Validity of exercise treadmill test in diagnosis of coronary artery disease

Hassan Mohammed AL-Rubaye[1], Ahmad Abood AL-Maliki[2], Hassan Ahmed AL-Bawi [3.]

ABSTRACT

Background: **Exercise is commonly used as a physiological test to determine cardiovascular disorders not appearing at rest and to assess the functional status of the heart. It is a widely used non-invasive test for assessment of suspicious or proved cardiovascular disorders. It is mainly performed to clarify the prognosis and to assess the functional capacity, the possibility and severity of coronary artery disease (CAD), and the efficacy of treatment. Coronary angiograprhy is the standard method for diagnosis of coronary artery disease (CAD), and it determins the type of therapy according to severity of coronary involvement wether by medical therapy, percutanous coronary intervention (PCI), or coronary artery bypass grafting (CABG) surgery in patients with CAD.**

Aim: **To estimate the sensitivity, specificity, positive and negative predictive values and accuracy of exercise treadmill test in diagnosis of coronary artery disease.**

Methods: **Exercise treadmill test and coronary angiography were performed on 77 consecutive patients (men and women), age range between 30-70 years, they were evaluated at Basrah Cardiac Center (February-June-2012). Both examinations were performed primarily for diagnostic reasons. All clinical data and results of ECG and exercise treadmill test were collected before coronary angiography.**

Results: **The total number of patients included in the study was 77; mean age was 56.9 ± 8.9 years. The mean age for men was 57.0 ± 8.7 years (n= 53), women had a mean age of 56.0 ± 9.5 years (n=24), 90.9% of patients had CAD risk factors. Hypertension was the frequent risk factor present in 72% of patients. Exercise test was positive in 75.3%, negative in 20.8%, pseudonormalization in 3.9%. The sensitivity and positive predictive value of the test were 88% and 79% respectively, while its specificity, negative predictive value and accuracy were 46%, 63% and 75% respectively.**

Conclusion: **Exercise test is a relatively safe, non- invasive and valuable test in the diagnosis of CAD in patients with signs and symptoms of this disease, but still considered below the coronary angiography (which is the gold standard method) for the diagnosis of CAD. The sensitivity of the test increases as the number of diseased coronary arteries increases as in left main and three vessel diseases. ST depression in women with abnormal resting ECGs is probably of less diagnostic value than in men, false positive and false negative tests were more common in women than men.**

Key words: **Exercise Treadmill Test, Coronary Angiography, Coronary Artery Disease.**

قيمة فحص اجهاد القلب في تشخيص مرض تصلب الشرايين التاجية

المقدمة: يعتبر فحص اجهاد القلب من الفحوصات الفيسيولوجية الغير اجتياحية الشائعة التي تستعمل لتشخيص الاختلالات القلبية الوعائية الغير موجودة في حالة الاستراحة، وكذلك لتقييم كفاءة عمل القلب، حيث يستعمل لتحديد وتخمين السعة الوظيفية للمريض، احتمالية وشدة تصلب الشرايين التاجية وكذلك كفاءة العلاج الدوائي ،ولكن تبقى القسطرة القلبية هي الفحص الاساسي لتشخيص مرض تصلب الشرايين التاجية ويبين المعلومات التشريحية الدقيقة التي على ضوؤها يحدد العلاج الدوائي او التداخل القسطاري او التداخل الجراحي لمرض تصلب الشرايين التاجية.

الهدف: دراسة الحساسية، الخصوصية،القيمة التنبؤية الموجبة والسالبة والدقة لفحص اجهاد القلب في تشخيص مرض تصلب الشرايين التاجية.

طرق العمل: تم اجراء فحص اجهاد القلب والقسطرة القلبية لـ ٧٧ مريض (رجال ونساء) تتراوح اعمارهم بين ٣٠–٧٠ سنة في مركز البصرة لطب وجراحة القلب للفترة من شباط الى حزيران ٢٠١٢. كل المعطيات السريرية ونتائج فحص اجهاد القلب تم جمعها قبل اجراء القسطرة القلبية.

النتائج: العدد الكلي للمرضى المشمولين بهذه الدراسة هو ٧٧ مريض، متوسط العمر ٥٦،٩±٨،٧ سنة، الرجال (٥٣) ٥٧±٨،٧ سنة، النساء (٢٤) ٥٦±٩،٥ سنة. ٩٠،٩% لديهم عوامل خطورة، بينما ٩،١% ليس لديهم عوامل خطورة. ارتفاع ضغط الدم كان اكثر عوامل الخطورة شيوعا وكان موجود في٧٢% من المرضى، فحص اجهاد القلب كان موجب في ٧٥،٣%، سالب في ٢٠،٨%، التطبيع الكاذب ٣،٩%. الحساسية =٨٨%، الخصوصية ٤٦%، القيمة التنبؤية الموجبة =٧٩%، القيمة التنبؤية السالبة =٦٣%، الدقة =٧٣%.

الاستنتاج: فحص اجهاد القلب اقل دقة من القسطرة القلبية التي تعتبر الفحص الاساسي والدقيق في تشخيص مرض تصلب الشرايين التاجية.حساسية فحص اجهاد القلب تزداد مع ازدياد عدد الشرايين المتصلبة كما في حالات تصلب الجذع الايسر وتصلب الشرايين التاجية الثلاث.النتائج الموجبة الكاذبة والسالبة الكاذبة اكثر شيوعا في النساء مقارنة بالرجال.

[1]Cardiologist -Basrah Cardiac Center
[2,3] Internist-Department of Medicine-Al-Fayhaa General Hospital

INTRODUCTION

The diagnosis of coronary artery disease can be obtained usually by history taking and functional tests. Exercise treadmill test is a relatively safe, not expensive and can be easily performed and interpret.[1] The appropriateness of exercise test for a patient depends on his symptoms, presence of significant illnesses, drug therapy, and physical activity.[2] The report of the test includes the achieved level of exercise, maximal heart rate, electrocardiographic changes, arrhythmias, vital signs and symptoms.[2] Interpretation of the exercise test should include the capacity of exercise obtained, the extent of ST segment deviation and hemodynamic and clinical responses to exercise.[3] The exercise test alone and in combination with other non-invasive tests can be considered as an essential test due to its high functional, diagnostic and prognostic informations. The coronary angiography is considered as the gold standard test for diagnosis of CAD. Understanding exercise physiology and pathophysiology in addition to expertise in electrocardiography is essential for interpretation of exercise test result.[4] There are many protocols used for performing exercise test, of which the Bruce protocol is the commonest on.[5] ST segment depression during exercise testing wether horizontal or down sloping is the most reliable sign of ischemia.[6] The result of exercise test includes positive, negative, equivocal and uninterpretable, and in case of equivocal and uninterpretable results, further investigations are indicated to confirm the diagnosis of CAD.[2]

The Aim: To estimate the sensitivity, specificity, positive and negative predictive values and accuracy of exercise test in diagnosis of coronary artery disease.

METHODS

Exercise treadmill test and coronary angiography were performed on 77 consecutive patients (men and women) aging 30-70 years in a cross-sectional study. All attending patients were evaluated at Basrah Cardiac Center from February-June-2012. This study was performed primarily for diagnostic reasons to confirm the presence of coronary artery disease. The coronary angiography was considered as the gold standard method for diagnosis of coronary artery disease. Patients with stable angina, unstable angina, non ST elevation myocardial infarction (NSTEMI) and ST elevation myocardial infarction (STEMI) were included in this study. The presenting symptoms of patients were either typical chest pain (retrosternal, exertional and relieved by rest or sublingual nitroglycerine) or angina equivalent (palpitation, easy fatiguability, dyspnea on exertion, nausea and vomiting). All patients were underwent exercise treadmill test according to standard Bruce protocol. Coronary angiograms were performed by standard Judkin technique (via femoral artery) or Sons technique (via Brachial artery), they were interpreted independently by the catheterizing cardiologist. Only patients with $\geq$ 50% stenosis in at least one of the three major arteries (left anterior descending artery, left circumflex artery, and right coronary artery) or their first-order branches was considered as a positive coronary angiography. The data were analysed by using SPSS version 16. The results of all quantitative data were expressed as mean $\pm$ SD. Sensitivity, specificity, positive and negative predictive values and accuracy were calculated. All clinical data and results of exercise tests were collected before coronary angiography and were evaluated without knowledge of the results of coronary angiography.

RESULTS

The total number of the patients in this study was 77 patients, 90.9% of them had CAD risk factors, while 9.1% were devoid of CAD risk factors, 72.7% of the patients had hypertension,

55% had obesity, 39% had sedentary life style, 33% had diabetes, 32% were smokers, 11.5% had family history of premature CAD and 3.9% were heavy alcoholics.

The mean age was 56.9 ± 8.9 years, 53 (68.8%) patients were males, mean age 57.0 ± 8.9 years and 24 (31.2%) patients were female, mean age 56.0 ± 9.5 years.

Clinically, 65% of patients had stable angina, 16% had unstable angina, 10% had NSTEMI (Non ST Elevation Myocardial Infarction), 9% had STEMI (ST Elevation Myocardial Infarction). Exercise test was positive in 75.3% of patients, negative in 20.8% of patients, Pseudonormalization in 3.9%. False negative in females= 12.5%, false negative in males= 5.6%, false positive in female= 29.4%, false positive in males= 21%, Sensitivity= 88%, Specificity= 46%, Positive predictive value= 79%, Negative predictive value=63%, Accuracy 75%.

Table 1. Demographic and clinical characteristics of population under study.

Variables	No. of patients	Frequency %
Male	53	68.8
Female	24	31.2
Hypertension	56	72.7
Diabetes	26	33
Smoking	25	32
Obesity	43	55
Sedentary life style	30	39
Heavy alcohol consumption	3	3.9
Family history of premature CAD	9	11.7
Stable angina	50	64.1
Unstable angina	12	15.6
NSTEMI	8	10.4
STEMI	7	9.1
Typical chest pain	61	79.2
Dyspnea on exertion	50	64.0
Palpitation	19	24.7
Easy fatigability	12	15.6
Nausea and vomiting	1	1.3
Baseline ECG abnormalities	11	14.3
Positive exercise test	58	75.3
Negative exercise test	16	20.8
Pseudonormalization	3	3.9

Table 2. The results of exercise treadmill test and coronary angiography.

Results of coronary angiography	Results of exercise test			Total
	Positive Test	Negative Test	Pseudonormalization	
Patients with proved coronary lesion(s)	True Positive = 46(59%)	False Negative = 6(7.7)	3(3.9%)	55(71.)
Patients with normal coronary arteries	False Positive =12(15.6%)	True Negative = 10(13%)		22(28.)
Total	58(75.3%)	16(20.7%)	3(3.9%)	77(100)

Sensitivity=88%
Specificity=46%
Positive Predictive Value=79%
Negative Predictive Value=63%
Accuracy=75%

DISSCUSION

The traditional risk factors for coronary artery disease are hypertension, hypercholesterolemia, diabetes mellitus, cigarette smoking, family history of premature coronary artery disease and obesity. In our study, hypertension was more prevalent in exercise test positive group than negative group. Typical chest pain was the most common presentation of patients with ischemic heart disease and most significantly indicate ischemia. The diagnostic accuracy of exercise test varies, depending upon the age, gender, and clinical characteristics of the patient, prevalence of CAD and modality of the test used, it is more useful at excluding CAD than confirming it.[7] The sensitivity of exercise test ranges from 61%-73% and specificity ranges from 59%-81% as reported by different studies.[8] A meta-analysis of 58 consecutively published reports including 11,691 patients who underwent exercise test and coronary angiography showed wide variation in specificity and sensitivity with mean sensitivity was 67% and mean specificity was 72%.[8] The sensitivity and specificity of exercise test for detection of CAD are 78% and 70% respectively.[6] It is reported that the sensitivity of exercise test in single-vessel CAD patients ranges from 25%-71%, and patients with multi-vessel CAD the sensitivity and specificity are 81% and 66% respectively, while the sensitivity and specificity of those patients with left main or three-vessel CAD are 86% and 53% respectively.[9] ST–segment depression and exercise induced chest pain are the most important factors in the diagnosis of CAD.[10] Our study showed high sensitivity (88%) comparing to specificity (46%) which may reflect the severity of CAD patients examined in the study as the sensitivity increases as the number of diseased coronary arteries increases. False negative results are more common in females (12.5%) than males (5.6%) and it is true for false positive result of exercise test which is high (29.41%) in females compared to (21.07%) in males, this made diagnosing coronary artery disease is more difficult in women than men. The sensitivity of exercise test for the diagnosis of CAD is low in women in comparison with men because of lower prevalence of severe CAD in women and most of women are unable to perform maximum aerobic capacity. [8] More than 50% of women assessed for angina pectoris have non-obstructive CAD (microvascular angina or syndrome X) which is proved by coronary angiography.[11] In elderly age group, the prevalence of severe CAD is high and exercise test in this age group is slightly of high sensitivity in comparison with younger age group, but slightly lower specificity due to

coexistence of left ventricular hypertrophy resulted from hypertension and valvular heart disease.[8] Pseudonormalization of T-wave (invertion of T- wave at rest and becoming upright at exercise test) is considered as a non-diagnostic sign of CAD, but in rare cases may be a sign of myocardial ischemia in patients with proved CAD.[9] T-wave normalization during exercise test seen in 10-15% of patients with abnormal T-waves on their baseline Electrocardiograms, and it is found that pseudonormalization has low sensitivity and poor positive predictive value for reversible myocardial ischemia.[12] Pseudonormalization noticed in our study in 3 of 77 patients and all of them had history of STEMI concomitantly have significant coronary artery disease on coronary angiography.

CONCLUSION

Exercise test is a relatively safe, non - invasive and valuable test in the diagnosis of CAD in patients with sign and symptoms of this disease, but still considered below the coronary angiography (which is the gold standard method) for the diagnosis of CAD. The sensitivity of the test increases as the number of diseased coronary arteries increases as in left main and three vessel disease. ST segment depression in women with abnormal resting ECGs is probably of less diagnostic value than in men. False positive and false negative results were more common in women than men. Pseudonormalization during exercise test in patients with ischemic heart disease may indicate severely obstructed coronary arteries and these patients should be treated on an urgent bases.

Limitations

This study was limited by its small sample size (77 patients). It also lacks information about heart rate variability and hemodynamic evaluations such as blood pressure. We combined existing data from several different hospitals and exercise treadmill test clinics.

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