Section: Cardiology

Original Research Article

STUDY OF CORRELATION OF TMT RESULTS WITH CORONARY ANGIOGRAM IN PREDICTING CORONARY ARTERY DISEASE

Harikrishnan K[1], Pramod PC[2], KS Mohanan[3], VL Jayaprakash[4], Rajan Joseph Manjuran[4]

[1]*Assistant Professor, Department of Cardiology, Pushpagiri Medical College, Thiruvalla, Kerala, India*
[2]*Consultant Cardiology, Pushpagiri Medical college, Thiruvalla. Kerala, India*
[3]*Professor & HOD, Department of Cardiology, Pushpagiri Medical College, Thiruvalla. Kerala, India*
[4]*Professor, Department of cardiology, Pushpagiri, Medical College, Thiruvalla. Kerala, India*

Received *: 05/06/2025*
Received in revised form *: 02/08/2025*
Accepted *: 19/08/2025*

Corresponding Author:
Dr .Harikrishnan k
Assistant Professor, Department of Cardiology, Pushpagiri Medical College, Thiruvalla, Kerala, India
Email:drharik2005@gmail.com

DOI: 10.70034/ijmedph.2025.3.420

Source of Support: Nil,
Conflict of Interest: None declared

Int J Med Pub Health
2025; 15 (3); 2278-2283

ABSTRACT

Background: Tread mill stress test (TMT) is the most commonly performed stress test for diagnosis of coronary artery disease (CAD) in outpatient setting. The present study was conducted to find correlation of TMT with coronary angiography (CAG) in patients.

Materials and Methods: Total 100 patients who had undergone CAG and TMT were enrolled in the present study. TMT test was done using Bruce protocol, and results were classified as inconclusive, negative and high probability for inducible ischemia.

Results: The study comprised 100 patients. Of the study population, 48% were female and 52% were male. A median age of 59 years (IQR: 53–64.75 years) and a mean age of 58.32 ± 9.6 years. The bulk (38%) were between the ages of 61 and 70, with 33% falling into the 51–60 age range. The most common risk factor among those evaluated was hypertension (61%), which was followed by diabetes mellitus (49%), and dyslipidemia (48%). 6 % of the participants had a family history of coronary artery disease (CAD), while just 9% smoked. In terms of presenting symptoms, 74% reported chest discomfort as the major symptom.29% of the individuals reported experiencing dyspnoea during exertion, whereas Syncope (2%) and palpitations (5%) were less frequent. 15% of subjects got Inconclusive results on the Treadmill Test (TMT), while 85% of participants tested positive. While 25% of patients had normal angiograms, 75% of patients had anomalies found by coronary angiography (CAG). Minor CAD was the most common CAD pattern on angiography (24%), followed by Double vessel disease (DVD) in 18 %of patients.

Conclusion: Our study supports the fact that in patients with symptoms like chest pain, dyspnoea on exertion, palpitations with positive TMT with suspicion of coronary ischemia along with CAG provides an important diagnostic tool for diagnosis and management of coronary artery disease. TMT is a good test for functional assessment of patients, also an important aid in management of CAD implications on society.

Keywords: Coronary artery disease; Exercise Treadmill Test; Bruce protocol; Coronary angiography; Myocardial ischemia; Non-invasive cardiac testing; Risk stratification; Double vessel disease; Minor CAD; Diagnostic correlation.

INTRODUCTION

Coronary artery disease (CAD) remains the leading cause of morbidity and mortality globally, with an increasing prevalence in both developed and developing nations. In India, the burden of CAD has been steadily rising due to urbanisation, sedentary lifestyles, dietary changes, and the growing prevalence of risk factors such as hypertension, diabetes mellitus, dyslipidemia, and tobacco use. Early detection of CAD is crucial to initiate timely medical or interventional therapy and to reduce the

incidence of acute coronary events, heart failure, and sudden cardiac death.[1,2]

The evaluation of suspected CAD traditionally begins with a combination of clinical assessment, risk stratification, and non-invasive testing. Among the various non-invasive tests, the Exercise Treadmill Test (TMT), performed using protocols such as the Bruce protocol, is widely utilized in outpatient and hospital settings. TMT is cost-effective, non-invasive, and provides valuable functional information, including exercise-induced electrocardiographic (ECG) changes suggestive of myocardial ischemia, exercise tolerance, blood pressure and heart rate responses, and the occurrence of arrhythmias.[3,4]

TMT is particularly useful as an initial screening tool in patients with intermediate pre-test probability of CAD. However, while TMT offers high sensitivity in certain populations, its specificity may be limited, especially in the presence of baseline ECG abnormalities or non-cardiac factors that affect exercise capacity. For this reason, coronary angiography (CAG) remains the gold standard for the anatomical assessment of coronary artery patency and the severity of stenotic lesions.[5,6]

Correlation studies between TMT and CAG can help clinicians better understand the predictive value of TMT in diagnosing significant CAD and refine diagnostic algorithms for patients presenting with symptoms such as chest discomfort, dyspnea on exertion, palpitations, or syncope.[3-6] This study was undertaken to analyse the correlation between TMT results and CAG findings in a cohort of symptomatic patients, aiming to evaluate the accuracy of TMT in predicting angiographically proven CAD and its role in guiding clinical decision-making.

MATERIALS AND METHODS

This is a retrospective study done in our Institution of 100 patients after obtaining ethical clearance and informed consent from all patients who had symptoms of chest pain, dyspnoea on exertion, and palpitations with normal ECHO findings. Risk factors taken into consideration for the study included weight, presence/absence of HTN, presence/absence of diabetes mellitus (DM), dyslipidemia, smoking, and family history of coronary artery disease. TMT was done using Bruce protocol/ Modified Bruce protocol, and results were evaluated as negative, inconclusive, positive [high probability for inducible ischemia)

TMT positive: >1mm ST depression below baseline or slow upsloping ST depression or ST elevation on exertion. TMT inconclusive: patients who failed to achieve 6 METs or who failed to achieve 85% of age-predicted maximum heart rate without ischemic responses in ECG. TMT negative: patient who completed their protocol, achieved target heart rate, without symptoms and ECG changes of ischaemia. ECG changes with rapid upsloping changes or ST depression < 1 mm was also considered as negative.

A patient was considered as diabetic if the fasting blood glucose was ≥ 126 mg/dL or if the 2-hour (postprandial) blood glucose level was ≥ 200 mg/dL, or if the hemoglobin A1c (HbA1c) (glycosylated Hb) was ≥ 6.5%. Family history of premature CAD in first-degree relatives was defined as ischemic heart disease (IHD) or sudden cardiac death before 55 years of age (in men) or 65 years of age (in women). (HTN) is systolic blood pressure (SBP) values of 130 mm Hg or more and/or diastolic blood pressure (DBP) of more than 80 mm Hg.

Current smoking status was noted. Details of the CAG were noted. CAG was classifies as normal or abnormal. Abnormal CAG includes mild CAD, single-vessel disease (SVD), double-vessel disease (DVD), triple-vessel disease (TVD), and left main coronary artery (LMCA) disease.

Inclusion Criteria

In this study, we included male and female patients of age 25 and above who had symptoms of chest discomfort, dyspnoea on exertion, palpitations with normal echo findings with positive TMT

Exclusion Criteria

Patients already with valvular heart disease, those with pacing devices,LBBB, COPD patients ,arthritis patients, old and fragile patients, patients on cytotoxic cancer therapy and those with abnormal echo findings were excluded.

Sample Size

$$n = \frac{\left(z_{1-\propto/2}\right)^2 p(1-p)}{r^2}$$

P= Positive predictive value (PPV) of TMT for detection of CAD on CAG was 53%

r=Precision 10%

z_(1-∝/2)=Desired Confidence level 5%

Sample size= 96

Statistical Analysis: Data were entered using Microsoft Excel and analyzed with SPSS version 23. The qualitative variables are presented as percentages, while the quantitative variables are expressed as mean and standard deviation. Categorical variables were compared using chi-square test. Diagnostic accuracy test will be performed for TMT. Nominal logistic regression analysis will be performed to determine the significant parameters (age, DM, HTN, smoking, etc...) that influences the increase in positivity of CAG. Results with a p value < 0.05 are considered to be significant.

RESULTS

The study comprised 100 patients. A median age of 59 years (IQR: 53–64.75 years) and a mean age of 58.32 ± 9.6 years.

Table 1: Mean age distribution of study participants

	Mean	Std. Deviation	Median	25th quartile	75th quartile
Age	58.32	9.603	59.00	53.00	64.75

Table 2: Distribution of age and gender among study the participants

		Frequency	Percent
Age	≤40	5	5.0
	41-50	16	16.0
	51-60	33	33.0
	61-70	38	38.0
	≥71	8	8.0
Sex	Female	48	48.0
	Male	52	52.0

The bulk (38%) were between the ages of 61 and 70, with 33% falling into the 51–60 age range. Of the study population, 48% were female and 52% were male.

Table 3: distribution of risk factors among study the participants

Risk factors	Present		Absent	
	Frequency	Percent	Frequency	Percent
DM	49	49.0	51	51.0
DLP	48	48.0	52	52.0
Smoking	9	9.0	91	91.0
Family H/O CAD	6	6.0	94	94.0
HTN	61	61.0	39	39.0

The most common risk factor among those evaluated was hypertension (61%), which was followed by diabetes mellitus (49%), and dyslipidemia (48%). Six percent of the participants had a family history of coronary artery disease (CAD), while just nine percent smoked.

Table 4: distribution of symptoms among study the participants

Symptoms	Present		Absent	
	Frequency	Percent	Frequency	Percent
Chest discomfort	74	74.0	26	26.0
Dyspnoea on exertion	29	29.0	71	71.0
Palpitation	5	5.0	95	95.0
Syncope	2	2.0	98	98.0

In terms of presenting symptoms, 29% of the individuals reported experiencing dyspnea during exertion, whereas 74% reported experiencing chest discomfort. Syncope (2%) and palpitations (5%) were less frequent.

Table 5: distribution of TMT positivity vs inconclusive TMT among study the participants

TMT	Frequency	Percent
Inconclusive	15	15.0
Positive	85	85.0
Total	100	100.0

15% of subjects got Inconclusive results on the Treadmill Test (TMT), while 85% of participants tested positive.

Table 6: distribution of normal coronary angiographic patients vs abnormal coronary angiographic patients among study the participants

CAG	Frequency	Percent
Normal	25	25.0
Abnormal	75	75.0
Total	100	100.0

While 25% of patients had normal angiograms, 75% of patients had anomalies found by coronary angiography (CAG).

Table 7: distribution of cag results of study participants

CAG	Present		Absent	
	Frequency	Percent	Frequency	Percent
MINOR CAD	24	24.0	76	76.0
SVD	17	17.0	83	83.0
DVD	18	18.0	82	82.0

TVD	17	17.0	83	83.0
LMCA >50 %	2	2.0	98	98.0
LM+TVD	-	-	100	100.0

Minor CAD was the most common CAD pattern on angiography (24%), followed by Double vessel disease (DVD) 18 %. Triple vessel disease (TVD) and Single vessel disease (SVD) on angiography was the same 17%, followed by left main coronary artery (LMCA) stenosis >50% in 2% of the patients

Table 8: association between cag parameters and tmt results

CAG	TMT		Total	P value (fisher's exact test)
	Inconclusive	Positive		
MINOR CAD	6(25%)	18(75%)	24	0.133
SVD	3(17.6%)	14(82.4%)	17	0.742
DVD	1(5.6%)	17(94.4%)	18	0.172
TVD	0(0%)	17(100%)	17	0.013
LMCA >50 %	0(0%)	2(100%)	2	0.418

Angiographic subtypes such as minor CAD, SVD, DVD, and LMCA >50% did not exhibit significant relationships with TMT findings, there was a statistically significant correlation between TVD and TMT positivity (p=0.013).

Table 9: association between study variables and cag results

		CAG		Total	P value
		Positive	Negative		
Age	≤40	1(20%)	4(80%)	5	0.002@
	41-50	9(56.3%)	7(43.8%)	16	
	51-60	24(72.7%)	9(27.3%)	33	
	61-70	33(86.8%)	5(13.2%)	38	
	≥71	8(100%)	0(0%)	8	
Sex	Female	34(70.8%)	14(29.2%)	48	0.355
	Male	41(78.8%)	11(21.2%)	52	
DM	Present	42(85.7%)	7(14.3%)	49	0.015
	Absent	33(64.7%)	18(35.3%)	51	
DLP	Present	36(75%)	12(25%)	48	0.999
	Absent	39(75%)	13(25%)	52	
Smoking	Present	8(88.9%)	1(11.1%)	9	0.276@
	Absent	67(73.6%)	24(26.4%)	91	
FAMILY H/O CAD	Present	4(66.7%)	2(33.3%)	6	0.637@
	Absent	71(75.5%)	23(24.5%)	94	
HTN	Present	50(82%)	11(18%)	61	0.044
	Absent	25(64.1%)	14(35.9%)	39	
Chest Discomfort	Present	55(74.3%)	19(25.7%)	74	0.792
	Absent	20(76.9%)	6(23.1%)	26	
Dyspnoea On Exertion	Present	23(79.3%)	6(20.7%)	29	0.525
	Absent	52(73.2%)	19(26.8%)	71	
Palpitation	Present	5(100%)	0(0%)	5	0.085@
	Absent	70(73.7%)	25(26.3%)	95	
Syncope	Present	1(50%)	1(50%)	2	0.443@
	Absent	74(75.5%)	24(24.5%)	98	

Abnormal angiographic results were substantially correlated with age (p=0.002), and the prevalence of CAD rose with age. Hypertension (p=0.044) and diabetes mellitus (p=0.015) were substantially linked to aberrant CAG results. There were no statistically significant correlations found between angiographic results and other risk variables, such as smoking, cholesterol, family history of CAD, and symptoms like dyspnea or chest pain.

Table 10: association between TMT and cag results

TMT	CAG		Total
	Positive	Negative	
Positive	65(76.4%)	20(23.6%)	85
Negative	10(66.7%)	5(33.3%)	15
Total	75	25	100

Fisher's exact test p value =0.431

TMT has a high sensitivity of 86.67% in diagnosing CAD, but a low specificity of 20% when compared to CAG results. While a positive TMT frequently correlated with CAD on angiography, a negative TMT did not consistently rule out illness, as evidenced by the positive predictive value (PPV) of 76.47% and the negative predictive value (NPV) of 33.33%.

Table 11

Statistics	Value	95% CI
Sensitivity	86.67%	76.84% to 93.42%
Specificity	20.00%	6.83% to 40.70%
Positive Predictive Value	76.47%	72.38% to 80.12%
Negative Predictive Value	33.33%	15.89% to 56.96%

DISCUSSION

Accurate screening and diagnosis of IHD is one of the most important mechanisms of timely intervention and prevention of mortality. TMT is the most widely used cardiac stress test. This is described as poor man's angiogram. In a person at high risk for coronary heart disease (e.g., advanced age, multiple coronary risk factors), an abnormal TMT is highly predictive of the presence of coronary heart disease (> 90% accurate).

However, a relatively normal TMT may not reflect the absence of significant disease in a person with the same risk factors. Conversely, in a person with a low-risk, a normal TMT is very predictive of the absence of significant coronary heart disease (>90%accurate), but an abnormal test may not reflect the true presence of coronary heart disease (so-called "false-positive TMT").

Even though the TMT remains a cost-effective, easily available, and widely applicable approach for early diagnosis of CAD, it has a relatively low sensitivity and specificity.

The study comprised 100 patients. Of the study population, 48% were female and 52% were male. A median age of 59 years (IQR: 53–64.75 years) and a mean age of 58.32 ± 9.6 years. The bulk (38%) were between the ages of 61 and 70, with 33% falling into the 51–60 age range. The most common risk factor among those evaluated was hypertension (61%), which was followed by diabetes mellitus (49%), and dyslipidemia (48%). 6 % of the participants had a family history of coronary artery disease (CAD), while just 9% smoked. In terms of presenting symptoms, 74% reported chest discomfort as the major symptom.29% of the individuals reported experiencing dyspnoea during exertion, whereas Syncope (2%) and palpitations (5%) were less frequent. 15% of subjects got Inconclusive results on the Treadmill Test (TMT), while 85% of participants tested positive. While 25% of patients had normal angiograms, 75% of patients had anomalies found by coronary angiography (CAG). Minor CAD was the most common CAD pattern on angiography (24%), followed by Double vessel disease (DVD) in 18 % of patients.

According to Khanam et al from indoor, out of 50 TMT-positive female patients, 12 were having CAD on angiography (24%) indicating a low predictive value of TMT. The prevalence of CAD was 70% in high pretest probability group compared with 5% in low pretest probability group indicating high predictive value of TMT in high pretest probability group. SVD was most common (58%) followed by TVD (25%) and DVD (17%). Similar findings were revealed by Ismail.[1-3]

Kim et al and others in their study, suggested that in the interest of cost-effectiveness, screening for asymptomatic CAD could be limited to elderly patients with a duration of diabetes 10 years.[2,5-8] In the present study, only high probability of TMT positivity is not sufficient to predict the obstructive coronary artery disease (CAD) on CAG. Along with TMT positivity, if older age and diabetes also are present, the likelihood of CAD detection increases. Many other authors and Periyapattana and AVS from south India and Stanley suggested in their study that combined TMT and MPI increases the PPV to 94% and diagnostic accuracy to 88% and together performs the gatekeeper function for CAG so that optimal decision making can be achieved.[4,9,10]

Limitations: Small number of subjects recruited in our study. TMT is a good test for functional assessment of patient, especially with low pretest probability of disease. Because of the low sensitivity and all other drawbacks of TMT, negative test or inconclusive test should not be considered as normal, should be confirmed by further tests such as repeat TMT, CT coronary angiography, invasive coronary angiography.

CONCLUSION

Our study supports the fact that in patients with symptoms like chest discomfort, dyspnoea on exertion, palpitations with positive TMT with suspicion of coronary ischemia along with CAG provides an important diagnostic tool for diagnosis and management of coronary artery disease. TMT is a good test for functional assessment of patients, also an important aid in management of CAD

Implications on society

Our study of TMT correlation with angiographic findings is in concordance with national and international study data has proved that TMT is a reliable and sensitive tool which is non-invasive to detect CAD and it properly guides us with management at the earliest without any delay.

REFERENCES

1. Khanam B, Bansal R, Bansal A. An evaluation of coronary artery disease by coronary angiography in TMT positive female patients. J Evid Based Med Health Care 2017;4(25):1460–1462.
2. Kim MK, Baek KH, Song KH, et al. Exercise treadmill test in detecting asymptomatic coronary artery disease in type 2 dia betes mellitus. Diabetes Metab J 2011;35(01):34–40.
3. Ismai M, Andrab SM, Rashi A, et al. Coronary artery profile on coronary angiography in TMT positive female patients.J Evol Med Dental Sci 2015;4:100.

4. Periyapattana GK, AVS AK. Correlation of TMT, MPI & Coronary angiography– our experience at a tertiary care hospital. Paper presented at: International Conference on Integrated Medical ImaginginCardiovascular Diseases; October 1014, 2016; Vienna. Available at https://conferences.iaea.org/indico/event/100/con tribution/34 .
5. George S. Angiographic profile and treadmill test relationship of women with chest pain suggestive of coronary artery disease. World J Cardiovasc Dis 2017;7(08):225–232.
6. Sun JL, Han R, Guo JH, Li XY, Ma XL, Wang CY. The diagnostic value of treadmill exercise test parameters for coronary artery disease. Cell Biochemistry and Biophysics. 2013;65(1):69–76. doi:10.1007/s12013-012-9401-y
7. Jian-ling S, Ying Z, Yu-lian G, et al. Coronary heart disease diagnosis bases on the change of different parts in treadmill exercise test ECG. Cell Biochemistry and Biophysics. 2013;67:969–975. doi:10.1007/s12013-013-9591-y
8. Babapulle MN, Diodati JG, Blankenship JC, et al. Utility of routine exercise treadmill testing early after percutaneous coronary intervention. BMC Cardiovascular Disorders. 2007;7:12. doi:10.1186/1471-2261-7-12
9. Silva AML, Armstrong AC, Silveira FJC, et al. Prevalence and factors associated with inappropriate use of treadmill exercise stress test for coronary artery disease: a cross-sectional study. BMC Cardiovascular Disorders. 2015;15:54. doi:10.1186/s12872-015-0048-7
10. Banerjee A, Newman DR, Van den Bruel A, Heneghan C. Diagnostic accuracy of exercise stress testing for coronary artery disease: a systematic review and meta-analysis of prospective studies. International Journal of Clinical Practice. 2012;66(5):477–492. doi:10.1111/j.1742-1241.2012.02900.x.