Evaluation of the Relation between Electrocardiographic Changes during Exercise Test and Anatomy of Coronary Artery in Coronary Angiography

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Abstract

Background and Objectives- Although exercise test is a highly reliable procedure for diagnosis of coronary artery disease (CAD), its value in assessing the extent and severity of CAD is yet unexplained. The present study aims to examine the relation between severity of ST segment depression in treadmill exercise test and left ventricular performance, number of involved arteries and severity of coronary artery disease.

Patients and Methods- This prospective, cross-sectional case control study of 103 patients was conducted in 1995 at Shahid Rajaie Heart Center, Tehran, Iran. The inclusion criteria were a) having stable angina pectoris, having abnormal exercise test findings, being a candidate for coronary angiography and b) having abnormal coronary angiography findings and being a candidate for exercise test. Any evidence of unstable angina pectoris, or history of myocardial infarction or other heart disease comprised the exclusion criteria.

Findings- ST segment depression in V4-V6 chest leads upon exercise test were meaningfully related to triple-vessel disease. However, no relation was found between severity and timing of ST segment depression in exercise test and triple-vessel disease. Depression of ST segment in the inferior chest leads with exercise test was an indicator of single-vessel disease; nevertheless, it did not suggest the disease of any particular vessel. No relation was observed between ST segment depression in exercise test and left ventricular dysfunction. The prevalence of ST segment elevation during exercise test was low and there were no statistically significant findings. (***Iranian Heart Journal.*** **2002; 2(4)&3(1): 20-24)**

Keywords: exercise test < ST segment depression < coronary artery disease

Exercise is a physiological stress, which in addition to its documented benefits in preventing a lot of disorders, can be of great diagnostic value when undertaken in a controlled fashion at a center properly equipped with exercise test facilities. Diagnosis of coronary artery disease during rest in some cases is not possible, so the treadmill exercise test (ET) is used to diagnose and assess the prognosis and extent of coronary artery disease, and determines the patient's exercise capacity. Electrocardiographic changes during ET, i.e. elevation or depression of ST segment in different chest lead groups, exercise-induced hypotension, and the development of chest pain are indicatives of coronary occlusion.[1] Electrocardiographic changes often are manifested in V5 - V6 chest leads.[2]

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The following criteria are suggestive of the involvement of more than one coronary vessel and herald a poor prognosis: a short exercise time and early beginning of exercise-induced chest pain, inability to raise blood pressure to 120 mmHg, lowering of blood pressure to the level prior to ET, inability to raise systolic blood pressure by 10 mmHg, ST segment depression >2 mm, involvement of more than 5 leads and persistence of electrocardiographic changes for more than 5 minutes. Unlike ST segment elevation, which in certain leads provides a clue to the site of coronary occlusion, ST segment depression does not show this purpose.[1]

Previous studies about exercise test in the literature revolve around the following topics: a) ET as a diagnostic tool, b) ET as a highly valuable tool for assessing prognosis, especially following myocardial infarction, c) the relation between physiological tests (ET) and anatomical evaluations (coronary angiography), which is the subject of the present study. Coronary angiography is undoubtedly the best tool for revealing coronary lesions, however, the high costs and invasiveness of this procedure, and the strong relation between coronary lesions and physiological dysfunction favor more frequent use of ET for diagnosing coronary artery disease. The present study was undertaken with the objective of using exercise test findings to assess the extent of coronary artery disease, applying conservative medical treatment for low risk patients, and administering coronary angiography and further therapeutic measures for those identified as high risk patients.

The main objectives of this study are as follows: investigating the relation between severity of ST segment depression during exercise test and left ventricular performance, investigating the relation between severity of ST segment depression during exercise test and the number of involved vessels, and investigating the relation between severity of ST segment depression during exercise test and the severity of coronary artery disease.

A number of studies have examined the relation between severity of ST segment changes and the anatomy of coronary artery lesions. In a comparative study of 12-lead chest electrocardiography and precordial mapping during exercise test involving 19 patients with single-vessel disease and 61 patients with multiple-vessel disease in 1976, Fox et al. concluded that single-vessel disease of left anterior descending artery (LAD), right coronary artery (RCA), and left circumflex artery (LCX) are correlated with depression of ST segment in anterior precordial leads (V1-V4), inferior leads (D2, D3, AVF), and lateral leads (D1, AVL V5, V6), respectively. They also found that ST segment depression in all these regions (anterior, inferior and lateral) is suggestive of triple-vessel disease.[3]

In 1982, Fuchs et al. in another study concluded that the region where ST segment depression is seen is not helpful in localizing coronary artery lesions.[9] Longhurst et al. found in their extensive study that ST segment elevation has a low prevalence and its presence in V1-V4 chest leads favors LAD lesions. However, ST segment elevation in the inferior and lateral chest leads was not correlated with the occlusion of the respective coronary arteries.[5] Goldman et al. concluded that the severity of ST segment depression during exercise test could serve as a basis for differentiating between low-risk patients and those with advanced coronary disease (involvement of three vessels or proximal LAD lesion) and hence had a poor prognosis.[6]

Patients and Methods

The Patients were 103 patients (96 men and 7 women) among patients with

abnormal exercise test findings, who presented to Chamran Cardiology Center to undergo coronary angiography or those who had documented coronary disease (confirmed by coronary angiography) and were candidates for exercise test. 103 patients (96 male and 7 female) with the following characteristics were selected for the study: 1) Patients with coronary artery disease (documented by coronary arteriography) and abnormal exercise test findings, 2) No history of valvular heart disease or previous congenital or genetic heart disease. Exclusion criteria included lack of evidence of the presence of the following conditions: left ventricular hypertrophy, severe aortic stenosis, severe hypertension, hypertorphic cardiomyopathy, anemia, hypokalemia, severe hypoxia, recent consumption of digoxin, sudden strenuous exercise, glucose consumption, mitral valve prolapse, left bundle branch block, intraventricular conduction disease, pacemaker rhythm, ST-T segment changes, T wave changes in resting state electrocardiogram and situations that exercise test are contraindicated.

Exercise test was conducted according to the standard Bruce protocol by using the METs (Metabolic Equivalent) coefficient. The exercise test was considered abnormal in the following conditions: J-point depression = 1 mm or 0.1 mV relative to the isoelectric line (PQ interval was accounted), ST segment slope < 1 mm/sec and its persistent decline ≥ 1 mm, 60-80 milliseconds after the J-point in three consecutive complexes. All patients were normal in respect of electrolyte balance. Beta-blockers or calcium channel blocker drugs were discontinued 48 hours prior to the exercise test. Neither of the patients had a history of receiving digoxin. The exercise test was performed and the results were interpreted by at least two cardiologists. Selective coronary angiography was conducted in different views using the Judkin's technique. Two

cardiologists who were unaware of ET results interpreted each view separately. Obstruction of more than 75% of the coronary cross-section was considered as significant stenosis. Left ventricular angiography was mostly conducted in the right anterior oblique view (RAO). Left anterior oblique view (LAO) angiography was conducted for patients with left ventricular regional wall motion abnormality (RWMA) upon echocardiography. Ejection fraction (EF) was calculated after measurement of left ventricular volume in echocardiography with Simpson's method.[7] The relation between ST segment depression and coronary artery occlusion was examined using the Chi Square statistical test, with P value < 0.05 considered as the accepted hypothesis.

Results

ST segment depression was seen in 43% of V4-V6 chest leads, 39% of inferior leads, 9.5% of D1 and AVL leads and 8.5% of V1-V3 leads. Distribution of single-vessel coronary artery disease in 18 patients was as follows (Table 1): 13 and 4 patients had disease of LAD and LCX disease, respectively. RCA was affected in one patient. Distribution of marked coronary occlusion was as follows: 15 patients had disease of RCA and LAD, 6 had disease of RCA and LCX, and 17 had disease of LAD and LCX. 20% of patients had triple-vessel disease and left main (LM) coronary lesion.

Table I. Distribution of involved coronary arteries according to number of involved vessels

Number of involved Arteries	Number of patients	Percentage of patients
Single-vessel disease	18	17%
Two-vessel disease	38	37%
Triple-vessel disease	40	39%
Normal	7	7%
Total	103	100%

Distribution of ejection fraction in the patients was as follows: EF≥60% in 65 patients, 40%<EF<60% in 25 patients,

20%<EF<40% in 10 patients, and below 20% in 3 patients.

1) ST segment depression in V4-V6 chest leads strongly favors occlusion of all three coronary vessels (P<0.05).

2) ST segment depression in the inferior chest leads during exercise test favors single-vessel coronary disease, regardless of the type of coronary artery (0.1<P<0.05).

3) Severity of ST segment depression and its timing in exercise test is not related to EF.

4) Triple-vessel occlusion is not related to ST segment depression in other leads during the exercise test.

5) Triple-vessel occlusion is not related to the severity and timing of ST segment depression during the exercise test

6) Occlusion of two coronary vessels is not related to ST segment depression in any of the 12 chest leads.

7) Single vessel disease is not related to ST segment depression in 12 chest leads.

8) ST segment elevation was not a frequent finding in this study; nevertheless, other studies have reported a prevalence of up to 9% for ST segment elevation.

Discussion

The diagnostic and therapeutic approach to patients with ischemic heart disease entails taking history of the disease, physical examination, electrocardiography at rest, routine exercise test, thallium perfusion scanning combined with exercise test and finally angiography. The value of patient history in predicting different types of angina pectoris is 82-87% and 42-70% in men and women, respectively.[8] However, the value of history in diagnosis of cardiac ischemia remains limited owing to the influence of such factors as the patient-physician relation, denial reaction, hysteria, varying thresholds of pain, different life-styles, amount of physical activity and the presence of silent or painless ischemia. Physical examination is of low sensitivity and specificity in diagnosing ischemic heart disease. Normal history findings in a patient with advanced disease may completely mislead the physician. Resting state electrocardiogram is normal in 70% of the patients with stable angina.[4] It is also of low sensitivity and specificity in patients with other types of angina. Routine exercise test alone, or combined with thallium perfusion scanning are both valuable ways of detecting myocardial ischemia. The former reveals ischemia via physiological effects, and the latter does so through biochemical mechanisms (i.e. speed of thallium uptake and release by myocytes). Exercise test combined with thallium perfusion scanning is of high sensitivity and specificity in diagnosing ischemia. It is a fairly expensive and invasive procedure; nevertheless, it can localize the coronary lesions.[9] Coronary angiography in conjunction with left ventricular angiography remains the gold standard for diagnosis of coronary artery disease[1] (CAD), however, the diagnosis of ischemic heart disease[1] (IHD) and planning the correct treatment strategy occasionally necessitate physiological tests (ET alone, or combined with thallium perfusion scanning). Coronary angiography, on the other hand, is an expensive and invasive procedure, which cannot be used on a large scale.[2] Annual mortality rate due to single-vessel disease, LAD lesion, two-vessel disease, triple-vessel disease, and left main artery (LM) lesions stands at 2%, 4-8%, 7%, 11% and 15-20% respectively. The presence of lesion at the origin of LAD and LCX (equivalent of LM lesion) is associated with a mortality rate of nearly 11%.

The number of arteries with lesions, the number of special arteries with lesions, as well as distal branch lesions or those affecting the main coronary trunk can be diagnosed with routine exercise test.

Hence, the exercise test can be used to identify patients who require invasive treatment (i.e. percutaneous coronary intervention or coronary artery bypass graft). Given the large sample volume in this study, it can be concluded that the likelihood of observing abnormal exercise test findings increases with the number of diseased arteries (higher sensitivity). ST segment depression in exercise test is more marked in V4-V6 (81%) and inferior chest leads (74%). This is consistent with findings of previous studies.[4] ST segment depression in V4-V6 chest leads during exercise test is strongly suggestive of triple-vessel disease. ST segment depression in the inferior leads during exercise test may favor single-vessel disease, regardless of the type of involved artery. ST segment elevation in exercise test has a low prevalence. In spite of documented correlation between ST segment elevation and anatomical coronary artery disease,[10] reexamining this correlation was not possible owing to the small number of patients who developed ST segment elevation during exercise test in the present study. ST segment depression was observed in 96% of patients. There was no strong correlation between left ventricular performance and severity of ST segment depression during exercise test in this study. Neither was there a correlation between severity and timing of ST segment depression during exercise test, and triple-vessel disease. Given that only 8 patients had lesion of left main trunk, the relation between LM lesion and ST segment depression could not be studied.

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