Akinesis becoming dyskinesis during dobutamine stress echocardiography. A predictor of poor functional recovery after surgical revascularization

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Akinesis Becoming Dyskinesis During Dobutamine Stress Echocardiography*

A Predictor of Poor Functional Recovery After Surgical Revascularization

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Background: **Akinesis becoming dyskinesis at high-dose dobutamine stress echocardiography (DSE) has been disregarded as a marker of myocardial ischemia. However, to our knowledge, the relationship between this pattern and myocardial viability has not been assessed.**
Methods: **We studied 42 patients with myocardial infarction who underwent DSE (up to 40 μg/kg/min) before coronary artery bypass surgery, and resting echocardiogram 3 months after surgery. Viability in akinetic segments was considered to be present if systolic thickening occurred with low-dose dobutamine (LDD).**
Results: **During high-dose DSE, dyskinesis occurred in 35 of the 164 akinetic segments (group A). The remaining 129 segments comprised group B. Segments of group B had a higher prevalence of viability pattern with LDD (18% vs 0%; $p<0.01$) and a higher prevalence of functional improvement (20% vs 0%; $p<0.005$) compared with group A. In absence of viability pattern with LDD, postoperative improvement occurred in 10% of segments in group B and in none of segments in group A, resulting in a higher negative predictive value of LDD in group A vs B (100% vs 90%; $p<0.05$).**
Conclusion: **The phenomenon of akinesis becoming dyskinesis with high-dose DSE is associated with absence of viability pattern with LDD and poor functional outcome after surgical revascularization. Observation of this pattern provides additional data to those obtained only with LDD echocardiography.** ***(CHEST 1996; 110:155-58)***

Key words: coronary artery bypass surgery; dobutamine stress echocardiography; myocardial viability

Abbreviations: LDD=low-dose dobutamine

In patients with coronary artery disease and left ventricular dysfunction, the detection of myocardial viability is important for the proper identification of patients in whom left ventricular function may improve after revascularization.[1,2] Recent studies have demonstrated the value of dobutamine stress echocardiography for the detection of myocardial viability at low dose[2,3] and ischemia at high dose.[4,5] We have recently reported that akinetic segments at baseline echocardiogram, developing dyskinesis at high-dose dobutamine, without improvement at low-dose dobutamine (LDD) represent a mechanical phenomenon unrelated to myocardial ischemia assessed by simultaneous perfusion scintigraphy.[6] However, to our knowledge, the relationship between this pattern and functional improvement after revascularization has not been studied. Therefore, the aims of this study were (1) to assess the relationship between the pattern of akinesis becoming dyskinesis at high-dose dobutamine stress echocardiography and functional improvement after surgical revascularization, and (2) to find if observation of this phenomenon improves the value of LDD echocardiography for the prediction of postoperative functional improvement.

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Materials and Methods

Study Population

The study population comprised 42 patients with coronary artery disease and left ventricular dysfunction, undergoing coronary artery bypass surgery, who fulfilled the following study inclusion criteria: history of previous (>3 months old) myocardial infarction; two or more akinetic segments on preoperative resting echocardiography; absence of unstable angina, severe heart failure, or significant valvular disease; and absence of perioperative myocardial infarction. Mean age was 59±9 years. There were 33 men and 9 women. Thirty-nine patients had typical angina and 9 patients had exertional dyspnea before the test. Single-vessel disease, defined as diameter stenosis greater than 50% of a major coronary artery, was present in 6 patients, 2-vessel disease was in 15 patients, and 3-vessel disease was in 21 patients. The mean ejection fraction determined by angiography was 39±14%. Thirty-nine patients were receiving an-

tianginal therapy. In patients receiving beta-blocking agents, treatment was withdrawn 2 days before stress testing.

Dobutamine Stress Test

The test was performed according to a previously described protocol.[2] Dobutamine was infused through an antecubital vein starting at a dose of 5 μg/kg/min for 3 min, 10 μg/kg/min for 3 min, increasing by 10 μg/kg/min every 3 min to a maximum of 40 μg/kg/min. Atropine (up to 1 mg) was given in patients not achieving 85% of their age-predicted maximal heart rate.[7] The ECG was monitored throughout dobutamine infusion and recorded each minute. Cuff BP was measured every 3 min. The test was interrupted prematurely if severe chest pain, ST-segment depression greater than 2 mm, significant ventricular or supraventricular arrhythmia, or systolic BP fall of more than 40 mm Hg occurred during the test.

Stress Echocardiography

As previously described,[2] the echocardiogram in standard views was performed and recorded on videotape at rest and during stress. Rest, low-dose, and peak stress images were also digitized and stored on an optical disk (CFM 800; Vingmed; Horten, Norway) for a display in quad-screen format. Left ventricular function was assessed using a 16-segment model. Both inward endocardial motion and myocardial thickening were considered for analysis. Each segment was graded with a 4-point grading score (1=normal or hyperkinesis; 2=hypokinesis; 3=akinesis; and 4=dyskinesis). Akinesis was considered in the absence of systolic wall motion and thickening. Dyskinesis was defined as absence of systolic thickening with outward bulging away from the center of left ventricular cavity in systole. To reduce the confounding effect of tethering, segmental wall thickening was analyzed frame by frame during the first half of systole. Wall motion score index was derived by dividing the summation of the 16 segments by 16. Viability in akinetic segments was considered if myocardial thickening was observed during LDD infusion (5 to 10 μg/kg/min). Ischemia was defined as the appearance of new wall motion abnormalities or worsening of a hypokinetic segment. Two experienced investigators assessed the images. In case of disagreement, a third investigator viewed the images and a majority decision was achieved. We have previously reported a good interobserver and intraobserver agreement on the assessment of rest and stress echocardiographic images in our laboratory.[2,8]

Follow-up Studies

At rest echocardiogram was performed in all patients 3 months after surgery. An improvement of akinetic segments was considered if systolic thickening occurs postoperatively. Absence of improvement was considered in case of surgical excision of the segment or absence of systolic thickening at follow-up. Myocardial segments that were not revascularized were not included in analysis.

Statistical Analysis

Continuous data are expressed as mean±SD. Univariate analysis for categorical variables was performed using the χ^2 test with Yates' correction or Fisher's Exact Test. Differences were considered significant if the null hypothesis could be rejected at the 0.05 probability level. Sensitivity, specificity, and positive and negative predictive values were based on their standard definitions and are reported with the corresponding 95% confidence intervals.

Results

Dobutamine Stress Test

Heart rate increased from 71±12 at rest to 139±13 beats/min at peak stress ($p<0.001$) and rate pressure product from 9,112±2,744 to 16,776±4,126 ($p<0.001$). Rate pressure product did not change significantly at LDD (10 μg/kg/min). Angina occurred in 29 patients (59%). In 10 patients (24%), the test was interrupted prematurely before reaching the maximal dose or the target heart rate. Reasons for premature termination of the test were angina (three patients), ST-segment depression (one patient), and hypotension (six patients).

LDD Echocardiography

Wall motion score index decreased significantly from rest to LDD (1.82±0.4 to 1.57±0.38; $p<0.01$). Among 164 akinetic segments at baseline echocardiogram that were revascularized, improvement at LDD was observed in 23 segments (14%).

High-Dose Dobutamine Echocardiography

Ischemia (new or worsened wall motion abnormalities) was detected in 38 patients (90%). Dyskinesis at peak stress developed in 35 of the 164 akinetic segments (group A). This pattern was observed in 12 patients. The remaining 129 akinetic segments constituted group B. Systolic thickening at LDD was observed in 23 segments of group B (18%) and in none of segments in group A ($p<0.01$). There was no significant difference between both groups with regard to the corresponding rate pressure product at rest, LDD, or peak stress. Baseline wall motion score index was not different between patients with or without akinesis becoming dyskinesis in one or more segments (1.84±0.41 vs 1.81±0.40, respectively).

Postoperative Results

A significant improvement of symptoms occurred after surgery. At follow-up echocardiography, improvement occurred in 26 of the 164 akinetic segments (16%). Improvement occurred in 26 segments in group B (20%) and none of segments in group A ($p<0.005$). Eight segments in group A (23%) and 12 segments in group B (9%) were excised due to the presence of gross abnormalities identified during surgery ($p<0.05$). Functional improvement occurred in 15 of 23 segments with and in 11 of 141 segments without viability pattern at LDD echocardiography. The sensitivity, specificity, predictive value, and accuracy of LDD echocardiography for the prediction of postoperative functional improvement in akinetic segments are shown in Table 1. The negative predictive value was significantly higher in group B compared with group A (100% vs 90%; $p<0.05$; Fig 1). The agreement between LDD echocardiography and functional improvement is shown in Figure 2 (*top*, group A; and bottom, group B).

Coronary Angiography

Coronary angiography was performed in 15 patients (5 patients with and 10 patients without akinesis

Table 1—*Diagnostic Accuracy of LDD Echocardiography for the Prediction of Functional Improvement of Akinetic Segments After Surgical Revascularization

	SENS	SPEC	PPV	NPV	ACC
%	58	94	65	92	88
95% CI	50-65	91-98	58-73	88-96	83-93

*ACC=diagnostic accuracy; CI=confidence intervals; NPV=negative predictive value; PPV=positive predictive value; SENS=sensitivity; SPEC=specificity.

becoming dyskinesis) after surgery and revealed patency of grafts to analyzed segments in all patients.

Discussion

In symptomatic patients with coronary artery disease and left ventricular dysfunction, myocardial revascularization aims at improvement of baseline function, amelioration of symptoms, and improvement of prognosis.[9] For that reason, the noninvasive assessment of myocardial viability and ischemia before revascularization is important for the selection of patients who will benefit from the procedure. Dobutamine stress echocardiography is increasingly used for the functional assessment of patients with ischemic left ventricular dysfunction.[2-5] The diagnosis of myocardial viability relies on the occurrence of a contractile response of dyssynergic segments during LDD infusion.[2,3] Myocardial ischemia is considered when new or worsening wall motion abnormalities occur during the test.[4,5,7] We have reported previously that akinetic segments that do not respond to LDD and develop dyskinesis at high dose are associated with absence of perfusion scintigraphic evidence of ischemia.[6] In the previous study, we could not identify any segment showing the pattern of akinesis becoming dyskinesis with improvement at LDD. Consequently,

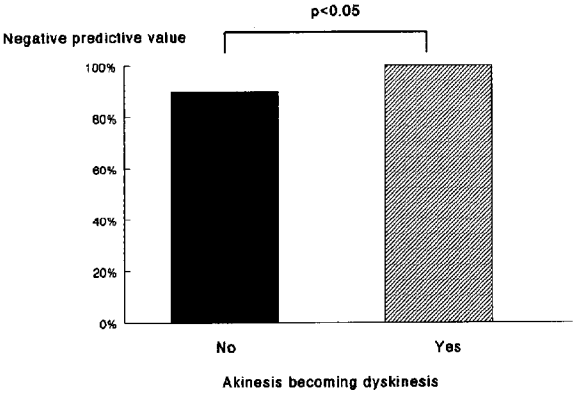

FIGURE 1. The negative predictive value of LDD echocardiography for postoperative functional improvement in akinetic segments with and without dyskinesis at high-dose dobutamine.

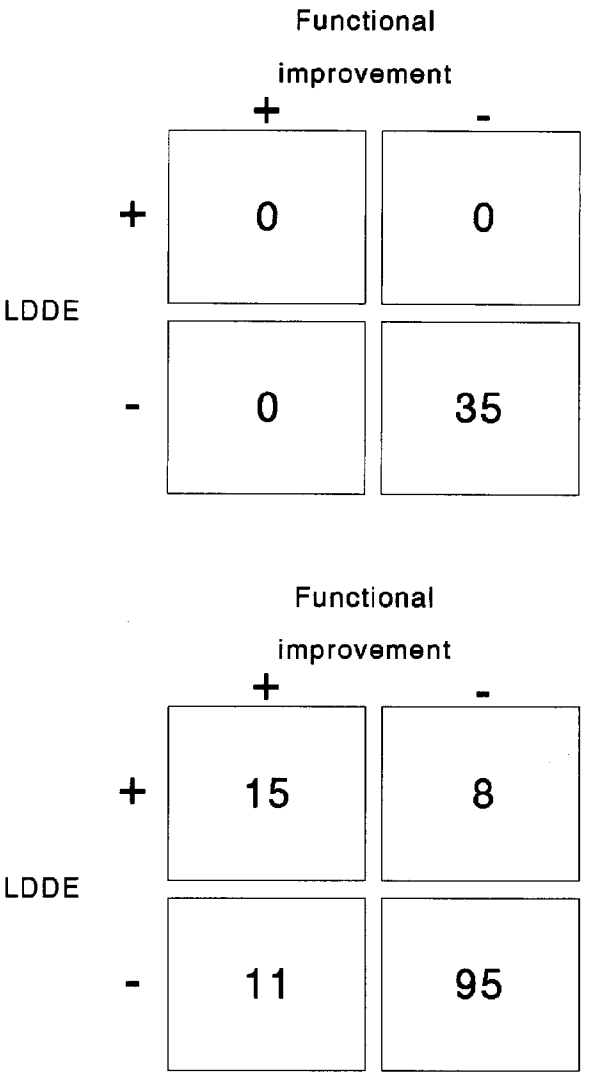

FIGURE 2. Two-by-two tables showing the relationship between viability pattern at LDD echocardiography (LDDE) and postoperative functional improvement in akinetic segments with *(top)* and without *(bottom)* dyskinesis at high-dose dobutamine.

the question remains whether this pattern is compatible with the presence of myocardial viability and awaits extension of the previous study. Furthermore, the detection of reversible perfusion defects in presence of severe resting hypoperfusion represents a technical challenge.[10] Therefore, we assessed, in a new series of patients, the relationship between the pattern of akinesis becoming dyskinesis and myocardial viability at LDD and we studied the more relevant issue of postrevascularization outcome of these segments.

Our data show that in symptomatic patients with coronary artery disease, the phenomenon of akinesis becoming dyskinesis at high-dose dobutamine stress test is consistently associated with absence of viability pattern at LDD and absence of functional improve-

ment after surgical revascularization. Some of these segments were excised owing to gross abnormalities identified at surgery and the remaining segments failed to exhibit systolic thickening 3 months after surgery. Furthermore, the observation of this pattern at high dose gave additional information to those obtained only at LDD. In absence of this pattern, 10% of akinetic segments identified at LDD as nonviable showed functional improvement after surgery. Thus, the negative predictive value of dobutamine stress echocardiography for postoperative improvement was significantly higher in association with this pattern (100% vs 90%).

The steady increase of myocardial contractility in normal segments[11,12] and possibly in viable dyssynergic segments during dobutamine infusion may cause akinetic segments with severe necrosis to bulge paradoxically in systole. Therefore, akinetic segments showing this pattern failed to demonstrate systolic thickening at LDD or after revascularization. Despite the fact that myocardial ischemia is considered when a normal or hypokinetic segment at rest becomes dyskinetic at peak stress, this condition did not seem to apply to akinetic segments. It can be postulated that dyskinesis developing in a normal or hypokinetic segment represents severe ischemia, which in turn requires a substantial mass of preserved myocardium that may not be available in akinetic segments.

We have reported previously the value of LDD echocardiography for the prediction of recovery of regional function after recent myocardial infarction[3] and after coronary artery bypass surgery in patients with chronic left ventricular dysfunction.[2] The results of this study demonstrate an additional value of observation of worsening of akinetic segments at high-dose dobutamine for the prediction of functional recovery.

Limitation of the Study

Coronary angiography was performed only in 36% of patients after surgery. In all of these patients, however, sustained patency of the grafts to the analyzed segments was demonstrated. Additionally, symptomatic improvement occurred in all patients after surgery denoting successful revascularization.

Conclusion

In symptomatic patients with coronary artery disease and left ventricular dysfunction, the phenomenon of akinesis becoming dyskinesis at high-dose dobutamine stress test is associated with absence of viability pattern at LDD echocardiography and lack of functional improvement after surgical revascularization. Observation of this pattern at high dose provides additional data to those obtained at LDD and improves the negative predictive value of dobutamine stress echocardiography for postoperative functional improvement of akinetic segments.

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