cardiac death (overall χ²=56, P<.0001) included age (χ²=5.7, P<.05), history of congestive heart failure (χ²=12, P=.0005), and the percentage of fixed wall motion abnormalities (χ²=20, P<.0001). Among 443 patients with rest regional wall motion abnormalities, independent predictors of cardiac events (overall χ²=44, P<.0001) were history of congestive heart failure (χ²=12, P<.001), abnormal left ventricular end-systolic volume response (χ²=7.7, P<.01), and percentage fixed wall motion abnormalities (χ²=4.6, P<.05).

Table 5 illustrates the incremental prognostic value of clinical and rest and stress echocardiographic data. Prior myocardial infarction and a history of congestive heart failure contributed significantly to the clinical model (χ²=49, P<.0001). The addition of rest echocardiographic data, in particular the percentage of abnormal segments at rest, provided additional prognostic value (χ²=49 to 58). The stress echocardiogram was the single most important predictor of outcome (χ²=65). The addition of the percentage of abnormal segments at peak stress provided incremental value to the clinical and rest echocardiographic data (χ²=74). An abnormal left ventricular end-systolic volume response to stress had additional prognostic value. If the variables that were obtained by semiquantitative wall motion scoring (that is, the percentage of segments that were abnormal at rest and at peak stress, stress wall motion score index, the number of ischemic segments, and the number of infarcted segments) were not entered into the model, the prognostic value of the model decreased (χ²=81 to 69).

Discussion

In this study of 860 patients, dobutamine stress echocardiography provided significant incremental value compared with clinical and rest echocardiographic variables for predicting cardiac events, including cardiac death and myocardial infarction. The independent predictors of cardiac events were an abnormal left ventricular end-systolic volume response, history of congestive heart failure, and percentage of abnormal segments at peak stress. The dobutamine stress ECG and the presence of cardiovascular risk factors were not useful for predicting events, nor was age, sex, prior myocardial infarction, or angina pectoris.

Independent predictors of myocardial infarction and cardiac death differed. Indicators of the extent of ischemia, including percentage of ischemic segments, were better predictors of myocardial infarction, whereas age and markers of left ventricular dysfunction, including percentage of fixed wall motion abnormalities, were more predictive of cardiac death.

In the present study, 86 patients had “hard” cardiac events, including cardiac death and nonfatal myocardial infarction, during a mean follow-up of 24 months. We extended the findings of others, confirming the excellent prognosis of patients with normal results of dobutamine stress echocardiography in an older population. In our study, the 1-year and 2-year event-free rates of patients with normal study results were 98% and 97%, respectively. In contrast, a positive dobutamine study was associated with a fourfold higher risk of cardiac events. Furthermore, dobutamine stress echocardiography provided significant incremental value for predicting cardiac events compared with clinical and rest echocardiographic variables.

In addition to classifying the results of dobutamine stress echocardiography as positive or negative, we assessed the prognostic value of additional findings of the test, including the wall motion score index; the percentages of segments that were abnormal, ischemic, or showed fixed wall motion abnormalities at peak stress; the ischemic threshold; and the change in left ventricular end-systolic volume. Poldermans et al found that the ischemic threshold could be used to identify patients at risk for cardiac events during major vascular surgery but was not predictive of late cardiac events. They found that patients with extensive (three or more segments) stress-induced wall motion abnormalities were at increased risk of cardiac events. In our population, ischemic threshold was predictive of cardiac events only in patients who were not receiving β-adrenergic blockers. We found that semiquantitative wall motion scoring, in particular the percentage of abnormal segments at peak stress, provided independent prognostic information.

The percentage of segments that were abnormal at peak stress was superior to the peak wall motion score index or the change in wall motion score index as a predictor of cardiac events. Among patients with established coronary artery disease, prognosis is dependent on the extent of left ventricular dysfunction and the amount of myocardium at risk. The percentage of abnormal segments at peak stress provides an assessment of these factors during dobutamine stress testing.

In our study, an abnormal left ventricular end-systolic volume response to dobutamine stress was an important independent predictor of outcome. Prior studies have shown that an increase in left ventricular volume during dobutamine stress identifies
patients with more severe coronary artery disease. The prognostic significance of this finding with dobutamine stress echocardiography has not been considered previously.

In the present study, follow-up was censored at the time of revascularization. Because the decision to proceed with revascularization may be influenced by the results of the stress test, inclusion of this as an end point would have increased the prognostic value of a positive test result. Patients who underwent revascularization were characterized by markedly abnormal dobutamine echocardiograms, as evidenced by a higher wall motion score index at rest, a greater increase in wall motion score index with stress, and a greater percentage of segments that were abnormal at peak stress. By not including revascularization as an event, any error is in the direction of underestimating the true predictive value of dobutamine stress echocardiography.

Limitations of this study include subjective semiquantitative assessment of regional wall motion. Although concern has been raised regarding the interinstitutional reproducibility of this technique, excellent interobserver agreement has been described by others and was obtained in this study. Left ventricular end-systolic volume response was assessed qualitatively. There was good agreement between the qualitative assessment and volumetric measurement in a subset of patients.

We did not exclude from our analyses the 280 patients (33%) who had a submaximal test, that is, those who failed to achieve either target heart rate or echocardiographic evidence of ischemia. Among patients with fixed wall motion abnormalities, the cardiac event rate tended to be higher in those who had a submaximal test (16.2% versus 8.4%, P = .07). β-Adrenergic blocker medications, used by 26% of patients with submaximal tests, may have had a protective effect during follow-up. The use of atropine in only 7% of patients during dobutamine stress echocardiography reflects the standard protocol in 1991. The incremental value of atropine for detecting coronary artery disease has subsequently been demonstrated. The use of atropine in a larger percentage of patients would have increased the numbers with an ischemic response and might have further increased the negative predictive value of the test.

Summary

Dobutamine stress echocardiography using segmental wall motion scoring provides important incremental prognostic information. In addition to a history of congestive heart failure, the percentage of abnormal segments at peak stress and an abnormal response of the left ventricular end-systolic volume during dobutamine stress identify patients at greatest risk of cardiac death and myocardial infarction.

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References


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