Usefulness of ST Segment Depression Limited to the Recovery Phase of Exercise Stress Test

Muhammad Ammar Rashid, Nadeem Hayat Mallick, Saima Naz Alam, Ahmed Noeman, Asma Ehsan and Aamir Hussain

ABSTRACT

Objective: To determine the diagnostic value of ST segment depression limited to recovery phase of Exercise Tolerance Test (ETT).

Study Design: An observational cross-sectional study.

Place and Duration of Study: The study was carried out at Punjab Institute of Cardiology, Lahore, from March to August 2007 for a period of 6 months.

Methodology: In this study, 100 patients were selected with purposive non-probability sampling technique and were divided into two groups, group A having ST segment depression during exercise phase of ETT, and group B having ST segment depression only in recovery phase after undergoing ETT according to Bruce protocol. The patients were subjected to coronary angiography later on. The chi-square or Fischer’s exact test of significance was applied at 0.05 level of significance to compare the coronary angiographic finding between two groups. Diagnostic value of ST segment depression was computed keeping angiographic finding as Gold standard.

Results: There were no major differences between the two groups regarding angiographic finding. Significant coronary artery stenosis (> 50% narrowing) was found in 68 (93%) patients of group A and 23 (85%) patients of group B (p=0.18). Three vessel disease was found in 30 (41%) patients in group A and 7 (26%) patients in group B (p=0.08). Left main stem disease was found in 5 (6.8%) patients of group A and 1 (3.7%) patient of group B. Normal coronaries were found in 6% of patients among group A and 14% of patients among group B (p=0.12). Specificity, sensitivity, Positive Predictive Value (PPV) and Negative Predictive Value (NPV) of ST segment depression in recovery phase was 55, 25, 85 and 6 percent respectively (95% CI; 1.16 – 2.25).

Conclusion: In patients undergoing exercise stress test, ST segment depression occurring only in recovery phase of ETT has a diagnostic value largely comparable with that of ST segment depression induced during exercise phase of ETT. Thus careful evaluation of ST segment depression occurring only in recovery phase may add significantly to the clinical information derived from the results of ETT.

Key words: Exercise test. ST segment depression. Recovery phase.

INTRODUCTION

Ischemic heart disease remains a major public health problem. In USA alone, more than 2 million patients are admitted annually in hospitals for clinical suspicion of ischemic heart disease.1,2 Coronary Artery Disease (CAD) imposes physical, social and economic burden. It is amongst the leading causes of mortality and morbidity.3 Standard care for patients presenting to emergency room with chest pain is admission to coronary care unit.4 This results in fairly large number of unnecessary admissions because only one-third of these are found to have coronary artery disease.

Exercise-induced ST segment depression is considered reliable ECG finding for the diagnosis of obstructive coronary atherosclerosis.5-7 Exercise testing has an excellent safety record.8,9 Mortality is less than 0.01% and morbidity is less than 0.05%. Risk is less for low-risk patients, who are seen in emergency and undergo exercise testing for risk stratification.10 The predictive value according to American Heart Association for detection of coronary artery disease is 90%, if typical chest discomfort occurs during exercise with horizontal or downsloping ST segment depression of upto 1 mm or more.11-13 Sensitivity of exercise testing in patients with coronary artery disease is 68% and specificity is 77%. Recent approach is based on evidence that low-risk patients with suspected coronary event could be identified clinically by gender, age, symptoms, past history of coronary artery disease and electrocardiography.8,13 While the diagnostic and prognostic value of ST segment depression during exercise in ETT is well recognized, only a few studies have investigated the clinical importance of ST segment depression during the recovery phase of ETT.14 Coronary angiography is an expensive and invasive procedure, if ST segment depression during recovery phase of exercise phase of ETT can detect coronary heart disease patients.
The aim of this study was to determine the diagnostic power of recovery-only ST segment depression in consecutive patients who were referred for exercise testing because of suspected CAD and who underwent coronary angiography later on.

**METHODOLOGY**

This observational cross-sectional study was done at Punjab Institute of Cardiology (PIC), Lahore, from March to August 2007 with purposive non-probability sampling technique. A total of 100 consecutive patients who presented to the ETT department for the chest pain diagnosis with age > 30 years, either gender, and ST segment depression > 1 mm at 0.08 sec from J-point during exercise or recovery phase of ETT, were included in the study. Patients with prior history of coronary artery bypass graft, percutaneous intervention or Myocardial Infarction (MI), ECG abnormality at rest that could have interfered with ST segment analysis (atrial fibrillation, baseline ST segment depression greater than 0.5 mm, left bundle branch block and pace maker rhythm), and patients not consenting for the study were excluded. An informed consent was taken from all the patients. They were asked about the demographic information and subjected to ETT. All patients underwent a symptom and sign limited treadmill exercise stress test according to Bruce protocol. Indications for interruption of the test were crescendo angina, ST segment changes > 2 mm compared with baseline, clinically significant arrhythmias, hypotension (> 20 mmHg reduction in systolic blood pressure compared with a previous measurement) or hypertension (systolic blood pressure > 240 mmHg or diastolic blood pressure > 140 mmHg) in response to exertion, and other potentially dangerous clinical conditions (such as arrhythmias or dyspnea). The recovery phase of exercise always lasted 5 minutes, but it was prolonged, if clinically indicated. ST segment depression was considered to be significant when it was > 1 mm at 0.08 seconds from the J-point and was either horizontal or downsloping. After completion of the ETT, these patients were divided in two study groups; group A having patients with ST segment depression during exercise and group B having ST segment depression during recovery phase only. These patients with positive ETT were then referred for coronary angiography. The presence of coronary stenoses was assessed visually by experienced angiographers. A stenosis in a major coronary artery was considered to be significant when it was > 50% of the lumen diameter. The angiographic findings of both groups were also compared. Significant coronary artery narrowing was seen in Left Main Stem (LMS), Left Anterior Descending (LAD), Left Circumflex (LCX), Ramus Intermedius (RI) and Right Coronary Artery (RCA).

The information obtained was analyzed by the SPSS version 13 for windows. Discrete variables i.e. gender difference and angiographic findings were compared by chi-square or Fischer’s exact test analysis, whereas unpaired student’s t-test was used to compare the age difference between two groups. A probability value of p < 0.05 was required for significance. The ST segment changes of two groups were cross tabulated with the results of coronary angiography. Specificity, sensitivity, positive predictive value and negative predictive value was computed to evaluate the diagnostic values of recovery-only, compared with effort induced ST segment depression keeping angiographic finding as Gold standard.

**RESULTS**

Out of the 100 patients, 84 were males and 16 were females with male to female ratio of 7:1. The mean age was 51±19 years. Mean age in group A was 46±13 and in group B 48±18 years (p=0.18). There were 73 patients in group A and 27 patients in group B. All these patients underwent coronary angiography. Table I summarizes the main results of coronary angiography of both groups. Normal coronaries were found in 6% and 14% of group A and B patients respectively. Single vessel disease was found in 30% of patients of group A and 48% patients of group B, while double vessel disease was found in 23% of patients of group A and 11% of group B patients. Although triple vessel CAD was more prevalent in group A i.e., 30 patients (41%) it was also found in clinically relevant proportion of group B patients i.e., 7 patients (26%, p=0.08). Left main stem disease was found in 6.8% of group A patients and 3.7% of group B patients. There was no significant difference between the two groups in the presence of critical stenosis in Left Anterior Descending (LAD) artery, and it was found 80% in group A patients vs. 74% in group B (p=0.31), whereas group A had higher prevalence of disease in right coronary artery (52% in group A vs. 18.5% in group B, p=0.002). There were no major differences between the two groups. Significant coronary artery stenoses were found in 68 (93%) patients of group A and 23 (85%) patients of group B (p=0.19).

<table>
<thead>
<tr>
<th>Variables</th>
<th>Group A (n=73)</th>
<th>Group B (n=27)</th>
<th>p-value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of vessels</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nil</td>
<td>5 (6%)</td>
<td>4 (14.8%)</td>
<td>0.12</td>
</tr>
<tr>
<td>Single vessel</td>
<td>22 (30%)</td>
<td>13 (48%)</td>
<td>0.03</td>
</tr>
<tr>
<td>Double vessel</td>
<td>16 (23%)</td>
<td>3 (11.1%)</td>
<td>0.17</td>
</tr>
<tr>
<td>Triple vessel</td>
<td>30 (41%)</td>
<td>7 (26%)</td>
<td>0.08</td>
</tr>
<tr>
<td>Type of vessel</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LMS</td>
<td>5 (6.8%)</td>
<td>1 (3.7%)</td>
<td>0.48</td>
</tr>
<tr>
<td>LAD</td>
<td>59 (80.8%)</td>
<td>20 (74%)</td>
<td>0.31</td>
</tr>
<tr>
<td>LCX</td>
<td>43 (58.9%)</td>
<td>11 (40.7%)</td>
<td>0.08</td>
</tr>
<tr>
<td>RCA</td>
<td>38 (52%)</td>
<td>5 (18.5%)</td>
<td>0.022</td>
</tr>
<tr>
<td>RI</td>
<td>3 (4.1%)</td>
<td>2 (7.4%)</td>
<td>0.51</td>
</tr>
</tbody>
</table>

LMS: left main stem, LAD: left anterior descending, LCX: left circumflex, RCA: right coronary artery, RI: ramus intermedius. * by Fischer’s exact test and chi-square test.
Of the 100 patients who had abnormal ST segment responses, 27 had such responses only during recovery. The positive predictive value of this pattern for significant angiographic disease (85%) was not statistically different from the predictive value of ST depression occurring during exercise (93%). Inclusion of ST depression during recovery significantly increased the sensitivity of the exercise test from 60% to 69% (p=0.04) without a change in predictive value. In addition, ST segment depression occurring only during recovery is more associated with single vessel coronary artery disease (positive predictive value=0.48, p=0.03). Diagnostic value of ST segment depression is given in Table II.

Table II: Diagnostic value of ST segment depression in group A and group B to detect coronary artery disease.

<table>
<thead>
<tr>
<th></th>
<th>CA* stenosis</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>PPV</th>
<th>NPV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group A (n=73) &gt; 50%</td>
<td>74</td>
<td>44</td>
<td>93</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>Group B (n=27) &gt; 50%</td>
<td>25</td>
<td>55</td>
<td>85</td>
<td>6</td>
<td></td>
</tr>
</tbody>
</table>

CA*: coronary artery, PPV: positive predictive value, NPV: negative predictive value.

DISCUSSION

The diagnostic value of ST segment depression is well studied in many group of patients internationally,13-15 as well as in Pakistan.7-8 However, the clinical usefulness of ST segment depression limited to recovery phase of exercise stress test is poorly understood. There are no international guidelines as to how these findings should be considered. ST segment is part of ECG tracing immediately succeeding QRS complex and its depression is considered significant, if it is depressed more than 1 mm at 0.08 second from J-point and is either downsloping or horizontal.16-17 Screening with ECG and ETT could potentially reduce CHD events either by detecting people at high-risk for CHD events who could benefit from more aggressive risk factor modification, or by detecting people with existing severe CAD whose life could be prolonged by Coronary Artery Bypass Graft (CABG) surgery or PCI. However, the current evidence is inadequate to determine the extent to which people detected through screening in either situation would benefit from either type of intervention.

Whether ST segment depression in recovery phase alone adds to positive predictive value of ETT was not proved to be true as the data suggest that the diagnostic value of ST segment depression only in recovery phase of exercise stress test is almost similar to ST segment depression occurring during exercise phase of ETT. Although, it increased the sensitivity but positive predictive value was same. The reason for appearance of ST segment depression in the recovery phase rather than exercise is unclear. So as in previous studies, it could not be predicted clinically. This also highlights that recovery only ST segment depression has frequent occurrence. So if patients develop ST segment depression during recovery phase of ETT, this should also be carefully assessed in patients of suspected or documented CAD and should be prolonged to at least 5 minutes and more, if needed.

In this study, 100 patients were included who came to ETT department for chest pain diagnosis and their ETT was done according to Bruce protocol and was proved to be positive. In group A, those patients were included who had ST segment depression during exercise phase of ETT and in group B patients having ST segment depression only in recovery phase were included. These patients underwent coronary angiography later on. Any vessel disease was found in 93% of group A and 85% of group B. Although severe CAD (3-vessel disease or LMS disease) was more prevalent in group A (41% and 6.8%), it was also found in clinically relevant proportion of patients of group B (26% and 3.7% respectively). The results were merely comparable with some of the international studies. A similar study by Lanza, et al. showed any vessel disease in 85% of patients in group 1 having ST segment depression during exercise phase of ETT and 78% of group 2 having recovery only ST segment depression, while severe CAD was found in 29% patients of group 1, and 18% of group 2.11 Another study by Lachterman and colleagues published in 1990 showed prevalence of severe CAD in 32% of exercise induced ST segment depression patients and 19% of recovery only ST segment depression patients.15

The consequences of false-positive tests may potentially outweigh the benefits of screening. False-positive tests are common among asymptomatic adults, especially women, and may lead to unnecessary diagnostic testing, over treatment, and labeling. Because the sensitivity of these tests is limited, screening could also result in false-negative results. A negative test does not rule out the presence of severe CAD or a future CHD event.18-19 Potential harms of screening asymptomatic patients for CHD include unnecessary invasive testing (for example, coronary angiography) and “labeling” of those who have had false-positive test results. In low-risk asymptomatic populations, most positive ECG test results occur in those who will not have a CHD event in the next 5-10 years.20

One of the limitations of this study was that different variables regarding risk factors of CAD like diabetes, hypertension and smoking etc. were not studied. It is not known whether these variables could effect different phases of ETT and severity of CAD. Another limitation was the use of medicines as many patients were on different cardiac medicines like beta-blockers, calcium channel blockers etc. These medicines might have influenced exercise results. However, it is not known whether any medicine can significantly affect exercise or recovery phase. In this study, the prognostic value resting only ST segment depression was not studied.
Whether these patients had different outcome than exercise induced ST segment depression patients, needs further studies.

CONCLUSION
The occurrence of ST segment depression during the recovery period only, does not generally represent a "false-positive" response. The inclusion of findings from this period increases the diagnostic yield of the exercise test. So in patients undergoing exercise stress test, ST segment depression only in recovery phase of ETT has a diagnostic value largely comparable with that of ST segment depression induced during exercise phase of ETT. Thus, careful evaluation of ST segment depression only in recovery may add significantly to the clinical information derived from the results of ETT.

REFERENCES