

The relationship between exertional chest pain/dyspnoea — heart rate in patients with Coronary artery disease using Exercise Tolerance Test

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Abstract

Objectives: To observe the relationship between chest pain/dyspnoea-heart rate during exertion in patients with angiographically proved Coronary artery disease compared to patients having negative Exercise Tolerance Test, in a private and public sector hospital.

Methods: This is an observational two centre study from Karachi in which 150 patients referred for Exercise Tolerance Test (ETT) at Ziauddin University Hospital, Clifton campus and National Institute of Cardiovascular Diseases Karachi were included. The period of study extended from September 2008 to March 2010.

All patients performed a maximal progressive exercise on Bruce protocol. Age, Body Mass Index, target heart rate and risk factors of Coronary artery disease were noted for each patient. The resting heart rate and resting systolic Blood Pressure (BP) were noted. The maximum systolic BP, maximum heart rate, total exercise time and Multiples of resting oxygen consumption (METS) were recorded at the end of exercise. The chest pain and dyspnoea score were plotted against maximum heart rate.

Results: Out of 136, 51 were ETT positive and 76 were ETT negative. The ETT positive were older in age, had lesser maximal heart rate, lesser total exercise time and lesser METS than ETT negative. Out of 51 ETT positive patients, 20 had chronotropic incompetence.

Conclusion: In patients having positive ETT and referred for angiography, the chest pain-heart rate relationship correlated well with number of vessel disease. The dyspnoea-heart rate relationship was not different in the two groups.

Keywords: Coronary artery disease, Chest pain, Dyspnoea, Exertion, Karachi (JPMA 61: 845; 2011).

Introduction

The commonest cause of morbidity and mortality all over the world is Coronary artery disease (CAD). The traditional risk factors for Coronary artery disease are hypertension,¹ diabetes mellitus,² family history³ of Coronary artery disease, smoking,⁴ dyslipidaemia (hypercholesterolaemia)⁵ and obesity.⁶ Chest pain and dyspnoea are the two major complaints of patients with Coronary artery disease. Chest pain is the most frequent indication for Coronary angiography.⁷ Dyspnoea is a symptom of undiagnosed Coronary artery disease when exertional angina and EKG (ECG) evidence is not present.⁸

In the field of clinical Cardiology, the largest recruited population in exercise testing is patients with CAD.¹⁰ Bruce protocol is the commonest protocol used for Exercise Tolerance Test (ETT). ETT can go on till six stages, every stage is of 3 minutes duration. At the end of each stage of ETT, Blood pressure, heart rate and ECG are recorded. Patients developing pain in the chest or arms and ECG changes with ST depression of 1mm from the baseline 80 ms after the J point.^{7,8,11} are considered ETT positive. ETT positive patients are referred for Coronary angiography and the diagnosis of CAD is confirmed by it. When the patient achieves target heart rate without

complaint of chest pain or ECG change, the ETT is considered to be negative.

The intercept and slope of linear relationship between breathlessness and expired ventilation have been investigated. After Visual Analogue Scale/Ventilation (VAS/VE), Visual Analogue Scale/Heart Rate (VAS/HR) was also studied.¹² This study deals with investigation of both parameters of cardiac patients complaint, chest pain and dyspnoea.

The study was performed to establish the effect of angiographic based multi vessel coronary disease on the relationship between chest pain/dyspnoea-heart rate using ETT in patients with Coronary artery disease and to compare this finding with patients having negative ETT.

Patients and Methods

This was a an observational study conducted from September 2008 to March 2010. One hundred and fifty male patients complaining of chest pain and dyspnoea, referred for ETT were recruited in the study. Fourteen were excluded as they had suffered from Myocardial Infarction in the last six months. One hundred and thirty six were included in the study. Patients were recruited first from Ziauddin Hospital, Clifton Campus and then from National Institute of Cardiovascular Diseases (NICVD), Karachi. The findings of ETT positive were compared with ETT negative.

The study was approved by Ethical committee of Ziauddin University. After taking informed consent, a questionnaire was filled for each patient that included age, height, weight, smoking status, family history of CAD, history of diabetes, hypertension and dyslipidaemia. The history of chest pain and dyspnoea was also taken. All subjects undertook a maximal progressive exercise test following a Bruce protocol on treadmill. At the end of each stage of ETT, Blood pressure, heart rate and ECG were obtained for every patient. The end point of exercise was 1) achievement of target heart rate (at least 85% of the predicted maximal heart rate) 2) pain in the chest or arms 3) leg pain 4) exhaustion 5) maximal dyspnoea 6) ECG changes consistent with ischaemia and 7) others. Chest pain and dyspnoea score were noted in patients who complained of chest pain and dyspnoea.

The VAS is drawn as a straight line from 0 to 100 mm on a card. The extremes of VAS were labeled as "no breathlessness" (0mm) and "extreme breathlessness" (100mm). Similarly for chest pain it was "no chest pain" (0mm) and "extreme chest pain" (100mm).

Before the start of each ETT, the term dyspnoea was explained to patients as a feeling of shortness of breath or

the breathing is not sufficient for the need.¹³ The term chest pain was also explained to patients as a feeling of discomfort (heaviness or tightness) in the chest.

Statistical Analysis:

The data was analyzed using the SPSS version 17 for Windows software. The results of all quantitative data were expressed as mean \pm SD. Means and standard deviations of all quantitative variables were compared between groups by student's 't' test. The comparison of qualitative data was expressed by Chi square test.

The Correlation Coefficient was estimated between heart rate and chest pain score and heart rate and dyspnoea score. Heart rate was dependent variable and chest pain and dyspnoea score were independent variables. The dyspnoea scores of ETT positive group was compared with ETT negative group.

The Chest pain score was plotted against heart rate in ETT positive group and it was correlated with the number of vessel disease.

In all statistical analysis, only p-values < 0.05 and correlation coefficient of >0.4 or <-0.4 were considered significant.

Results

The baseline characteristics of the 127 studied patients are shown in Table-1. It was observed that the patients in ETT positive group were older as compared to the patients in ETT negative group. Hypertension was significantly more common in ETT positive group than in ETT negative group. BMI, smoking status, diabetes mellitus, dyslipidaemia, family history of CAD and the other indications for performance of ETT were not

Table-1: Baseline Characteristics of 127 studied patients in ETT positive and ETT negative group.

	ETT positive n=51(%)	ETT negative n=76(%)	p Value
Age	50.84	46.26	0.006
Body Mass Index	24.64	24.92	0.455
Target Heart Rate	169	174	0.003
Smoking	8(15)	15(19)	0.668
Hypertension	27(52)	27(35)	0.052
Diabetes Mellitus	11(21)	13(17)	0.529
Dyslipidaemia	10(19)	20(26)	0.383
Family History	18(35)	24(31)	0.663
overweight	5(9.8)	15(29.4)	0.132
Chest Pain	33(64)	45(59)	0.533
Dyspnoea	6(11)	8(10)	0.827
Chest Pain & Dyspnoea	9(17)	15(19)	0.768
Other indications	3(5.8)	8(15.6)	0.362

different in the two groups.

Table-2 shows that the resting systolic blood pressure was higher in ETT positive than in ETT negative. The maximum systolic blood pressure was not different in the two groups. The resting heart rate was not different in the two groups. The Maximum heart rate achieved at the end of exercise was significantly less in ETT positive than ETT negative. The ETT positive were older and had lesser target heart rate, but, they could not achieve it as shown in Table-3 in comparison with ETT negative. The total time of exercise and the METS were lesser in ETT positive than ETT negative.

Typical findings in ETT positive patients inferred from Table 2 & 3 are:

1. Reduced peak heart rate.
2. Reduced total exercise duration.
3. Reduced METS.
4. Attenuated heart rate recovery
5. Earlier termination of exercise.
6. Low CI.

Chronotropic incompetence is considered when patients are unable to achieve at least 85% of the predicted heart rate. In our study 20 out of 51 ETT positive patients could not achieve 85% target heart rate, so they were labeled to be chronotropic incompetent.

This study has some typical findings in Coronary artery disease patients as reported in previous studies. The new information in this study is that the perception of pain that is considered to be subjective, correlates with the scientific tests performed to confirm about CAD.

Table-2: Exercise parameters of patients with ETT positive and ETT negative patients.

	ETT positive n=51	ETT negative n=76	p Value
Resting Systolic BP	128.63	119.87	0.003
Maximum Systolic BP	170.78	171.84	0.783
Resting Heart rate	77.22	76.74	0.839
Maximum Heart Rate	147.67	168.29	<0.001
Total Exercise Time	6.27	8.86	<0.001
METS	7.36	9.69	<0.001
Recovery immediate heart rate	138.47	159.64	<0.001

Table-3: Heart rate response to exercise.

	ETT positive n=51 (%)	ETT negative n=76 (%)	p Value
CI ≥ 1.0	11(21.5)	38(50)	<0.001
CI 0.8-1.0	20(39.2)	33(43.4)	
CI < 0.8	20(39.2)	5(6.5)	

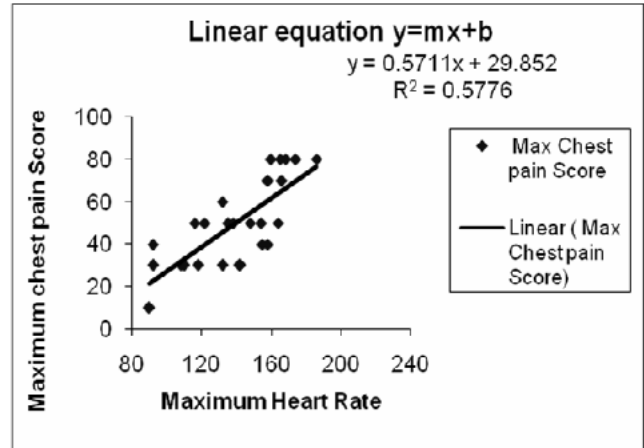


Figure-1: Relationship between Maximum heart rate and Maximum chest pain score in ETT Positive.

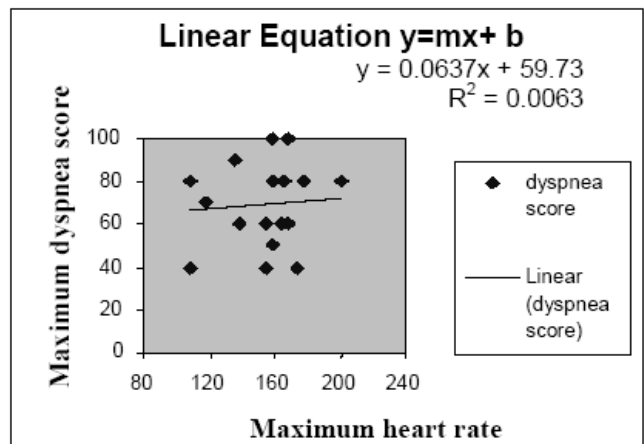


Figure-2: Relationship between Maximum heart rate and Maximum dyspnoea score in ETT positive.

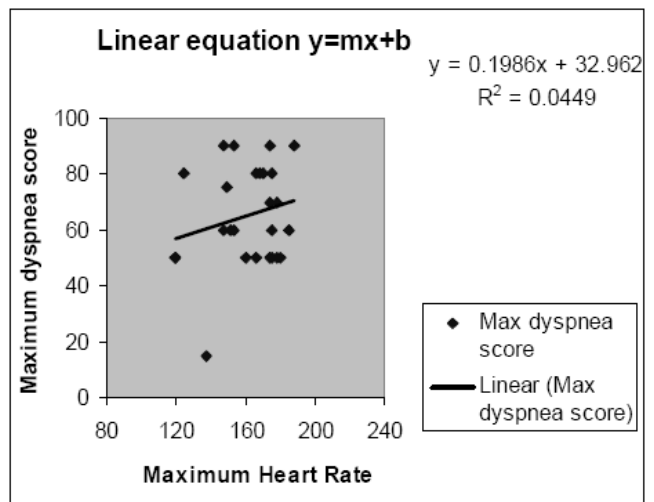


Figure-3: Relationship between Maximum heart rate and Maximum dyspnoea score in ETT negative.

ETT positive patients showed attenuated heart rate recovery after exercise.

Relationship between Maximum heart rate and Maximum chest pain score in ETT

Positive:

The relationship between maximum heart rate and maximum chest pain score was found to be linear in 29 ETT positive patients. A Positive correlation was found between these two variables. As the heart rate increased the chest pain score also increased (Figure-1). When the VAS-chest pain score was matched with angiography results it was found that patients having minimum chest pain score (10-40) had 0 vessel disease, pain score (30-60) had 1 vessel disease, chest pain score (40-70) had 2 vessel disease and those having maximum chest pain score (70-80) had 3 vessel disease.

Relationship between Maximum heart rate and Maximum dyspnoea score in ETT

positive:

Out of 51 ETT positive patients, 19 developed dyspnoea. Out of 19, in 11 patients the end point of exercise was chest pain and dyspnoea both. In 8 patients it was dyspnoea and ECG change. When dyspnoea score was plotted against heart rate, no correlation was found in ETT positive patients (Figure-2).

Relationship between Maximum heart rate and Maximum dyspnoea score in ETT

negative:

Out of 76 ETT negative patients, 28 developed dyspnoea. When the VAS-dyspnoea score was plotted against heart rate, no significant correlation was found between these two variables (Figure-3).

Discussion

In this observational study, the Visual analogue scale score of both chest pain and dyspnoea were taken from the patients who performed ETT either due to chest pain or dyspnoea or both. It was shown for the first time that chest pain can be quantified using the indices of chest pain-heart rate relationship in response to progressive increase in workload in ETT positive patients. This study answers the cardinal question whether the chest pain-heart rate relationship can be investigated in subjects undergoing ETT. Important observations from this study are: 1) the relationship between chest pain and heart rate is linear in ETT positive patients. 2) The onset of dyspnoea was not different in the ETT positive and the ETT negative groups. 3) patients perception of pain and

marking of pain score had a positive correlation with increasing heart rate and number of vessel disease.

This study aims to quantify the estimation of chest pain and dyspnoea in relation to heart rate increase in patients with CAD during exercise using Bruce protocol. Therefore, the relationship between chest pain and breathlessness based on the visual analogue scale (VAS) and increasing heart rate has been investigated. Additionally, the effects of ETT positive and negative on the slopes and intercepts of these relationships [VAS/heart rate Ratio] is hypothesized to be cost effective non-invasive markers of early screening of coronary artery disease.

In this study, the heart rate was not different in ETT positive and ETT negative group in the resting stage. However, the maximum heart rate achieved was lesser in ETT positive group than ETT negative group. For maximum heart rate it is true that ETT positive were older and they had lesser target heart rate to be achieved by the formula $220 - \text{age}$ but still they could not achieve this heart rate while ETT negative achieved it. As it is mentioned that the major determinant of myocardial oxygen demand is heart rate.¹⁴ Heart rate also affects the coronary blood flow through diastolic filling time. The heart rate increases during exercise due to sympathetic activation and parasympathetic withdrawal.¹⁵ The chronotropic response to exercise and heart rate recovery 1 minute after exercise has the prognostic significance.^{15,16} It has been suggested that abnormal cardiovascular autonomic control results in chronotropic incompetence.¹⁷ In a study by Huang et al¹⁸ it was reported that angina patients had a low chronotropic index as had impaired endothelial function, raised markers of systemic inflammation and raised concentrations of N terminal pro BNP as compared to those having normal heart rate response.

The traditional risk factors for Coronary artery disease are hypertension, hypercholesterolaemia, diabetes mellitus and smoking, family history of Coronary artery disease and obesity. The first four above mentioned risk factors damage the endothelium of blood vessel and promote endothelial dysfunction. The endothelial dysfunction plays a role in initiation of atherosclerosis.¹⁹ In our study, hypertension was found to be more prevalent in ETT positive group than ETT negative. This finding is same as a study done by Ishaq et al.²⁰ that reported hypertension as the most prevalent risk factor found in Coronary artery disease. There was no significant difference in the prevalence of other risk factors in the two groups.

The resting systolic blood pressure was higher in ETT positive group than ETT negative. This finding could

be due to increased number of hypertensive patients in the ETT positive group. For maximum systolic BP, the reading is similar in both groups, but ETT positive developed this BP earlier (6.27 min) as compared to ETT negative who developed it later (8.86 min). The total time of exercise and the METS were lesser in ETT positive than in ETT negative group.

It has been reported that both dyspnoea and pain are unpleasant subjectively perceived sensations.^{21,22} Both these sensations motivate adaptive behaviour to regain homeostasis.²¹ Anterior insular cortex is the area of brain that is known to have an activation in perception of both dyspnoea and pain.²²⁻²⁴

In relation to perception of dyspnoea, it has been reported that there is a linear relationship between dyspnoea and expired ventilation in response to progressive exercise. The dyspnoea-heart rate relationship was also shown to produce a similar response to that of dyspnoea/ventilation relationship.¹² Shabbir et al.¹³ showed that dyspnoea can be quantified in cardiac patients using the dyspnoea-heart rate relationship with increasing workload. This study showed that relationship between the dyspnoea and heart rate was linear in both ETT positive patients and controls. The onset of dyspnoea was earlier in ETT positive patients as they had lower intercept. In our study, the dyspnoea score was compared between ETT positive and ETT negative groups and no difference was found between the two groups.

The objective of this study was to determine whether or not the ratio of VAS for chest pain and dyspnoea in proportion to heart rate increase [VAS/HR ratio] could be identified as a non invasive predictive marker for early detection of coronary artery disease. This study also aimed to establish the potential ability of predicting a marker. This can be a hypothesis generating and not the last study in this direction. Management was not the objective of the study, however, management will be helped by targeting better. To the best of our knowledge, none of the research papers have shown a linear correlation between chest pain score and increasing heart rate and also none matched its results with angiography reports. This finding in this study is new and it shows for the first time that the subjective and the objective findings are similar in patients with Coronary artery disease.

In conclusion, this study confirmed that exertional chest pain-heart rate relationship can be quantified in patients with myocardial ischaemia. This relationship was found to be linear. The chest pain score had a positive correlation with number of vessel disease. The dyspnoea score was not different in ETT positive and ETT negative

groups. Forty percent of patients in the ETT positive group had chronotropic incompetence.

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