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# Exercise Capacity Based Prediction of Multi-Vessel Disease from Exercise Treadmill Test (ETT) and Correlation of the Findings with Coronary Angiography (CAG)

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## ABSTRACT

**Background:** Stress testing is frequently used for a preliminary evaluation of individuals with suspected coronary artery disease, acting as a prognosis for cardiac catheterization and provides a clear indication of the condition of the coronary arteries, and further action can be taken considering that information

**Objective:** To determine the patients' exercise capacity that could predict the presence of multivessel disease.

**Methods:** A retrospective cohort study of 70 patients at Shalamar Hospital, Lahore analyzed Exercise Tolerance Test (ETT) and Coronary Angiography (CAG) data. Patients with stable angina, normal baseline ECG, and between 30-60 years were included, excluding those with CAD, limited mobility, or lung pathology.

**Results:** The study involved 70 patients who underwent ETT followed by CAG. Out of them, 59 (84.3%) were males 48 (68.6%) have coronary artery disease (CAD), 21 (43.8%) having SVD and 27 (54.2%) having MVD. Hypertension (HTN) was observed in 28 (58.3%), Diabetes mellitus in 27 (56.2%), Family History of heart disease was recorded in 7 (14.6%), 12 (25%) were smokers and Coronary Calcium was observed in 9(18.8%) patients. No statistical association between METs and MVD (p=0.2). Unit increase in duke treadmill score reduces the chances of multivessel disease 0.159 times (r=0.159). There was moderate correlation between vessels involved and duke treadmill score (r= -.752).

**Conclusion:** Duke Treadmill Score (DTS) reveals a significant difference in obstructive CAD prevalence among low, middle, and high-risk categories, predicting CAD severity and MVD. Patients in intermediate and severe DTS should only be referred for CAG to avoid unnecessary invasive catheterization and improve medical management.

***Keywords:*** *Coronary Angiography, Multi-Vessel Disease, Exercise-Treadmill Test (ETT), Duke Treadmill Score (DTS)*

## INTRODUCTION

Mortality due to cardiovascular disease (CVD) is highest globally and Pakistan is ranked at 30th among affected countries.[1] Early detection of coronary artery disease (CAD) or ischemic hard disease is crucial for prognosis and further actions. Exercise tolerance test (ETT) is conventionally used for the early prognosis, followed by invasive coronary angiography and cardiac catheterization. ETT is an economical, non-invasive diagnostic test and accompanying the St-segment response increases the accuracy ETT diagnosis among symptomatic patients.[2,3,4,5] Among the different treadmill scores, Duke treadmill score (DTS) shows relatively good accuracy i.e. approximately 45%.[6,7]

In Pakistani population, where diabetes is highly prevalent comorbidity among cardiac patients, silent coronary artery disease needed to be addressed.[8] Recent Pakistani literature has documented the CAD prevalence among diabetic patients as high as 45.1%.[9] Diabetes effects the vessel quality and DTS has moderate reliability in detecting CAD in both diabetic and non-diabetic patients.[10, 11]

Stress testing is frequently used for a preliminary evaluation of individuals with suspected coronary artery disease, acting as a gatekeeper for cardiac catheterization and avoiding the dangers of an invasive procedure. Stress testing provides a clear indication of the condition of the coronary arteries, and further action can be taken considering that information.[12] Different studies have shown an association between different risk factors and ETT as well as false positive outcome. Ahmad & Ali 2023 documented the Significance of DTS and its association with obstructive CAD in the low, middle, and high-risk categories.[13,14,15] Our study was conducted to determine relation between Exercise Tolerance Test (ETT) and Coronary Angiography (CAG), to look for the predictors of severity of CAD and Multi Vessel Disease (MVD) on ETT and see whether there was any cutoff value based on patients' exercise capacity that could predict the presence

of MVD. The study revealed the parameters from which one can predict severe illnesses that call for prompt treatment, which will advance patient protocol. This research will help simplify and streamline the diagnostic process, allowing for more accurate and efficient identification of individuals with heart-related issues that will add in protocol to patient care, leading to improved outcomes and quality of life for CAD patients.

**METHODS**

After acquiring approval from IRB, the request for patients' data was made to the HOD of cardiology department. This retrospective cohort study was conducted at Rasheeda Begum Cardiac Center (RBCC), Shalamar Hospital Lahore. The data was collected records from January 2021 till October 2023 using the self-designed proforma. Files of 73 patients who had underwent coronary angiography after ETT were selected using non- probability sampling technique. Patients aged between 30-60 years who were presented with stable angina (chest pain on exertion), normal baseline ECG and left ventricular ejection fraction (LVEF)were selected and 3(4.11%) patients with coronary artery disease or any valvular disease were excluded from the study. The data was entered and analyzed using IBM SPSS 27. The data was presented in the form of frequencies and percentages the numerical data like age, metabolic equivalent score (METs), Duke treadmill score (DTS) etc. were converted to categorical data. Chi-square test was used to determine the association between Multi vessel disease and different risk factors considering p-value of 0.05 or less as significant.

**RESULTS**

Among the 70 patients who had positive Exercise Tolerance Test (ETT) and their Coronary Angiography (CAG) done at Cardiology Department, 21 (43.8%) had single vessel disease and 27 (54.2%) had Multi vessel disease (MVD). There was 5.3:1 male to female ratio, mean age of male was 50.58±8.35years sand female was 50.05±8.27years. Multivessel disease was associated with coronary artery disease (p-value <0.001). (Figure 1).

Among the patients, multi-vessel disease was absent in 22(31.4%), one vessel was affected in 21(30.0%), two vessels were affected in 15(21.4%) and three vessels were affected in 12(17.1%) of the patients. (Table-2) MVD was inversely and statistically significantly correlated with DTS (r= -.752) and METs (r=-.320). The predictive model showed that; *MVD=0.533-0.159DTS* the model was statistically fit (ANOVA, p value <0.001) and it explains 56.6% of the variations in MVD.

**DISCUSSION:**

The study revealed different predictive risk factors that can help in determining the severity of coronary artery disease and take preventive measures. It is a base line study and the study finding could be applied in different centers for early prognosis and further course of treatment. Our study findings have showcased the data of the local population. In our population middle aged female, due to different postural issues, have functional limitations therefore treadmill test was difficult to perform in female. Among the female 61.7% suffers from lower back pain mostly associated with obesity.[16] Age, hypertension, diabetes, dyslipidemia and smoking are independent risk factors of coronary artery disease.[13,17,18] Triglycerides and diabetes are associated variables[19] as epidemiological studies suggest that triglycerides cause pancreatitis[20] thus dyslipidemia rectification can be beneficial in reducing the diabetes as well as CAD. The prevalence of Coronary Calcium was 18.8% which serves as a marker for atherosclerosis. The coronary artery calcium and involvement of multivessel disease are risk factor for mortality.[21]

**Table 1:** *Comparison of Demographic Data Regarding Gender*

| Study variables | Gender | | Total | p-value |
|---|---|---|---|---|
| | Male 59(84.29%) | Female 11(15.71%) | | |
| Family History | 10(16.9%) | 0(0.0%) | 10(14.3%) | 0.344 |
| Hypertension | 32(54.2%) | 6(54.5%) | 38(54.3%) | 0.985 |
| Diabetes Mellitus | 33(55.9%) | 2(18.2%) | 35(50.0%) | 0.022* |
| Smoking Status | 17(28.8%) | 0(0.0%) | 17(24.3%) | 0.055 |
| Coronary Artery Disease | 42(71.2%) | 6(54.5%) | 48(68.6%) | 0.303 |
| Coronary Calcium | 9(15.3%) | 0(0.0%) | 9(12.9%) | 0.336 |

**Table 2:** *Comparison of Multivessel Disease Regarding Predictive Risk Factors*

| Predictive variables | Category | No. of Vessels Affected | | | | Total | p-value |
|---|---|---|---|---|---|---|---|
| | | Absent 22(31.4%) | I 21(30.0%) | II 15(21.4%) | III 12(17.1%) | | |
| Metabolic Equivalent (METs) | <7 | 3(13.6%) | 3(14.3%) | 5(33.3%) | 6(50.0%) | 17(24.3%) | 0.175 |
| | 10-12 | 12(54.5%) | 13(61.9%) | 9(60.0%) | 4(33.3%) | 38(54.3%) | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | 13-15 | 7(31.8%) | 5(23.8%) | 1(6.7%) | 2(16.7%) | 15(21.4%) | |
| Duke Treadmill Score (DTS) | Mild | 2(9.1%) | 0(0.0%) | 0(0.0%) | 0(0.0%) | 2(2.9%) | <0.001 |
| | Moderate | 20(90.9%) | 21(100.0%) | 12(80.0%) | 6(50.0%) | 59(84.3%) | |
| | Severe | 0(0.0%) | 0(0.0%) | 3(20.0%) | 6(50.0%) | 9(12.9%) | |
| Severity of Disease | Absent | 22(100.0%) | 1(4.8%) | 0(0.0%) | 0(0.0%) | 23(32.9%) | <0.001 |
| | 1 | 0(0.0%) | 5(23.8%) | 0(0.0%) | 0(0.0%) | 5(7.1%) | |
| | 2 | 0(0.0%) | 7(33.3%) | 7(46.7%) | 2(16.7%) | 16(22.9%) | |
| | 3 | 0(0.0%) | 8(38.1%) | 8(53.3%) | 10(83.3%) | 26(37.1%) | |

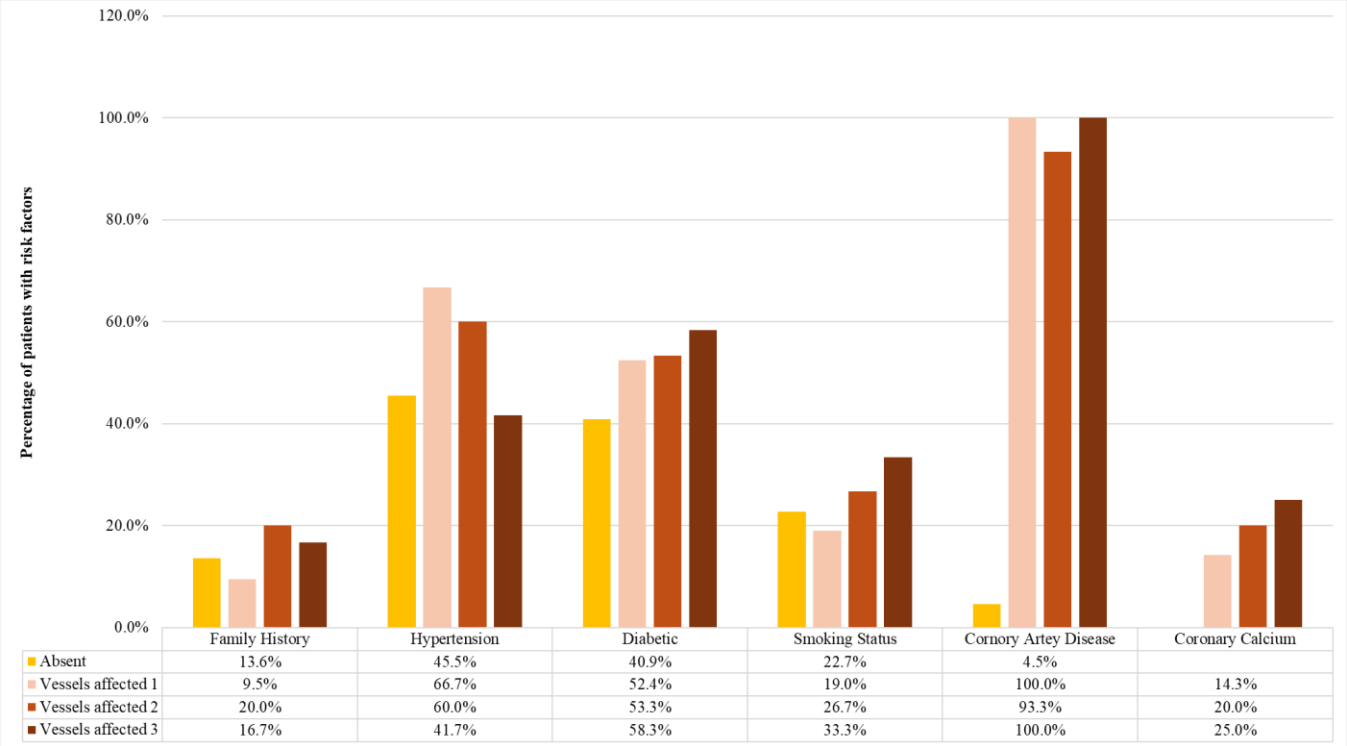


**Figure 1:** *Comparative Analysis of Multivessel Disease According to Different Risk Factors*

The Duke Treadmill Score (DTS) provides valuable insights into the prognosis and severity of coronary artery disease (CAD) based on ETT. In the context of our study, Patients with severe CAD had DTS ranging from -4to ≥-11. The DTS distribution also encompassed patients with mild (8.5%) and moderate (22.8%) disease. Among those with MVD, the majority fell within the DTS range of -4 to ≥-11. This suggests that the DTS effectively discriminates between different extents of CAD severity, aiding in the characterization of disease complexity.[22] Patients with severe CAD had DTS within the specified range.[23]

Our study depicted the negative DTS score might also predict the presence of multi-vessel disease which was not previously addressed in the literature reviewed. The classification aligns DTS values with the clinical presentation of disease severity and MVD. The inclusion of negative DTS values indicates a higher risk and poorer prognosis for patients. This aligns with the under-standing that lower DTS values correlate with a higher likelihood of adverse cardiac events.[24] DTS serves as a useful tool for risk stratification, helping clinicians assess the likelihood of significant coronary artery disease. The study's inclusion of DTS enhances the clinical relevance of the findings. The DTS of every patient must be calculated, the incorporation of DTS in the study enhances the precision of disease characterization and provides clinicians with a valuable tool for risk assessment. Although it is a unicentral study and data is collected retrospectively. A public private comparative prospective study can illuminate more aspects. Determining the ST-segment deviations during each stage of the ETT test is a time-consuming process and the test cannot be performed on functionally limited patients, yet the DTS values correlate well with the observed severity of CAD, contributing to a comprehensive understanding of the patients' cardiovascular health in this cohort. It is suggested to calculate the DTS of all the ETT positive patients before making any decision regarding CAG. This approach will streamline the patients will reduce the

burden of catheterization and revascularization.

## CONCLUSION

Duke treadmill Score can be used as a predictor of multivessel disease. A significant relation was observed between the increase in vessel and duke treadmill score. It is a cost effective and non-invasive method for prognosis of cardiovascular disease patients.

## IMPACT

The issue we encountered when calculating DTS led to the culture of first determining DTS for each patient undergoing ETT before moving on with treatment decisions.

**CONFLICT OF INTEREST / DISCLOSURE:** Nil.

**FUNDING SOURCE:** Nil.

**AUTHORS' CONTRIBUTION:**

**HA:** Conceived, designed and manuscript writing

**DA:** Data Collection

**FN:** Helped in data collection and manuscript writing

**MM:** Critical Review

**AH:** Helped in data collection and manuscript writing

**AS:** Statistical analysis and data interpretation

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