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SENSITIVITY OF EXERCISE TOLERANCE TEST AND CORONARY ANGIOGRAPHY IN THE DIAGNOSIS OF CORONARY ARTERY DISEASES IN REHMAN MEDICAL INSTITUTE PESHAWAR

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Abstract

Objective:
To determine and compare the sensitivity of the Exercise Tolerance Test (ETT) and Coronary Angiography (CA) in the diagnosis of coronary artery disease (CAD).

Methodology:
A cross-sectional observational study was conducted at the Cardiac Catheterization Laboratory and ECG/ETT Laboratory of Rehman Medical Institute (RMI), Peshawar. A total of 212 patients undergoing both ETT and coronary angiography were included using a non-probability convenient sampling technique. Data were analyzed using SPSS version 22.0.

Results:
The sensitivity of ETT in diagnosing CAD was 76.5%, while coronary angiography demonstrated a higher sensitivity of 89.7%. True positive findings were more frequent with coronary angiography compared to ETT, indicating superior diagnostic performance.

Conclusion:
Coronary angiography is a more sensitive diagnostic modality for detecting coronary artery disease than the Exercise Tolerance Test.

INTRODUCTION

Coronary artery disease (CAD) is a condition caused by atherosclerotic or thrombotic obstruction of the coronary arteries, leading to reduced blood supply to the myocardium. This reduction creates an imbalance between

myocardial oxygen supply and demand, resulting in ischemia and potentially life-threatening cardiac events. CAD remains the leading cause of morbidity and mortality worldwide and represents a major public health burden (Dai et al., 2016).

The pathogenesis of CAD primarily involves atherosclerosis, a progressive inflammatory process characterized by endothelial injury and lipid deposition within the arterial wall. Oxidized low-density lipoproteins are engulfed by macrophages, forming foam cells and fatty streaks. These lesions may progress to fibrous plaques that narrow the arterial lumen or rupture, triggering thrombus formation. Plaque rupture can lead to acute coronary syndromes such as unstable angina, non–ST-elevation myocardial infarction (NSTEMI), or ST-elevation myocardial infarction (STEMI), depending on the degree of occlusion (Libby & Theroux, 2005). Chronic plaque development often presents clinically as stable angina and is frequently the earliest manifestation of CAD.

The burden of CAD continues to rise globally. Epidemiological data indicate that CAD accounts for approximately one-third of cardiovascular-related deaths. In the United States, CAD prevalence between 2009 and 2012 was reported as 5.0% in women and 7.6% in men (Wilson, 1994). In Pakistan, CAD prevalence has been estimated at 26.9%, affecting men and women almost equally (Jafar et al., 2005). Advancing age, male gender, and genetic predisposition are recognized non-modifiable risk factors, while hypertension, diabetes mellitus, dyslipidemia, smoking, obesity, sedentary lifestyle, and psychosocial stress represent modifiable contributors to disease development.

Accurate diagnosis of CAD is essential for appropriate risk stratification and management. Initial evaluation includes clinical assessment and non-invasive investigations such as electrocardiography and echocardiography. Among non-invasive functional tests, the Exercise Tolerance Test (ETT) is widely used due to its simplicity, accessibility, and low cost. However, coronary angiography remains the gold standard for defining coronary anatomy and assessing the severity of luminal obstruction.

Sensitivity, defined as a test's ability to correctly identify individuals with disease, is a critical parameter in evaluating diagnostic tools. Understanding the relative sensitivity of ETT and coronary angiography is essential for optimizing diagnostic pathways and improving patient outcomes.

LITERATURE REVIEW

Several studies have examined the diagnostic accuracy of the Exercise Tolerance Test and coronary angiography in the evaluation of coronary artery disease. Attar et al. (2017) investigated the influence of coronary artery dominance on the accuracy of ETT. In their multicenter study of 270 patients, they observed a significantly higher prevalence of left coronary dominance among patients with abnormal ETT findings but normal coronary angiography. The authors concluded that left-sided coronary dominance may act as a confounding factor, contributing to false-positive ETT results and reducing test specificity.

Korkmaz et al. (2018) evaluated hematological changes associated with CAD before and after treadmill exercise testing. Their study included 113 patients with chest pain who underwent both ETT and coronary angiography. They found that neutrophil counts and neutrophil-to-lymphocyte ratio (NLR) increased significantly after exercise, particularly in patients with positive ETT results. When combined with ETT findings, changes in NLR improved diagnostic performance, achieving a sensitivity of 91% and specificity of 92% for predicting significant coronary stenosis. This study highlighted the role of inflammatory markers in enhancing the predictive value of functional stress testing.

Löffler et al. (2018) assessed the utility of exercise functional capacity combined with stress electrocardiography in identifying high-risk obstructive CAD. In a retrospective cohort of patients who underwent coronary angiography within three months of stress testing, high functional capacity coupled with a negative stress ECG demonstrated a high sensitivity and negative predictive value. The authors concluded that this combined approach could safely exclude high-risk

CAD in selected patients and reduce the need for additional imaging, thereby lowering costs and radiation exposure.

Foy et al. (2017) conducted a systematic review and meta-analysis comparing coronary computed tomography angiography (CCTA) with functional stress testing in patients with suspected CAD. Their analysis included over 20,000 patients and demonstrated that while CCTA was associated with a lower incidence of myocardial infarction, it led to increased rates of invasive coronary angiography, revascularization procedures, and initiation of preventive pharmacotherapy. Despite these findings, no significant reduction in mortality or cardiovascular hospitalizations was observed, emphasizing the importance of appropriate test selection.

Collectively, existing literature suggests that while ETT remains a valuable initial screening tool, its diagnostic accuracy is influenced by multiple patient-related and physiological factors. Coronary angiography, although invasive, provides superior sensitivity and anatomical detail, reinforcing its role as the definitive diagnostic modality for CAD.

METHODOLOGY

A cross-sectional observational study was conducted at the Cardiac Catheterization Laboratory and ECG/ETT Laboratory of Rehman Medical Institute, Hayatabad, Peshawar. The study duration was three months. A non-probability convenient sampling technique was used to recruit participants.

The study population included patients presenting with stable or unstable angina who underwent both Exercise Tolerance Testing and coronary angiography. Patients with comorbid conditions such as diabetes mellitus and hypertension, as well as those presenting with atypical chest pain, shortness of breath, or syncope, were included. Patients with incomplete medical records, those who declined consent, and individuals with mental disorders were excluded.

The sample size was calculated using the Open Epi calculator with a 95% confidence interval, a 5% margin of error, a population size of 560, and an estimated prevalence of 33%. The final sample size was 212 patients.

Data were collected using a structured questionnaire comprising demographic information and clinical variables. Statistical analysis was performed using SPSS version 22.0. Frequencies and percentages were calculated, and results were presented in graphical form.

Institutional approval was obtained from the DMS Office of RMI. Informed consent was obtained from all participants, and data confidentiality was strictly maintained.

RESULTS

Cardiovascular disease is a major disease with high mortality and morbidity for the detection of this disease there are certain diagnostic and non-invasive tests, which are exercise tolerance test and coronary angiography. As per this cross-sectional study it is hypothesized that coronary angiography is more sensitive for the detection of coronary artery disease than exercise tolerance test.

Among 212 patients analyzed during the study period. It was observed that sensitivity of ETT in the detection of coronary artery disease is (76.5%) and the sensitivity of coronary angiography in the detection of coronary artery disease patients is (89.7%).

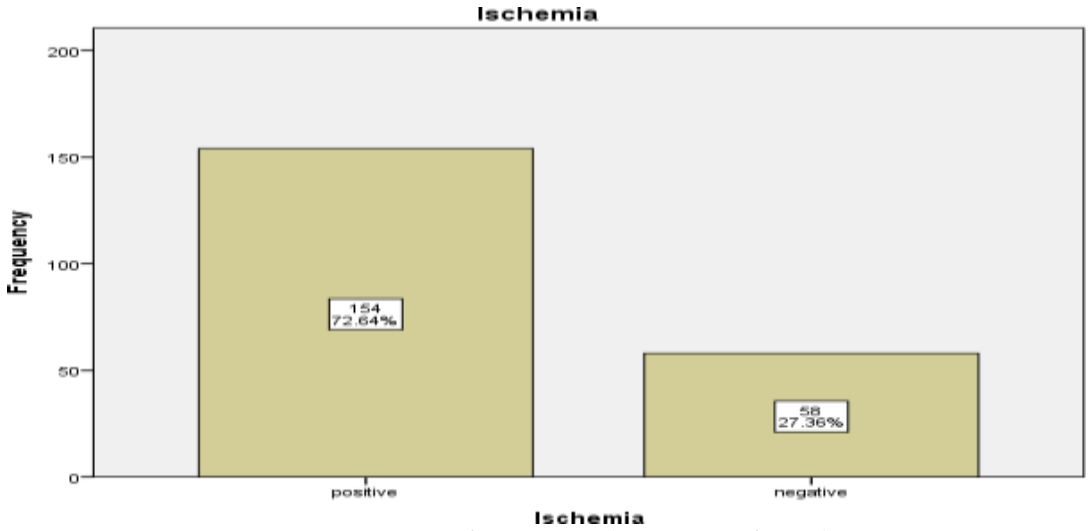


Figure 3.1: Frequency of Exercise tolerance test for ischemia

Table 3.1 Shows the data collection of the following question

Is the ETT is positive for ischemia					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Positive	154	72.6	72.6	72.6
	Negative	58	27.4	27.4	100.0
	Total	212	100.0	100.0	

Table 3.1 and figure 3.1 shows the frequency of ETT for ischemia in 212 patients were observed in which 154 (72.6%) patients were true positive and 58 (27.4%) patients were true negative in the CAD patients.

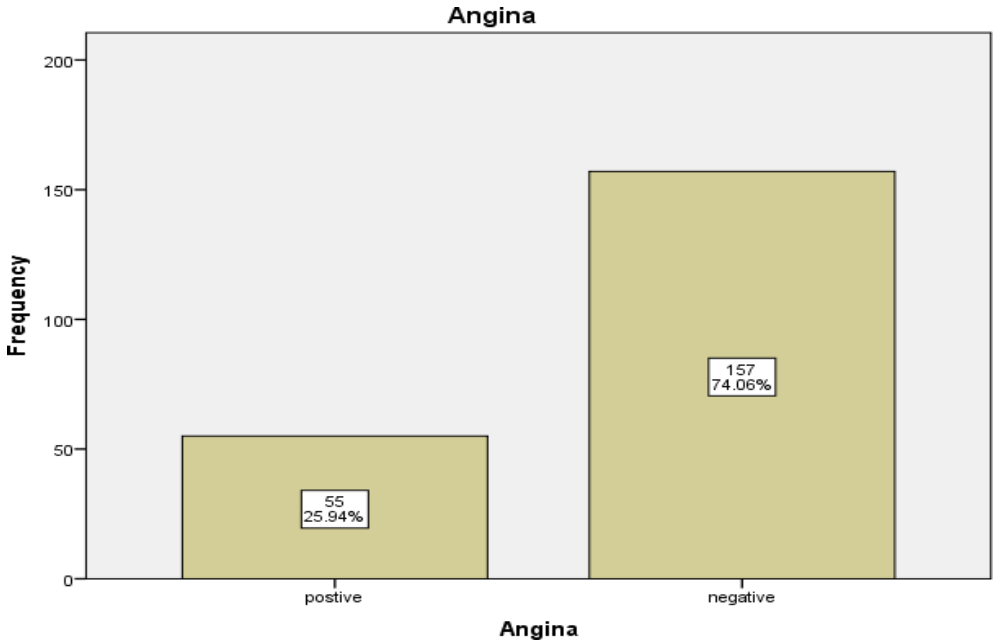


Figure 3.2: Frequency of Exercise tolerance test for Angina

Table 3.2 Shows the data collection of the following question

Is the ETT positive for Angina					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Positive	55	25.9	25.9	25.9
	Negative	157	74.1	74.1	100.0
	Total	212	100.0	100.0	

Table 3.2 and figure 3.2 shows Frequency of ETT for Angina in 212 patients were observed in which 55(25.9%) patients were true positive and 157 (74.1%) patients were true negative in the CAD patients.

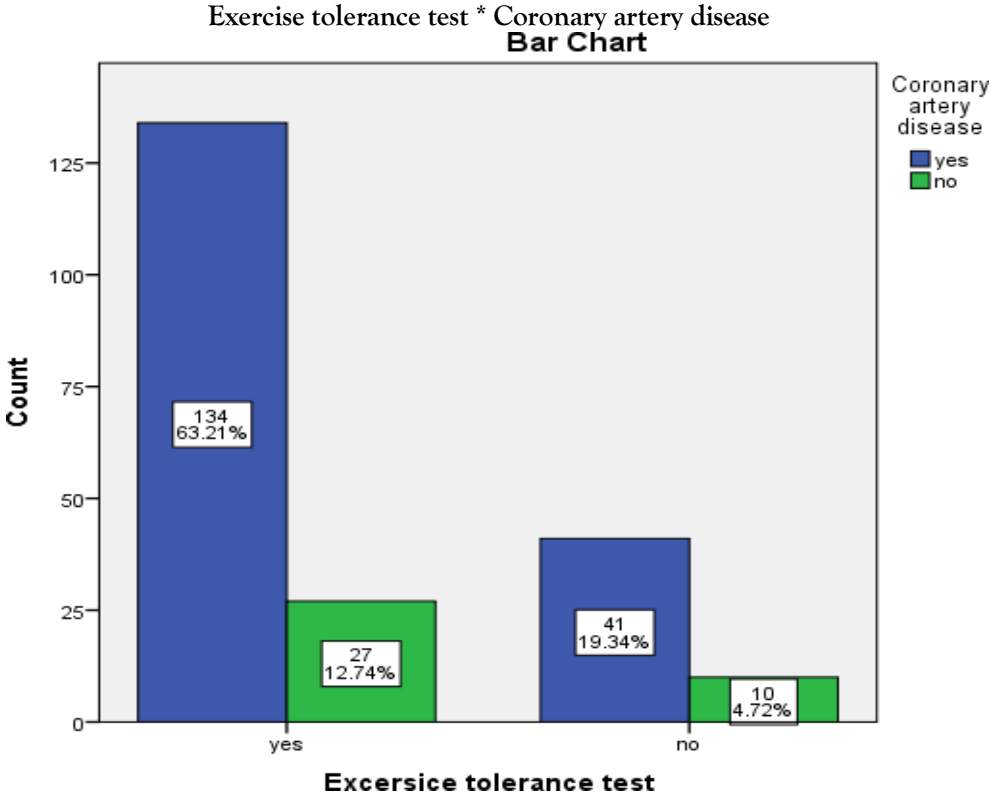


Figure 3.3 sensitivity of Exercise tolerance test in CAD Patients

Table 3.3 shows data collection of following question:

sensitivity of Exercise tolerance test in CAD				
		Coronary artery disease		Total
		Yes	No	
Exercise tolerance test	Yes	134	27	161
	No	41	10	51
Total		175	37	212

Figure 3.3 and Table 3.3 show crosstabulation of CAD with ETT were done in 212 patients in which the 134 (63.21%) patients were true positive, 27 (12.74%) patients were false positive,

41 (19.34%) patients true negative and 10(4.72%) false negative. overall sensitivity of ETT for CAD IS 76 %.

Table 3.4 Chi-Square Tests for Exercise tolerance Test

	Value	Df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.216[a]	1	.642		
Continuity Correction[b]	.064	1	.800		
Likelihood Ratio	.212	1	.645		
Fisher's Exact Test				.674	.391
N of Valid Cases	212				

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 8.90.
b. Computed only for a 2x2 table

Coronary Angiography * Coronary artery diseases

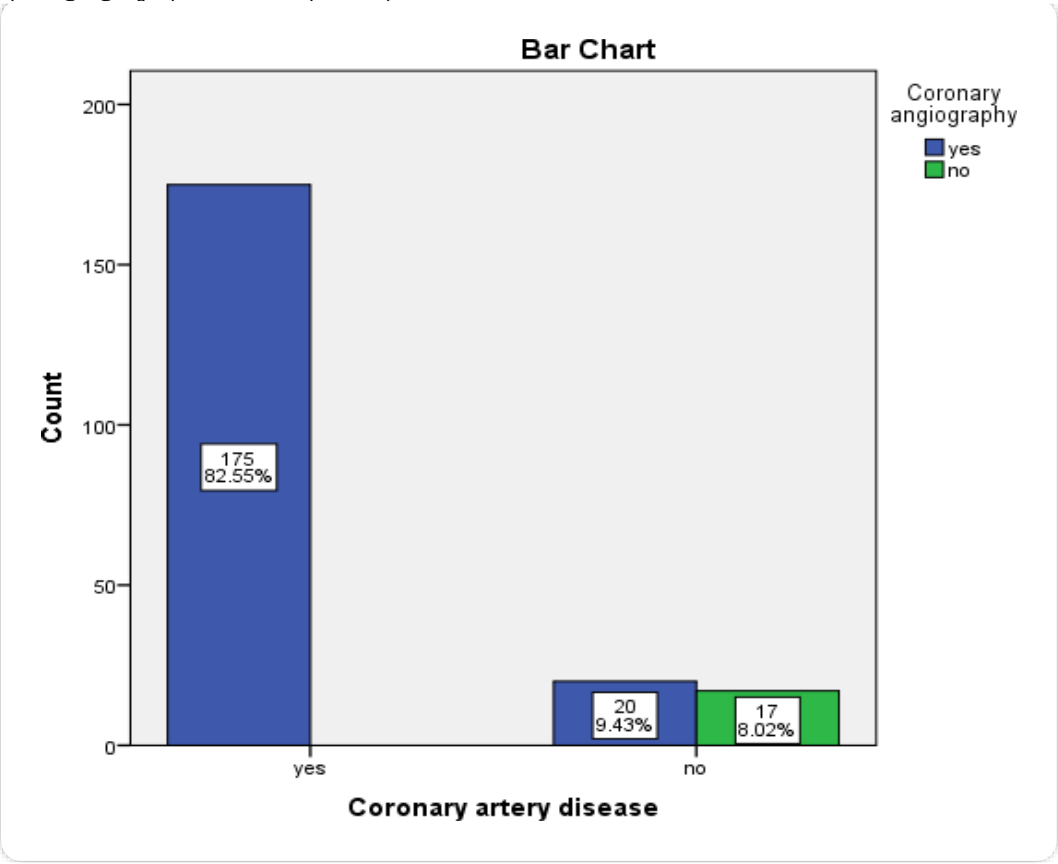


Figure 3.4 shows sensitivity of coronary angiography in CAD Patients

Table 3.5 Data collection of following Question:

sensitivity of coronary angiography in CAD			
	Coronary angiography		Total
	Yes	No	
Coronary artery disease Yes	175a	0b	175
No	20a	17b	37
Total	195	17	212

Each subscript letter denotes a subset of Coronary angiography categories whose column proportions do not differ significantly from each other at the .05 level.

Table 3.6 Chi-Square Tests for coronary angiography

	Value	Df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	87.415[a]	1	.000		
Continuity Correction[b]	81.297	1	.000		
Likelihood Ratio	67.344	1	.000		
Fisher's Exact Test				.000	.000
N of Valid Cases	212				

a. 1 cells (25.0%) have expected count less than 5. The minimum expected count is 2.97.
b. Computed only for a 2x2 table

Crosstabulation of CAD with coronary angiography done in 212 patients in which 175 (82.55%) patients were true positive having CAD, 20(9.34%) patients true negative having no CAD, 17(8.02%) patients false negative. overall sensitivity of coronary angiography in CAD patients is 89%. A p value show that coronary angiography is more significant for the detection of CAD.

DISCUSSION

The present study aimed to compare the sensitivity of Exercise Tolerance Test (ETT) and coronary angiography in detecting coronary artery disease (CAD) among patients at Rehman Medical Institute, Peshawar. The results demonstrated that while both ETT and coronary angiography are useful diagnostic tools, coronary angiography is more sensitive in detecting CAD. Specifically, ETT showed a sensitivity of 76.5%, whereas coronary angiography reached a sensitivity of 89.7%.

These findings align with previous literature suggesting that while ETT is a practical and non-invasive screening method, its diagnostic accuracy can be affected by multiple physiological and anatomical factors, including coronary artery dominance and pre-existing conditions (Attar et al., 2017; Korkmaz et al., 2018). In this study, ETT detected ischemia in 72.6% of patients and angina in 25.9% of patients, indicating that while it can identify functional abnormalities, it may not always accurately reflect the anatomical severity of CAD. False-positive and false-negative results, as observed in this study (12.74% and 4.72% for ETT, respectively), could be attributed to variations in patient-specific factors, such as exercise capacity, medications, and baseline ECG

abnormalities, which have been reported in prior studies (Löffler et al., 2018).

Coronary angiography, considered the gold standard for evaluating coronary anatomy, showed higher sensitivity and specificity in detecting CAD in this study. True positive cases comprised 82.55% of the sample, with a small number of false negatives (8.02%). The statistically significant association between coronary angiography and CAD ($p = 0.000$) confirms its reliability in detecting anatomical lesions that may not manifest as ischemia or angina during ETT. This is consistent with earlier findings showing that anatomical imaging provides more precise identification of luminal obstruction and plaque burden compared to functional tests alone (Foy et al., 2017; Grech, 2003).

The study underscores the complementary roles of ETT and coronary angiography in clinical practice. ETT remains a cost-effective, non-invasive first-line tool that can screen patients for CAD, especially in low-resource settings. However, in cases where accurate anatomical assessment is required, particularly for patients with positive or inconclusive ETT results, coronary angiography should be employed to guide management decisions and interventions. This approach optimizes the use of diagnostic resources while ensuring accurate detection of CAD.

Limitations of this study include the cross-sectional design, which precludes assessment of long-term outcomes, and the use of non-probability convenient sampling, which may limit generalizability. Additionally, factors such as medications, comorbidities, and patient compliance during ETT could have influenced test sensitivity. Future research should consider larger, multi-center prospective studies to further evaluate the predictive value of ETT combined with biomarkers or imaging modalities for CAD detection.

CONCLUSION

In conclusion, both Exercise Tolerance Test and coronary angiography are valuable diagnostic tools for detecting coronary artery disease. However, coronary angiography demonstrates higher sensitivity and diagnostic accuracy than ETT. ETT can serve as a useful initial screening test, particularly for identifying patients at risk or with limited access to invasive procedures, while coronary angiography remains the definitive method for accurately detecting the presence and severity of CAD. Integrating both modalities in clinical practice allows for efficient, cost-effective, and accurate diagnosis, thereby improving patient care and guiding appropriate therapeutic interventions.

LIMITATIONS

1. This was a single-center study, which may limit the generalizability of the results to a broader population. Conducting a multi-center study could reduce institutional bias and enhance the external validity of the findings.
2. The sample size was relatively limited. Inclusion of a larger study population would provide a more accurate representation of the target population and improve the reliability of the results.
3. The duration of the study was short, which restricted the ability to evaluate long-term outcomes and trends associated with diagnostic accuracy and disease progression.

RECOMMENDATIONS

1. Based on the findings of the present study, the following recommendations are proposed:
2. Coronary angiography is strongly recommended for patients suspected of having coronary artery disease, as it demonstrated higher sensitivity and diagnostic significance compared to other diagnostic modalities. It provides detailed anatomical information that is essential for accurate diagnosis and treatment planning.
3. Coronary angiography enables patients and clinicians to assess the severity and extent of coronary artery involvement, facilitating timely decisions regarding further management options such as percutaneous coronary intervention (PCI)

or coronary artery bypass grafting (CABG).

4. Exercise Tolerance Test remains a valuable, non-invasive initial screening tool for the early detection of coronary artery disease, particularly in patients with stable angina or low-to-intermediate risk profiles. It should be used as a preliminary diagnostic step before proceeding to invasive investigations.

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