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Validity of Positive Treadmill Test in Diagnosis of Coronary Artery Disease in Comparison With Coronary Angiography

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ABSTRACT

Background: Exercise stress test is commonly 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 CAD, and the efficacy of treatment. Coronary angiography is the standard method for diagnosis of CAD, and it determines the type of revascularization.

Objective: To estimate the sensitivity, positive values and accuracy of exercise treadmill test in diagnosis of CAD.

Methods: Exercise treadmill test and coronary angiography were performed on (70) patients (men and women), age range between 30-70 years, they were evaluated at Mosul. Al-Salam Hospital (1st of January 2018, to 1st of June 2018). All clinical results of ECG and exercise treadmill test were collected before coronary angiography.

Results: The total number of patients include in the study was 70, mean age was 54 ± 9 years. Males were more than females with male to female ratio as 3.3:1. , regarding risk factor of studied patients hypertension was most prevalent one 52.9% followed by family history 50% then dyslipidemia 37.1%. Exercise test was positive in 57 patients, equivocal in 13 patients. The sensitivity and positive predictive value of the test were 84.5% and 85.9% respectively, and accuracy were 75.7%.

Conclusion: Although appearance of new investigation in stress cardiac evaluation exercise test is remain easy and effective test in evaluation of coronary artery disease and use of duke treadmill score give an idea about severity of coronary artery disease involvement. The sensitivity of the test increases as the number of diseased coronary arteries increased.

Keywords: Coronary artery disease (CAD), Cardiovascular Disease (CVD), Circumflex artery (CX), Diabetes mellitus (DM), Duke treadmill scoring(DTS), Exercise Time(ET),

INTRODUCTION

Exercise testing is a cardiovascular stress test that uses treadmill bicycle exercise with electrocardiography (ECG) and blood pressure monitoring [1]. Pharmacologic stress testing, established after exercise testing , is a diagnostic procedure in which cardiovascular stress induced by pharmacologic agent is demonstrated in patients with decreased functional capacity or in patients who cannot exercise. Pharmacologic stress testing is used in combination with imaging modalities such as radionuclide imaging and echocardiography [2,3].

Exercise stress testing, which is now widely available at a relatively low cost, is currently used most frequently to estimate prognosis and determine functional capacity, to assess the probability and extent of coronary disease, and to assess the effects of therapy. Ancillary techniques, such as metabolic gas analysis, radionuclide imaging (see the image below), and echocardiography, can provide further information that may be needed in selected patients, such as those with moderate or prior risk [4] .

Exercise physiology

The initiation of dynamic exercise results in increase in ventricular heart rate, stroke volume, and cardiac output as a result of vagal withdrawal and sympathetic stimulation. Alveolar ventilation and venous return also increase as a consequence of sympathetic vasoconstriction. The overall hemodynamic response depends on the amount of muscle mass involved, exercise efficiency, conditioning, and exercise intensity [5].In the initial phase of exercise in the upright position, cardiac output is increased by an augmentation in stroke volume mediated through the use of the Frank-Starling mechanism and heart rate. The increase in cardiac output in the later phases of exercise is due primarily to an increase in ventricular rate [6] . During strenuous exertion, sympathetic discharge is maximal and parasympathetic stimulation is withdraw, resulting in auto regulation with generalized vasoconstriction, except in the vital organs (cerebral and coronary circulations) [7] .

Release of venous and arterial norepinephrine from sympathetic postganglionic never ending is increased, and epinephrine levels are increased at peak exertion, resulting in a rise in ventricular contractility. As exercise progresses, skeletal muscle blood flow increases, oxygen extraction. Increases as much as 3-fold, peripheral resistance decreases, and systolic blood pressure (SBP), mean arterial pressure, and pulse pressure usually increase. Diastolic blood pressure (DBP) remains unchanged or may increase or decrease by approximately 10 mm Hg [8] .

The pulmonary vascular bed can accommodate as much as a 6-fold increase in cardiac output, with only modest increase in pulmonary arterial pressure, pulmonary capillary wedge pressure, and right atrial pressure, this is not a limiting determinant of peak exercise capacity in healthy subjects, Maximum heart rate and cardiac output are decreased in older individuals, in part because of decreased beta-adrenergic responsiveness. Maximum heart rate can be calculated by subtracting the patients age (in years) from 220 (standard deviation, 10-12 beats/min) [7].

The age-predicted maximum heart rate is a useful measurement for safety purposes and for estimating the adequacy of the stress to evoke inducible ischemia. A patient who reaches 80% of the age-predicted maximum is considered to have a good test result, and an age-predicted maximum of 90% or better is considered excellent [9] .

The coronary angiography is considered as the gold standard test for diagnosis of CAD, coronary angiograms were performed by standard Judkin technique (via femoral artery). They are many protocols used for performing exercise test, of which the Bruce protocol is the commonest one.[12] ST segment depression during exercise testing wither horizontal or down sloping is the most reliable sign of ischemia [13] .

The primary goal of this study:

1- To assess the correlation between the results of exercise test and result of coronary angiography.
2- To assess correlation between exercise parameters and severity coronary artery disease.

PATIENTS AND METHODS

Study design and settings

A cross sectional study carried out in Mosul. Al-Salam Hospital Specialized Center for period from 1st of January 2018 to 1st of June 2018.

Population of the study

All patient with positive treadmill test during the study period were underwent coronary angiography in Erbil Cardiac Specialized Center.

Inclusion criteria

Consecutive 70 patients with positive and equivocal TMT.

Exclusion criteria

Patients with (bundle branch block, arrhythmia, acute and old MI, heart failure with low ejection fraction).

Sampling

A convenient sample of 70 patients mean age (54±9) with positive treadmill test and free of exclusion criteria was taken after their approval to participate In the study.

Data collection

The data were collected through direct interview and fulfilling a prepared questionnaire as shown in (figure1) at end of chapter.

After history and clinical examination, the patients were evaluated by resting ECG, Echo study and Exercise ECG performed on Treadmill using standard Bruce protocol, the starting point (stage 1) is 1.7mph at 10% grade (5MET), (Stage 2) is 2.5mph at 12% grade (7MET), (stage 3) is 3.4mph at 14% grade (9MET) this protocol include 3 min period to allow achievement of study state before workload increased [15].

Exercise continued without interruption until the occurrence of: symptom limiting angina, arrhythmia, severe fatigue, symptom limiting dyspnea. The patient who reached 80% of age-maximum predicted heart rate was included in this study (220 minus age in years) [16]. Interpretation should include exercise capacity and clinical, hemodynamic, and ECG response. The occurrence of ischemic chest pain consistent with angina is important, particularly if it forces termination of the test.

The results of exercise test include positive, negative, equivocal and uninterruptable.
The classic criteria for visual interpretation of positive stress test finding include the following:

- J point – This is defined as the junction of the point of onset of the ST-T wave; it is normally at or near the isoelectric baseline of the ECG
- ST80 – This is defined as the point that is 80 (millisecond) from the J point
- Depression of 0.1 mV (1mm) or more
- ST-segment slope within the range of ±1 mV/sec in 3 consecutive beats [8]

In current study patients with positive and equivocal Exercise ECG were advised for coronary angiography. The results of exercise ECG were compared with those of coronary angiography. Degree of coronary stenosis graded by angiography as critical stenosis (90%), significant stenosis (90% - 70%) or non-significant stenosis(70%) [20] .

RESULTS

A total 70 abnormal TMT patients were including in present study with mean age as 54±9 years, 47.1% of them were 50-59 years age. Males were more than females with male to female ratio as 3.3:1. Housewives represented 21.4%, public servants 27.1%, self-employed 25.7% and retired 25.7% of them.

Risk factors of cardiovascular diseases among patients were represented as following; dyslipidemia 37.1% smoking 40%, DM 17.1%, HT 52.9% and family history of CVD 50%, (Table 1).

Table 1: Risk factors of studied patients

Variable	No.	%
Dyslipidemia		
Yes	26	37.1
No	44	62.9
Total	70	100.0
Smoking		
Yes	28	40.0
No	42	60.0
Total	70	100.0
DM		
Yes	12	17.1
No	58	82.9
Total	70	100.0
HT		
Yes	37	52.9
No	33	47.1
Total	70	100.0
Family history of CVD		
Yes	35	50.0
No	35	50.0
Total	70	100.0

Mean ET for patients was 5±1.7 min and mean ST change was 1.4±0.8 mm; 52.9% of angina index showed no angina pain, 14.2% showed non-limiting angina and 32.9% showed exercise limiting angina.

Mean heart rate at resting ECG was 77.4±10; one patient had LVH, 19 patients had ST/T changes and no one had arrhythmias and new bundle branch block.

Exercise ST changes present among 84.3% of positive TMT patients and 57.6% of them were at stage II. Mean blood pressure of positive TMT patients after exercise were 159.9/90.1±32.9/14.5 mmHg, 12.9% of them had dropped BP. All these finding were shown in (Table 2)

Table 2: Exercise ECG and blood pressure of patients.

Variable	No.	%
Exercise ST changes		
Yes	59	84.3
No	11	15.7
Total	70	100.0
Stages of ST changes		
L	8	13.6
Ll	34	57.6
lV	2	3.4
At recovery	15	25.4
Total	15	100.0
Blood pressure mean ±SD (159.9/90.1±32.9/14.5 mmHg)		
Dropped Bp	9	12.9
Increased Bp	61	87.1
Total	70	100.0
Maximum HR mean±SD (135±5.9 %)		

Transthoracic Echo revealed that mean ejection fraction was 61.3±6.4 %, 30% of them had segmental hypokinesia and 2.9% trivial value abnormality. All these findings were shown in (Figure 1).

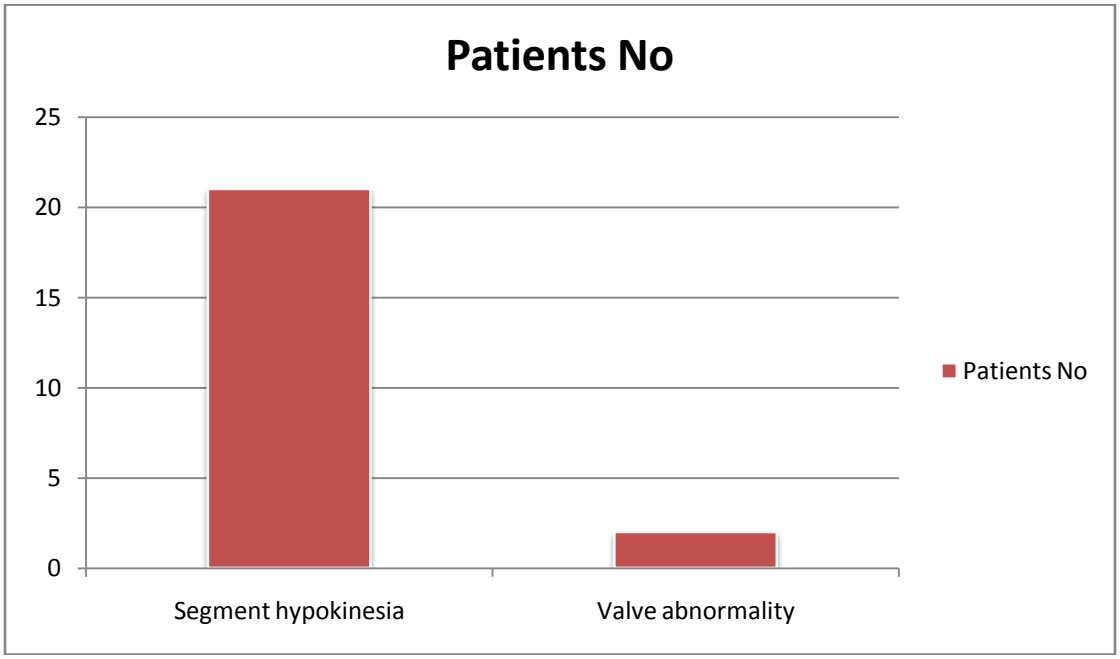

Figure 1: Echo findings.

Coronary angiography findings were abnormal for 82.9% of positive TMT patients. Critical stenosis lesions were found in LMS for 9 lesions of positive TMT, in LAD for 52 lesions, in CX for 27 lesions and in RCA for 37 lesions from total number of lesions. PCI was recommended for 54.3% of positive TMT patients, CABG for 18.6% of them and CABG versus PCI for 4.3% of them. All these findings were shown in (Table 3).

Table 3: Coronary angiography findings

Variable	No.	%
Coronary angiography		
Normal	12	17.1
Abnormal	58	82.9
Total	70	100.0
LMS		
Normal	61	87.1
Critical stenosis lesion	9	12.9
Total	70	100.0
LAD		
Normal	18	25.7
Critical stenosis lesion	52	74.3
Total	70	100.0
CX		
Normal	43	61.4
Critical stenosis lesion	27	38.9
Total	70	100.0
RCA		
Normal	33	47.1
Critical stenosis lesion	37	52.9
Total	70	100.0
Inervention		
No	16	22.8
PCI	38	54.3
CABG	13	18.6
CABG & PCI	3	4.3
Total	70	100.0

One vessel lesion was detected among 21 abnormal TMT, 2 vessels lesion as found among 12 abnormal TMT and 4 vessels lesion was detected among 5 abnormal TMT. More than two thirds of patients with abnormal angiography finings had critical lesions, 20.7% of them had significant lesions and 6.9% of them had non-significant lesions. All these findings were shown in (Table 4).

Table 4: Angiographic findings severity

Variable	No.	%
Angiography severity		
One vessel	21	36.2
Two vessels	12	20.7
Three vessels	20	34.5
Four vessels	5	8.6
Total	58	100.0
Degree of severity		
Critical	42	72.4
Significant	12	20.7
Non-significant	4	6.9
Total	58	100.1

As shown in (Table 5), abnormal LMS recording was significant associated with abnormal exercise ECG findings ($p=0.02$). Patients with critical stenosis lesions in CX and RCA were significantly had abnormal exercise ECG findings ($p<0.05$).

Patients with four vessels were significantly associated with abnormal exercise ECG (p=0.03). Patients with critical lesions had significantly abnormal ECG findings (p=0.003). A significant association was observed between high risk DTS scoring and abnormal exercise ECG findings of patients (p=0.02).

Table 5: Distribution of coronary angiography measurements and DTS scoring according exercise ECG findings

Variable	Equivocal TMT		Positive TMT		X^2	P
	No.	%	No.	%		
LMS					5.2*	0.02
Normal	9	13.3	52	86.7		
Critical stenosis lesion	4	44.4	5	55.6		
LAD					0.001	0.09
Normal	4	17.6	14	82.4		
Critical stenosis lesion	9	17.3	43	82.7		
CX					5.7*	0.1
Normal	11	26.2	31	73.8		
Critical stenosis lesion	2	3.7	26	96.3		
RCA					7.9	0.005
Normal	10	31.3	22	68.8		
Critical stenosis lesion	3	5.4	35	94.6		
Intervention					4.6*	0.2
No	3	18.8	13	81.3		
PCI	9	24.3	28	75.7		
CABG	0	-	13	100.0		
CABG&PCI	0	-	3	100.0		
Angiography severity					8.8*	0.03
One vessel	3	14.3	18	85.7		
Two vessel	5	41.7	7	58.3		
Three vessels	1	5.0	19	95.0		
Four vessels	0	-	5	100.0		
Degree of severity					11.9*	0.003
Critical	4	9.5	38	90.5		
Significant	2	16.7	10	83.3		
Non-significant	3	75.0	1	25.0		
DTS scores					7.4*	0.02
Low risk	3	50.0	3	50.0		
Moderate	10	20.4	39	79.6		
High risk	0	-	15	100.0		

Validity test of exercise ECG test for patients in comparison to coronary angiography findings revealed that the sensitivity of exercise ECG test was 84.5%, +ve predictive value 85.9% and accuracy 75.5%, (Table 6).

Table 6: Validity test results of exercise ECG test in comparison to coronary angiography.

Validity			Coronary angiography		
			Abnormal	Normal	Total
			No.(%)	No.(%)	No.(%)
Exercise ECG	Abnormal	No.(%)	49 (86.0)	8 (14.0)	57 (100.0)
	Equivocal	No.(%)	9 (69.2)	4 (30.8)	13 (100.0)
	Total	No.(%)	58 (82.9)	12(17.1)	70 (100.0)
Sensitivity		84.5%			
+ve predictive value		85.9%			
Accuracy		75.7%			

DISCUSSION

Risk factors of cardiovascular diseases among patients were represented as followings; hypertension 52.9% and family history of CVD 50%, dyslipidemia 37.1% smoking 40%, DM 17.1%, Table 2.

In current study hypertension was more prevalent in abnormal treadmill test p value less than 0.001 this finding was agreed with study done in France (predictive value of appositive exercise stress testing and correlation with cardiovascular risk factor) [14] .

Present study shows no significant association between age of patients and exercise ECG findings (p=0.06). There was a significant association between male gender of patients and abnormal exercise ECG findings (p=0.02) 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 [15] .

A significant association was observed between retired and self-employed patients with abnormal exercise ECG findings (p=0.03). This explained by coexistence with psychosocial and physical inactivity.

In current study there was a highly significant association between increased age of positive TMT and multi vessel involvement in coronary angiography (p<0.001) this finding disagree with study done in Iran [[16] probably of coexistence of other risk factor like dyslipidemia and DM among older age group in current study.

Current study shown significant association between high risk DTS and multi vessel disease (p=0.03) which is agree with study done in Emory university [17] , Table 13 and (figure 2).

Present study shows significant association between abnormal exercise ECG and left main stem lesion (p=0.02), also show significant association between critical lesion and abnormal exercise ECG (0.003) this result was agreed with study done in Basra cardiac center [19]

CONCLUSION AND RECOMMENDATION

Treadmill exercise test provide a noninvasive method for predicting the presence and extent of significant CAD in the individual patients with chest pain. The sensitivity of the test increases as the number of diseased coronary arteries increased. Regarding DTS risk classification we suggest the following:

Low risk patient (DTS≥5): may be safely managed with watchful waiting as well as symptomatic medical therapy without further testing because most of patient under this group had either single vessel disease or non-significant lesion.

Moderate risk patient (DTS +4 to-10): use an imaging modality has been proposed to further risk stratify these patient.

High risk patient (DTS ≤ -11): they may be considered candidate for more aggressive management that may include cardiac catheterization.

Limitation:
The stress test dose not detect (Atheroma, Vulnerable plaques, Relatively high rate of false positive and false negative).

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