ST segment elevation during dobutamine stress echocardiography after acute myocardial infarction: Clinical significance and correlation with contractile recovery

Mohamed A. Oraby *, Ihab M. Mohamed, Azza Z. El-Eraky, Fathy A. Maklady

Department of Cardiovascular Medicine, Suez Canal University, Egypt

Received 2 March 2012; accepted 25 July 2012
Available online 21 August 2012

Abstract Objectives: The aim of this study was the evaluation of the value of dobutamine stress induced ST-segment elevation after acute myocardial infarction in predicting spontaneous contractile recovery.

Methods: Fifty eight consecutive patients were studied within 7 days after first acute myocardial infarction (AMI) with dobutamine stress echocardiography (DSE). A score model based on 16 segments and four grades was used to assess the left ventricular function and a twelve-lead electrocardiography was continuously monitored throughout the test. Follow up was performed by trans-thoracic echocardiography at 90 days. At follow up, contractile recovery was defined as improvement of wall motion score by more than one grade in at least two myocardial segments.

Results: ST-segment elevation was observed in 24 (41%) out of the 58 patients studied. During DSE; persistent segmental wall motion abnormalities were more frequently observed in patients without ST-segment elevation while improvement without subsequent worsening was more frequently observed in patients with ST-segment elevation (P = 0.001). On follow up, contractile recovery was reported in 37 (64%) patients, it was more frequently observed in patients who already developed ST-segment elevation during DSE (P = 0.007). Dobutamine induced ST-Segment elevation has the sensitivity, specificity, positive and negative predictive values of 66%, 86%, 88% and 53%, respectively to predict spontaneous contractile recovery after AMI, while the combined sensitivity, specificity, positive and negative predictive values of dobutamine echocardiography and electrocardiography were 73%, 89%, 94% and 64%, respectively.
1. Introduction

After acute myocardial infarction (AMI), ST-segment elevation is often observed during stress testing, but its clinical significance remains controversial. In the pre-thrombolytic era, exercise-induced ST-segment elevation was usually considered to reflect severe left ventricular dysfunction related to the extent of the infarcted tissue, left ventricular aneurysm, or stress-induced dyskinesia. At that time, other studies already suggested that myocardial ischemia secondary to severe coronary disease may play an important role because coronary artery bypass surgery could result in abolition of exercise-induced ST-segment elevation. Some investigators concluded that these electrocardiographic changes may be caused by abnormal wall motion, peri-infarctional ischemia, or both. Recent studies have provided a new look to the significance of exercise-induced ST-segment elevation. These electrocardiographic changes have been shown to be associated with reversible perfusion defects and F-fluorodeoxyglucose uptake within the affected area, suggesting the presence of residual viability, transient myocardial ischemia, or both.

Dobutamine stress echocardiography (DSE) is increasingly used in patients with recent myocardial infarction because this method can identify both myocardial viability and ischemia in the infarct zone, at a distance, or both. Dobutamine-induced ST-segment elevation has been found to be associated with the presence of contractile reserve in the affected region, or, in contrast, to a significantly larger infarct size. Studies of the relationship among stress induced ST-segment elevation, myocardial viability and ischemia after myocardial infarction have gained increasing interest, particularly in the thrombolytic era, as a large proportion of patients retains viable myocardium which improves spontaneously or after revascularization. It is important to identify a viable myocardium in order to match the patients to the most appropriate strategy for improvement of left ventricular function. Although these studies have gained new insights, full interpretation and implications of stress-induced ST-segment elevation after acute myocardial infarction are not yet entirely established.

2. Subjects and methods

2.1. Study population

We studied patients admitted with a first acute ST-segment elevation myocardial infarction to the coronary care unit in Suez Canal University hospital. The diagnosis of myocardial infarction was made by the acute typical ST–T wave changes and typical increase and decrease in serum creatine kinase (CK) and the MB isoenzyme of creatine kinase (CK-MB) enzyme levels in the clinical setting of sustained precordial chest pain. We excluded patients with past history of myocardial infarction, electrolyte abnormalities, mechanical complications of myocardial infarction, conduction defects, post-infarction angina, or any other contraindications to dobutamine infusion.

2.2. Dobutamine stress echocardiography

2.2.1. Procedure

DSE was performed before hospital discharge (between days 5 and 7). Dobutamine was administered intravenously by an infusion pump at the initial dosages of 2.5, 5 and 10 μg/kg per minute for 3 min each, followed by increments of 10 μg/kg per minute every 3 min, up to a maximal dose of 40 μg/kg per minute. The infusion was stopped in the presence of any one of the following end points: the target heart rate (85% of maximum age-predicted heart rate), severe angina, 2 mm or more ST-segment depression compared with baseline, new or worsening wall motion abnormalities, significant arrhythmias, severe hypertension (blood pressure > 230/120 mmHg), or hypotension (decrease in systolic blood pressure > 30 mm Hg below the baseline measurement). Echocardiographic monitoring was performed continuously and digital acquisition of images was obtained at rest, at low dobutamine dose (10 μg/kg per minute); at peak dose, and during recovery. Blood pressure was manually measured at each stage by an arm-cuff sphygmomanometer.

2.2.2. Echocardiographic analysis

Analysis of wall thickening was performed with the classic 16-segment model. Wall thickening assessment of each segment was performed using a 4-point scoring system: (1) Normal wall thickening (2) Hypokinesis (3) Akinesis (4) Dyskinesis. For both rest and stress studies, wall motion score index was calculated by the sum of individual segment scores divided by 16. Improvement of contractile function in a segment during dobutamine infusion was defined when systolic myocardial thickening became apparent in a kinetic segment (from score 3 to 2 or 1) or when systolic thickening and wall motion comparable with those observed in the normal segments were observed in a previously hypokinetic segment (from 2 to 1). A patient was considered to have contractile reserve on dobutamine echocardiography if wall thickening improved in 2 or more contiguous segments. The development of new or worsening regional dysynchrony during dobutamine stress was considered to indicate ischemia.

Four different echocardiographic responses were identified (1) Sustained improvement implied contractile reserve with no ischemia (stunning), (2) Initial improvement followed by subsequent worsening at a higher dose was considered to represent a biphasic response (viable, and ischemic), (3) Ischemia of the adjacent area was defined by the development of new dysynchrony in 2 or more segments adjacent to the infarcted zone, with no change in the affected segments. (4) No change in basal dysynchrony throughout dobutamine infusion (non-viable).
2.3. Electrocardiographic analysis

A 12-lead electrocardiogram was monitored continuously and recorded at the end of each stage. When needed, the precordial leads were repositioned (one intercostal space below the standard position) for better application of the transducer. The electrocardiograms were revised by 2 experienced cardiologists unaware of the clinical and the echocardiographic data. Q waves were defined as Pathologic Q wave when they were equal to or more than 0.04 s in duration and equal to or more than 25% of the R wave in depth. ST–T segment characteristics were analyzed in the infarct-related electrocardiographic leads. During dobutamine stress testing, ST-segment elevation was defined as new or worsening of 1 mm or more, 80 ms after J point, in 2 or more contiguous infarct-related leads.

2.4. Follow-Up echocardiography

Contractile recovery was assessed on resting trans-thoracic echocardiography 90 days after the initial assessment. Contractile recovery was defined as wall thickening improvement in two or more contiguous dysynergic segments within the dysfunctional infarct area by one or more grade (e.g. from score 3 to 2). Ejection fraction was calculated as well as the wall motion score index (WMSI). During the follow up period, no patient had any form of revascularization.

2.5. Statistical analysis

Continuous data were expressed as mean ± SD. Two binary outcome variables were analyzed separately: ST-segment elevation versus no ST-segment changes and contractile recovery versus no contractile recovery. For these 2 outcomes, data were first examined by univariate analysis for differences between subgroups. Quantitative variables were tested by t test and nominal findings by a chi-square test. A value of $P < 0.05$ was considered to be statistically significant. Sensitivity, specificity, predictive values, and accuracy were all evaluated according to standard definitions.

3. Results

We included 58 patients, 39 (67%) of them were males with a mean age of 56 ± 9 years. Baseline clinical characteristics as well as the status of thrombolytic therapy among study population are shown in Table 1.

3.1. Baseline data

On resting ECG, the infarction location was anterior in 33 patients, anterolateral in 6 patients and infero-posterior in 19 patients. Nineteen (33%) patients had residual ST-segment elevation more than 1 mm in the infarct related leads, and 53 (91%) patients had T wave inversion in the infarct related leads. On resting echocardiography 34 patients had preserved systolic function (EF ≥ 50%), while 24 patients had reduced systolic function (EF < 50%).

3.2. Dobutamine stress electrocardiography

ST-segment elevation in the infarct related leads (at least 2 leads corresponding to the same territory) was observed in 24 (41%) patients who comprised group A, with ST-segment elevation occurring at a mean dobutamine dose of 10 ± 5 μg/kg per minute. Group B included 34 (59%) patients with no dobutamine induced ST-elevation. There was no significant difference between the two groups regarding their baseline clinical, electrocardiographic, or echocardiographic characteristics (Table 1).

| Table 1 | Baseline clinical, electrocardiographic and echocardiographic characteristics of patients with (group A) and without (group B) ST elevation during DSE. |
|---------|-------------------------------------------------|-----------------|-----------------|
| Age (mean ± SD) | 57.9 ± 8.6 | 54 ± 9.5 | NS* |
| Sex | | | |
| Male | 15 | 24 | NS |
| Female | 9 | 10 | |
| Smoking | 11 | 14 | NS |
| DM | 8 | 10 | NS |
| Hypertension | 11 | 17 | NS |
| Dyslipidemia | 22 | 32 | NS |
| Obesity | 10 | 15 | NS |
| Family history of CAD | 3 | 1 | NS |
| Infarction | | | |
| Anterior | 11 | 22 | NS |
| Inferior | 13 | 12 | |
| Thrombolysis | 21 | 32 | NS |
| Time to thrombolysis | 192.7 ± 160.1 | 217 ± 135.3 | NS |
| Residual ST elevation | 9 | 15 | NS |
| Ejection fraction | 49.8 ± 8.3 | 48.9 ± 7.8 | NS |
| WMSIb | 1.61 ± 0.3 | 1.72 ± 0.3 | NS |
| Peak CK-MB | 322 ± 216 | 363 ± 207 | NS |

* Non-significant.

b Wall motion score index.
During DSE, improvement in baseline dyssynergy at the infarcted area at low dobutamine dose (indicating residual viable myocardium) was more frequently observed in group A (16 out of 24 patients) compared with group B (13 out of 34 patients) \((P = 0.002)\). Chest pain during the procedure was encountered in 13 (54%) patients among group A, and only in 7 (21%) patients among group B \((P < 0.05)\).

3.3. Follow up echocardiography

Follow-up trans-thoracic echocardiography was performed after a mean period of 85 ± 11 days after the index AMI. In group A, 21 (88%) patients showed contractile recovery, while in group B, only 16 (47%) patients showed this contractile recovery \((P < 0.002)\). In group A, the mean EF raised from 49 ± 8 to 55 ± 7%, while in group B, EF showed no significant change from the baseline 48 ± 8 and 48 ± 10% \((P < 0.016)\). Group A had a significant decrease in the mean WMSI compared to the baseline (from 1.6 ± 0.3 to 1.3 ± 0.2) compared to the group B (1.7 ± 0.3–1.5 ± 0.4) \((P < 0.003)\) (Table 2).

In this study, ST-segment elevation during DSE had the sensitivity, specificity, positive and negative predictive values of 66%, 86%, 88% and 53%, respectively to detect spontaneous contractile recovery after AMI. Adding echocardiographic parameters of contractile reserve to ST-segment elevation result in a significant improvement in these variables (73%, 89%, 94% and 64%, respectively) (fig. 1).

Table 2 Three-month echocardiographic follow-up of patients with (group A) and without (group B) ST-segment elevation during DSE.

<table>
<thead>
<tr>
<th></th>
<th>Group A</th>
<th>Group B</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contractile recovery</td>
<td>21</td>
<td>16</td>
<td>0.002</td>
</tr>
<tr>
<td>Ejection fraction on follow Up</td>
<td>55 ± 7</td>
<td>48 ± 10</td>
<td>0.016</td>
</tr>
<tr>
<td>WMSI on follow Up</td>
<td>1.3 ± 0.2</td>
<td>1.5 ± 0.4</td>
<td>0.003</td>
</tr>
</tbody>
</table>

4. Discussion

The main finding of this study was that dobutamine-induced ST-segment elevation is predictive of spontaneous contractile recovery after AMI. This spontaneous contractile recovery was associated with reduction in wall motion score index and improvement in the ejection fraction after a 3-month follow up period in comparison to the baseline values.

Our results showed that the prevalence of ST-elevation was 41%. This value is actually low compared with previous studies. This discrepancy may be due to the fact that all patients in our study received intravenous thrombolysis as a stand alone reperfusion strategy with no other alternatives such as primary PCI in patients who are known to get better benefit over medical reperfusion or rescue PCI in patients who did not succeed to show any marker of reperfusion after thrombolysis. As our study proved a strong linkage between ST-segment elevation and viability, it is understandable that failure of reperfusion would decrease the possibility of the myocardium to retain any form of viability and hence would decrease the likelihood of ST-segment elevation on DSE.

Margonato et al. were among the first to show that exercise-induced ST segment elevation may allow the identification of residual viability after myocardial infarction. They first observed that transient ST segment elevation during exercise was frequently associated with a reversible perfusion defect on TI-201 myocardial perfusion scintigraphy. Piérard et al. using positron emission tomography observed that the uptake of F-fluorodeoxyglucose within the myocardium was more frequently encountered in patients with, rather than without, exercise induced ST segment elevation. In 21 patients with anterior myocardial infarction, the sensitivity, specificity and accuracy of exercise-induced ST segment elevation for detection of residual viability were 82%, 100% and 86%, respectively. Yamagishi et al. using positron emission tomography, also found a higher incidence of fluorine-18-fluorodeoxyglucose uptake in the infarct territory in patients with exercise-induced ST segment elevation compared to that observed in patients without an ST segment shift. Again a strong association between
dobutamine- and exercise-induced ST elevation with functional recovery following revascularization was proved by Mezlis et al. as they concluded that stress induced ST elevation in more than three leads can actually predict functional recovery.

Unlike previously reported studies, Bodí et al. found that exercise-induced ST-segment elevation after a Q-wave infarction is related to a lesser contractile reserve. This original finding, inconsistent with both ours and others data, can be explained by methodological limitations and patient selection. In fact, in Bodí’s study, in order to analyze the myocardial contractile reserve, only left ventriculography at low-dose dobutamine was used. Using this approach, instead of echocardiography, continuous monitoring of the wall motion and thickening throughout the stress cannot be performed, thus leading to a reduction in the sensitivity for viability assessment.

In our study a significant correlation was found between ST-elevation and the improvement in baseline segmental wall thickening throughout the stress cannot be performed, thus leading to a reduction in the sensitivity for viability assessment.

In our study a significant relationship between biphasic myocardial response and ST-segment elevation during DSE. In 19 patients who did show ST-segment elevation during DSE, 11 patients had a biphasic response.

We showed that combining ST-elevation during DSE with echocardiographic parameters of preserved viability (the improvement in baseline SWMA at low dose dobutamine) improves the sensitivity, specificity, and diagnostic accuracy of either technique alone for predicting spontaneous functional recovery. However, we did not compare sensitivity, specificity, and diagnostic accuracy between DSE alone and ST-elevation during DSE, or the combination of both; that might be considered one limitation of this study.

5. Conclusion

Dobutamine induced ST-segment elevation occurring in electrocardiographic leads exploring an infarct area is a predictor of spontaneous contractile recovery after AMI particularly when combined with echocardiographic parameters of preserved contractile reserve.

References


