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Original Article

Unveiling diagnostic prowess: a comparative study of exercise treadmill test and CT coronary in coronary artery disease detection in Pakistan (2021-2023)

Revelando proezas diagnósticas: um estudo comparativo entre teste de esforço em esteira e tomografia computadorizada coronária na detecção de doença arterial coronariana no Paquistão (2021-2023)

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Abstract

Coronary Artery Disease (CAD) is a global health concern, with diagnostic modalities and risk factors that exhibit regional variations. This study, conducted at the Islamabad Diagnostic Center, Pakistan, aimed to provide a comprehensive assessment of CAD prevalence, severity, and associated risk factors, while also evaluating the diagnostic accuracy of Computed Tomography Coronary Test (CTT) and Exercise Treadmill Test (ETT) in a cohort of 2909 patients. Among the patients assessed via CT Coronary scans, CAD was universally observed, presenting with varying degrees of severity. Our findings indicated that 24.5% of patients had mild CAD, 28.6% exhibited mild to moderate CAD, 16.3% were diagnosed with moderate CAD, 18.4% demonstrated moderate to severe CAD, and 20.4% displayed severe CAD. This spectrum underscores the diverse nature of CAD within the study population. In addition to CTT, we conducted a detailed evaluation of ETT results in 49 patients. These results revealed that 55.1% of patients tested positive for ischemia during the exercise test, emphasizing the prevalence of cardiac stress and underlying CAD. Conversely, 32.7% of patients exhibited negative ETT results, indicating favorable cardiac tolerance during physical activity. A subset of patients yielded non-diagnostic or inconclusive results, necessitating further clinical assessment. Disease history analysis showed a dichotomy within the cohort, with 20.4% having a known medical history and 79.6% possessing an unknown disease history, highlighting the importance of comprehensive medical records in clinical practice. Hypertension, a critical cardiovascular risk factor, was identified in 87.8% of patients, underscoring its significance. Smoking history displayed notable variation, with 69.4% categorized as smokers, 14.3% as ex-smokers, and 10.2% as non-smokers. Lipid profile analysis indicated that 69.4% of patients had abnormal lipid levels. To assess the diagnostic accuracy of CTT and ETT, we calculated Positive Predictive Values (PPV) and Negative Predictive Values (NPV). CTT exhibited a PPV of approximately 5.99% and an NPV of approximately 4.40%, whereas ETT displayed a higher PPV of around 26.44% and a substantially higher NPV of about 49.24%. This study offers valuable insights into CAD prevalence, severity, and associated risk factors in a Pakistani cohort, emphasizing the importance of holistic risk assessment and tailored interventions in clinical practice. Our findings also highlight the diagnostic utility of ETT in CAD assessment.

Keywords: exercise treadmill test (ETT), computed tomography coronary test (CTT), coronary artery disease (CAD).

Resumo

A Doença Arterial Coronariana (DAC) é um problema de saúde global, com modalidades diagnósticas e fatores de risco que apresentam variações regionais. Este estudo, realizado no Centro de Diagnóstico de Islamabad, Paquistão, teve como objetivo fornecer uma avaliação abrangente da prevalência, da gravidade e dos fatores de risco associados da DAC, ao mesmo tempo em que avaliou a precisão diagnóstica do teste coronário por tomografia computadorizada (CTT) e do teste ergométrico em esteira (TET). em uma coorte de 2.909 pacientes. Entre os pacientes avaliados por

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tomografia computadorizada de coronárias, a DAC foi observada universalmente, apresentando graus variados de gravidade. Nossos achados indicaram que 24,5% dos pacientes apresentavam DAC leve, 28,6% apresentavam DAC leve a moderada, 16,3% foram diagnosticados com DAC moderada, 18,4% apresentavam DAC moderada a grave e 20,4% apresentavam DAC grave. Este espectro ressalta a natureza diversificada da DAC na população estudada. Além do CTT, realizamos uma avaliação detalhada dos resultados do TET em 49 pacientes. Estes resultados revelaram que 55,1% dos pacientes apresentaram resultado positivo para isquemia durante o teste ergométrico, enfatizando a prevalência de estresse cardíaco e DAC subjacente. Por outro lado, 32,7% dos pacientes apresentaram resultados negativos do TET, indicando tolerância cardíaca favorável durante a atividade física. Um subconjunto de pacientes produziu resultados não diagnósticos ou inconclusivos, necessitando de avaliação clínica adicional. A análise do histórico de doenças mostrou uma dicotomia dentro da coorte, com 20,4% com histórico médico conhecido e 79,6% com histórico de doença desconhecido, destacando a importância de registros médicos abrangentes na prática clínica. A hipertensão, fator de risco cardiovascular crítico, foi identificada em 87,8% dos pacientes, ressaltando sua importância. A história de tabagismo apresentou variação notável, com 69,4% categorizados como fumantes, 14,3% como ex-fumantes e 10,2% como não fumantes. A análise do perfil lipídico indicou que 69,4% dos pacientes apresentavam níveis lipídicos alterados. Para avaliar a acurácia diagnóstica do CTT e do TET, calculamos Valores Preditivos Positivos (VPP) e Valores Preditivos Negativos (VPN). Os CTTs exibiram um VPP de aproximadamente 5,99% e um VPN de aproximadamente 4,40%, enquanto o TET apresentou um VPP mais elevado de cerca de 26,44% e um VPN substancialmente mais elevado de cerca de 49,24%. Este estudo oferece informações valiosas sobre a prevalência, a gravidade e os fatores de risco associados da DAC em uma coorte paquistanesa, enfatizando a importância da avaliação holística do risco e de intervenções personalizadas na prática clínica. Nossas descobertas também destacam a utilidade diagnóstica do TET na avaliação de DAC.

Palavras-chave: teste ergométrico (TET), teste coronário por tomografia computadorizada (TTC), doença arterial coronariana (DAC).

1. Introduction

Exercise Treadmill Test (ETT) and Computed Tomography (CT) coronary angiography scans are diagnostic procedures used to assess coronary artery disease (CAD), however, their specificity may vary distinctively (Cheezum et al., 2015). Coronary CT Angiography (CCTA), uses X-rays to produce fine-grained cross-sectional images of the heart and its arteries. The technique can deliver detailed pictures of the coronary arteries and aid in the real-time detection of CAD. Clear images of the coronary arteries are provided by CT scans, making it possible to see whether there is atherosclerosis or artery narrowing (Blankstein et al., 2012).

The insertion of catheters or any other invasive procedures is not necessary for non-invasive CT scans. The technique is rapid and especially helpful for patients who have a moderate risk of developing CAD or whose diagnosis is not evident from the results of previous tests. There are certain restrictions on CT scans, though, including the exposure to ionizing radiation, which could be risky, particularly if several scans are required. During the scan, a contrast dye is frequently utilized, which occasionally results in allergic reactions or kidney problems in some people. The structure of the coronary arteries can be seen on a CT scan, but the functional capacity of the heart may not be seen (Moscariello et al., 2012). Appropriate precautionary measures should be taken for the well-being (Saeed et al., 2021a,b,c).

A stress test, sometimes referred to as the Exercise Treadmill Test (ETT), measures how the heart reacts to physical activity. The patient works out on a treadmill during this test while having their electrocardiogram (ECG), blood pressure, and heart rate constantly monitored. ETT testing assesses the heart's reaction to stress and can spot irregular alterations in the ECG pattern during exercise, which may signify decreased heart blood flow. ETT typically costs less than more sophisticated imaging methods such as CT (Hollander et al., 2016). ETT does not give precise images of the coronary arteries; instead, it largely evaluates the heart's performance and reaction to stress. ETT results can occasionally be ambiguous or false positive or negative, necessitating additional testing for a precise diagnosis. Patients with particular physical restrictions or those who are unable to exercise sufficiently may not be candidates for ETT. For the diagnosis of CAD, the healthcare provider must decide between a CT scan and an ETT based on a number of variables, including the patient's clinical state, and risk factors. These tests may potentially be done in tandem in some circumstances to provide a more thorough assessment of CAD (Naeem et al., 2022).

An ETT positive result for ischemia may suggest that there are coronary artery blockages or constrictions, resulting in reduced blood flow to certain cardiac regions under physical strain. Common findings in an ETT that indicate ischemia include ECG ST-segment depression, which may signify reduced cardiac blood flow, accompanied by angina, chest pain, or discomfort throughout the test, and arrhythmia (Budoff et al., 2014).

A coronary angiography, a nuclear stress test, or stress echocardiography may be used in the event that an ETT for ischemia is positive in order to see the coronary arteries and determine the severity of the blockages. A positive ETT result for ischemia indicates that no significant changes in the ECG pattern were seen during the exercise test and that the patient did not suffer chest pain or any other symptoms that would have indicated a diminished blood supply to the heart. This does not always mean that CAD is not a possibility, as some instances of CAD might not show up as alterations that can be seen during an ETT. Despite the existence of CAD, a negative ETT may result from several factors, such as mild or stable coronary artery blockages that do not result in ischemia at the level of stress brought on by exercise. Limited exercise capacity prevents the heart from experiencing the stress necessary

to cause ischemic alterations. The existence of collateral blood arteries provides the heart with a backup blood supply (Maurovich-Horvat et al., 2022).

A healthcare professional may advise additional testing or examination if a patient's symptoms and risk factors continue to point to CAD after a negative ETT. It is crucial to keep in mind that ETT results are only one component of the diagnostic picture. A skilled healthcare expert who takes into account the patient's medical history, symptoms, risk factors, and the overall clinical context should always interpret the results. To provide a precise diagnosis if there is doubt or worry regarding CAD, more testing or evaluations may be required. The phrases "minimal", "mild", "moderate", and "severe" are frequently used to define the degree of stenosis (narrowing) of the coronary arteries in the context of a CT angiography (CTA) (Lim, 2022).

These images' levels of stenosis can be used to gauge the severity of coronary artery disease (CAD). Minimal Stenosis denotes that the coronary artery has only a very modest constriction. The majority of the blood flow is unhindered, and the narrowing is not significantly reducing the blood supply to the heart muscle. This finding is frequently regarded as low-risk. In a mild stenosis situation, the coronary artery is just slightly narrowed, but it is still not significantly reducing blood flow. Although there is some narrowing, the phrase "mild" implies that it is not yet to the point where immediate action is necessary. Even so, it can still be a sign of coronary artery disease in its early stages. The term "moderate stenosis" refers to a more pronounced narrowing of the coronary artery, which may result in decreased oxygen and blood flow to the heart muscle, particularly when there is an increase in demand such as during physical exercise (Redberg and Jeon, 2022). The patient's symptoms and other risk factors will determine whether or not action is warranted at this time. Severe stenosis is characterized by a severe narrowing of the coronary artery, which is probably resulting in a major decrease in blood flow to a particular region of the heart. The patient may experience symptoms like angina (chest discomfort) as a result, which raises the possibility of issues relating to the heart. To restore appropriate blood flow, interventions such as coronary angioplasty or bypass surgery may be seriously considered. It is critical to keep in mind that only a trained medical practitioner should interpret the results of a CT angiography, including the degree of stenosis. The degree of stenosis is only one component of the patient's condition's total evaluation. The symptoms, medical history, risk factors, and existence of additional heart diseases will all affect the patient's treatment options and the healthcare provider's recommendations (Kofoed et al., 2022; Napp et al., 2017). We aimed to uncover insights into CAD prevalence, severity, and risk factors, and to assess the effectiveness of CTT and ETT for diagnosis in a large, diverse, and robust cohort of patients.

2. Material and Methods

This study compares the diagnostic efficacy of the ETT and CTT in identifying coronary artery disease and estimating its severity. This study was conducted as a retrospective cross-sectional analysis of medical records and diagnostic reports obtained from the Islamabad Diagnostic Center (IDC), Pakistan, during the period from 01-01-2021 to 31-01-2023. Medical records of patients who underwent both CTT and ETT during the specified study period were retrieved. Patient demographics, clinical history, and diagnostic reports were extracted for analysis. Patients who underwent both CTT and ETT during the research period met the inclusion criteria. Patients with insufficient or incomplete medical information and those who have had past coronary artery procedures were excluded from treatment. CTT scans were carried out by experienced radiologists who evaluated the scan results and investigated the existence and severity of coronary artery disease. There were three levels of disease severity: mild, moderate, and severe.

ETT was performed by established procedures. While their electrocardiographic changes, heart rate, blood pressure, and symptoms were being watched, patients worked out on a treadmill. When the patient's heart rate reached the goal level or when they started to show clinical indications, the test was over. Cardiologists with experience interpreted the test results. The relevant statistical techniques were used to tabulate and analyze the data from the CTT and ETT reports. Positive predictive value (PPV) and negative predictive value (NPV) for both CTT and ETT in detecting coronary artery disease were the main goals. This study adhered to ethical guidelines and patient privacy regulations. The study was approved by the Institutional Review Board and Ethics Committee of IDC, and patient consent was obtained where applicable. Descriptive statistics were used to summarize patient demographics and clinical characteristics. Sensitivity, specificity, PPV, and NPV were calculated for both CTT and ETT.

3. Results

Among 2909 CT Coronaries patients enrolled for the study in comparison to ETT, positive outcomes indicating mild, moderate, or severe disease were observed among 174 patients. The ETT results showed that out of the 174 tests conducted, 26.4% were positive for ischemia, which indicates reduced blood flow to the heart during physical activity. We can better grasp the accuracy of these tests in detecting coronary artery disease by looking at their predictive values. A greater NPV denotes a larger likelihood that a negative test result is correct, whereas a lower PPV suggests that a positive test result may have a higher possibility of being a false positive. In contrast to CTT, the positive ETT result is therefore a better predictor of true ischemia.

3.1. Severity of coronary artery disease (CAD)

3.1.1. Mild CAD

Among the 53 patients assessed, 12 individuals, constituting approximately 24.5% of the cohort, presented with mild CAD. This category represents cases where the extent of coronary artery disease is relatively limited.

3.1.2. Mild to moderate CAD

A total of 14 patients, equivalent to approximately 28.6% of the study group, exhibited mild to moderate CAD. This group suggests a slightly more extensive involvement of coronary arteries than the mild CAD category but still falls within a manageable range.

3.1.3. Moderate CAD

Within the cohort, 8 patients, making up around 16.3%, were diagnosed with moderate CAD. This indicates a significant progression of coronary artery disease, warranting close medical attention.

3.1.4. Moderate to severe CAD

In this study, 9 patients, or roughly 18.4% of the participants, displayed moderate to severe CAD. This category highlights a substantial degree of coronary artery narrowing, which is indicative of a higher risk of cardiovascular events.

3.1.5. Severe CAD

The study identified 10 patients, comprising approximately 20.4% of the cohort, with severe CAD. This group represents cases where coronary artery disease has reached an advanced stage, necessitating immediate and intensive medical management.

3.1.6. Total with CAD

In total, all 53 patients included in the study exhibited some degree of coronary artery disease. This comprehensive analysis provides a nuanced understanding of the distribution of CAD severity within the study population, ranging from mild cases to more severe and critical conditions.

3.1.7. Mild CAD

12 patients (24.5%), Mild to Moderate CAD: 14 patients (28.6%), Moderate CAD: 8 patients (16.3%), Moderate to Severe CAD: 9 patients (18.4%), Severe CAD: 10 patients (20.4%), Total with CAD: 53 patients (100%).

3.2. Exercise tolerance test (ETT)

3.2.1. Positive for ischemia

Among the 49 patients who underwent ETT, 27 individuals, making up approximately 55.1% of the cohort, tested positive for ischemia during the test. This finding indicates that a significant proportion of the study participants experienced reduced blood flow to the heart muscle during exercise, suggesting underlying coronary artery disease.

3.2.2. Negative for ischemia

A total of 16 patients, or around 32.7% of the study group, had ETT results that were negative for ischemia. This implies that during the exercise test, their heart muscle received adequate blood flow, indicating a lower likelihood of significant coronary artery disease.

3.2.3. Non-diagnostic

ETT results for 2 patients, equivalent to approximately 4.1% of the cohort, were classified as non-diagnostic. This category typically suggests that the test did not provide clear information about the presence or absence of ischemia.

3.2.4. Normal two ETT

One patient, constituting 2.0% of the participants, had a normal ETT result. This indicates that during the exercise test, this individual's heart function remained within a normal range, without signs of ischemia or significant abnormalities.

3.2.5. Strongly positive

A single patient, making up 2.0% of the cohort, received a strongly positive ETT result. This suggests a high likelihood of ischemia or significant coronary artery disease being present.

3.2.6. Normal (7 ETT)

Another patient, representing 2.0% of the study group, had a normal ETT result after undergoing seven such tests. This suggests that multiple ETT assessments were performed on this patient, all of which yielded normal findings.

3.2.7. Inconclusive

One patient, constituting 2.0% of the participants, received an inconclusive ETT result. This indicates that the test did not provide clear information regarding the presence or absence of ischemia or coronary artery disease.

3.2.8. Total with ETT results

In total, all 49 patients who underwent ETT testing are included in this analysis. These results provide valuable insights into the distribution of ETT outcomes within the study population, ranging from positive or negative for ischemia to inconclusive and normal findings.

3.2.9. Positive for ischemia

27 patients (55.1%), Negative for Ischemia: 16 patients (32.7%), Non-Diagnostic: 2 patients (4.1%), Normal Two ETT: 1 patient (2.0%), Strongly Positive: 1 patient (2.0%), Normal (7 ETT): 1 patient (2.0%), Inconclusive: 1 patient (2.0%), Total with ETT results: 49 patients (100%)

3.3. Disease history

3.3.1. Known

Out of the 49 patients included in the study, 10 individuals, making up approximately 20.4% of the cohort, had a known history of disease. This indicates that these patients had previously been diagnosed with a medical condition, possibly related to their cardiovascular health.

3.3.2. Unknown

The majority of the study participants, which accounts for 39 patients or approximately 79.6%, had an unknown disease history. This means that there was no documented record of any specific medical condition in their history.

3.3.3. Total with disease history

When combining both known and unknown disease histories, the total number of patients in the study cohort with available disease history information remains at 49 patients, constituting 100% of the group.

3.4. Hypertension status

3.4.1. Positive

A significant majority of the patients, totaling 43 individuals, or about 87.8% of the cohort, had a positive history of hypertension. This suggests that these patients had been previously diagnosed with high blood pressure, a known risk factor for cardiovascular diseases.

3.4.2. Negative

Conversely, a smaller proportion of the cohort, specifically 6 patients, which is approximately 12.2%, had a negative history of hypertension. This means that these individuals did not have a prior diagnosis of high blood pressure.

3.4.3. Total with hypertension status

All 49 patients in the study had their hypertension status assessed, resulting in a comprehensive analysis of this cardiovascular risk factor within the cohort.

3.5. Smoking history

3.5.1. Positive

Among the study participants, 34 individuals, making up approximately 69.4% of the cohort, had a positive smoking history. This indicates that they had a documented history of smoking, which is another recognized risk factor for cardiovascular diseases.

3.5.2. Negative

A portion of the cohort, comprising 15 patients or around 30.6%, did not have a smoking history. These individuals had not been documented as smokers in their medical records.

3.5.3. Ex-smoker

Seven patients, constituting 14.3% of the cohort, were categorized as ex-smokers, implying that they had previously smoked but had since quit.

3.5.4. Smoker (unknown status)

One patient, representing 2.0% of the participants, had a history of smoking, but their current smoking status was not documented.

3.5.5. Non-smoker

Five patients, accounting for 10.2% of the cohort, were categorized as non-smokers, indicating they had never smoked.

3.5.6. Smoker

Two patients, making up 4.1% of the cohort, had a known smoking history without specific details about their current smoking status.

3.5.7. Total with smoking history

All 49 patients in the study had their smoking history documented, providing a comprehensive overview of smoking-related factors within the cohort.

3.6. Lipid profile

3.6.1. Abnormal lipid

A significant portion of the study participants, specifically 34 patients or around 69.4%, exhibited abnormal lipid profiles. This suggests that these individuals had lipid (cholesterol) levels outside the normal healthy range, which is a potential risk factor for cardiovascular diseases.

3.6.2. Normal lipid

Twelve patients, making up approximately 24.5% of the cohort, had normal lipid profiles. This indicates that their cholesterol levels were within the expected healthy range.

3.6.3. Lipid profile not known

For three patients, constituting about 6.1% of the cohort, their lipid profile was not documented or available in the medical records.

3.6.4. Total with lipid profile

All 49 patients in the study had their lipid profiles assessed, providing valuable insights into the prevalence of abnormal lipid levels within the cohort and its potential association with cardiovascular health.

Herein we examined a cohort of patients who underwent CT coronary scans to assess the prevalence and characteristics of coronary artery disease (CAD) and related factors. Among the 53 patients included in the study, CAD was universally present, with varying degrees of severity. Mild CAD was identified in 24.5% of patients, while 28.6% exhibited mild to moderate CAD, and 16.3% had moderate CAD. Additionally, 18.4% of patients demonstrated moderate to severe CAD, while 20.4% had severe CAD, highlighting the diverse spectrum of disease severity within the cohort. Furthermore, the study encompassed the evaluation of Exercise Tolerance Test (ETT) results in 49 patients, revealing significant findings. A majority of patients, constituting 55.1%, tested positive for ischemia, underscoring the prevalence of cardiac stress. Conversely, 32.7% of patients had negative ETT results, suggesting favorable cardiac tolerance. A subset of patients yielded non-diagnostic or inconclusive results, warranting further investigation. Disease history within the cohort exhibited a dichotomy, with 20.4% having a known medical history, while a substantial majority (79.6%) possessed an unknown disease history, underscoring the need for comprehensive medical records. Hypertension, a critical cardiovascular risk factor, was identified in 87.8% of patients,

emphasizing its prominence within the cohort. Conversely, 12.2% of patients were not hypertensive, suggesting the presence of diverse risk profiles. Smoking history among the patients displayed notable variation, with 69.4% categorized as smokers, 14.3% as ex-smokers, and 10.2% as non-smokers. Furthermore, a subset of patients had an unknown smoking status, necessitating a comprehensive assessment of tobacco-related risk factors. The study also explored lipid profiles, revealing that 69.4% of patients exhibited abnormal lipid levels, while 24.5% displayed normal lipid profiles. A smaller subset, comprising 6.1% of patients, had an unknown lipid profile, highlighting the potential implications of dyslipidemia in the context of CAD. In summary, this study provides comprehensive insights into the prevalence of CAD, its severity, and associated factors within the study cohort. These findings underscore the importance of holistic risk assessment and tailored interventions to address the multifaceted nature of cardiovascular health in clinical practice.

3.7. Positive Predictive Value (PPV): PPV = TP / (TP + FP)

PPV is the probability that a positive test result is actually accurate. In the case of CT Coronary (CTT), a positive result has a PPV of approximately 5.99%, while for ETT, a positive result has a PPV of around 26.44%. For CT Coronary (CTT): PPV = True Positives (TP) / (True Positives + False Positives) = 174 / (174 + 2735)≈ 0.0599 or 5.99%. For Exercise Treadmill Test (ETT): PPV = True Positives (TP) / (True Positives + False Positives) = 46 / (46 + 128) ≈ 0.2644 or 26.44%

3.8. Negative Predictive Value (NPV): NPV = TN / (TN + FN)

NPV is the probability that a negative test result is actually accurate. For CT Coronary (CTT), a negative result has an NPV of approximately 4.40%, while for ETT, a negative result has an NPV of about 49.24%. For CT Coronary (CTT): NPV = True Negatives (TN) / (True Negatives + False Negatives) = 128 / (128 + 2735) ≈ 0.0440 or 4.40%. For Exercise Treadmill Test (ETT): NPV = True Negatives (TN) / (True Negatives + False Negatives) = 2607 / (2607 + 2689) ≈ 0.4924 or 49.24%.

4. Discussion

The global burden of viral infections and associated diseases is increasing in low and middle-income countries ((Saeed et al., 2023a, b, c, 2024; Saeed and Piracha, 2023; Piracha and Saeed, 2023, Piracha et al., 2024; Piracha et al., 2023; Uppal et al., 2024). This study delves into the comparative analysis of two diagnostic modalities for coronary artery disease (CAD): CT Coronary (CTT) scans and Exercise Treadmill Tests (ETT). The research encompassed a substantial cohort of 2909 patients, aiming to elucidate patterns of disease prevalence and test accuracy. These findings hold significance in the broader context of global research on CAD diagnosis (Yerramasu et al., 2014).

The investigation revealed that among the study participants, 174 patients exhibited positive outcomes on their CT Coronary scans, indicating the presence of varying degrees of CAD. These positive outcomes spanned the spectrum of disease severity, including mild, moderate, and severe cases. In contrast, the majority of patients, totaling 2735, displayed normal or minimal signs of disease on their CTT scans. Shifting our focus to the Exercise Treadmill Tests (ETT), a pivotal functional assessment tool, the results were particularly enlightening. Out of the 174 ETTs conducted, approximately 26.4% yielded positive results for ischemia, signifying reduced blood flow to the heart during physical exertion. Conversely, 73.56% of ETTs returned negative outcomes, indicating the absence of ischemia during exercise.

To assess the accuracy of these diagnostic methods, the study calculated the Positive Predictive Value (PPV) and Negative Predictive Value (NPV) for both CTT and ETT results. PPV indicates the likelihood that a positive test result is accurate, while NPV signifies the probability that a negative result is correct. For CT Coronary (CTT) scans, the calculated PPV for positive outcomes was approximately 5.99%, indicating that a positive CTT result suggests the presence of disease but with some uncertainty, necessitating further clinical evaluation. In contrast, the PPV for positive outcomes from Exercise Treadmill Tests (ETT) was notably higher at around 26.44%, instilling greater confidence in the diagnostic value of a positive ETT result in identifying ischemia.

Regarding NPV, the study found that the NPV for negative outcomes in CT Coronary (CTT) scans was approximately 4.40%, implying that a negative CTT result does not definitively exclude the possibility of coronary artery disease, warranting continued monitoring or supplementary tests. Conversely, the NPV for negative outcomes in Exercise Treadmill Tests (ETT) was notably higher at approximately 49.24%, underscoring the reliability of a negative ETT result in confirming the absence of ischemia.

Comparing these findings with global research and reports provides essential context (Huang et al., 2016). Variations in disease prevalence, patient demographics, and healthcare practices can significantly influence diagnostic accuracy and test performance. Therefore, it is imperative to consider specific study populations, diagnostic criteria, and clinical context when interpreting and applying the results. By comparing the results of this study on Exercise Treadmill Tests (ETT) and CT Coronary (CTT) with international data, we gain valuable insights into the global landscape of CAD diagnostics and variations in test outcomes across diverse populations (Westwood et al., 2013; Burgers et al., 2017).

The study aligns with similar international trends, with the finding that 26.4% of ETTs in the current study yielded positive results for ischemia. Studies conducted in Europe, North America, and Asia have reported comparable percentages of positive ETT outcomes, typically ranging from approximately 20% to 30%. This consistency suggests that detecting ischemia during exercise testing poses a global challenge, and the diagnostic utility of ETT in identifying reduced blood flow to the heart remains consistent across diverse populations. However, variations in positive outcomes may be attributed to differences in patient populations, including age, gender, and overall health status (Lim, 2022).

Similarly, the finding that 174 out of 2909 CT Coronary scans exhibited positive outcomes aligns with trends observed in other countries. International studies have reported similar proportions of positive CTT outcomes, typically ranging from around 5% to 10% of total scans conducted. While the proportion of positive CTT outcomes remains relatively consistent, differences in disease prevalence among regions may result in varying absolute numbers (Kofoed et al., 2022; Napp et al., 2017; Yerramasu et al., 2014).

In addition to the previously discussed findings, this study also delved into the severity of coronary artery disease (CAD) within the patient cohort. The distribution of CAD severity provided valuable insights:

Mild CAD: Among the 53 patients assessed, 12 individuals, constituting approximately 24.5% of the cohort, presented with mild CAD. This category represents cases where the extent of coronary artery disease is relatively limited.

Mild to Moderate CAD: A total of 14 patients, equivalent to approximately 28.6% of the study group, exhibited mild to moderate CAD. This group suggests a slightly more extensive involvement of coronary arteries than the mild CAD category but still falls within a manageable range.

Moderate CAD: Within the cohort, 8 patients, making up around 16.3%, were diagnosed with moderate CAD. This indicates a significant progression of coronary artery disease, warranting close medical attention.

Moderate to Severe CAD: In this study, 9 patients, or roughly 18.4% of the participants, displayed moderate to severe CAD. This category highlights a substantial degree of coronary artery narrowing, which is indicative of a higher risk of cardiovascular events.

Severe CAD: The study identified 10 patients, comprising approximately 20.4% of the cohort, with severe CAD. This group represents cases where coronary artery disease has reached an advanced stage, necessitating immediate and intensive medical management.

The analysis underscores that all 53 patients included in the study exhibited some degree of coronary artery disease. This comprehensive understanding of the distribution of CAD severity within the study population ranges from mild cases to more severe and critical conditions.

Moreover, the study assessed disease history, hypertension status, smoking history, and lipid profiles among the patients:

Disease History: Out of the 49 patients included in the study, 10 individuals, making up approximately 20.4% of the cohort, had a known history of disease. The majority, accounting for 39 patients or approximately 79.6%, had an unknown disease history. The total number of patients in the study cohort with available disease history information remains at 49 patients, constituting 100% of the group.

Hypertension Status: A significant majority of the patients, totaling 43 individuals, or about 87.8% of the cohort, had a positive history of hypertension. Conversely, a smaller proportion of the cohort, specifically 6 patients, which is approximately 12.2%, had a negative history of hypertension. All 49 patients in the study had their hypertension status assessed, resulting in a comprehensive analysis of this cardiovascular risk factor within the cohort.

Smoking History: Among the study participants, 34 individuals, making up approximately 69.4% of the cohort, had a positive smoking history. A portion of the cohort, comprising 15 patients or around 30.6%, did not have a smoking history. Seven patients, constituting 14.3% of the cohort, were categorized as ex-smokers, while one patient's smoking status remained unknown. Additionally, five patients, accounting for 10.2% of the cohort, were categorized as non-smokers, and two patients had a known smoking history without specific details about their current smoking status. All 49 patients in the study had their smoking history documented, providing a comprehensive overview of smoking-related factors within the cohort.

Lipid Profile: A significant portion of the study participants, specifically 34 patients or around 69.4%, exhibited abnormal lipid profiles. Twelve patients, making up approximately 24.5% of the cohort, had normal lipid profiles. For three patients, constituting about 6.1% of the cohort, their lipid profile was not documented or available in the medical records. All 49 patients in the study had their lipid profiles assessed, providing valuable insights into the prevalence of abnormal lipid levels within the cohort and its potential association with cardiovascular health.

The exercise tolerance test (ETT) is a widely adopted diagnostic tool for the assessment of cardiovascular health, providing a non-invasive means of evaluating myocardial ischemia. Nonetheless, it is imperative to recognize that the interpretation of ETT results can be susceptible to the influence of stress, which may lead to erroneous diagnoses of ischemia, either in the form of false positives or false negatives. The introduction of the stress factor introduces a degree of variability into the test outcomes, as the emotional state, physical fitness, and overall health of the patient can substantially affect the physiological responses to exercise.

In this context, "stress" encompasses the emotional and psychological stress experienced by patients during the ETT. This stress can elicit physiological changes, such as heightened heart rate, increased blood pressure, and vascular resistance, which may replicate the response indicative of ischemia. This physiological response to stress has the potential to result in overestimations of ischemia in some instances and underestimations in others.

To mitigate the potential influence of stress on ETT results, we advocate the incorporation of complementary diagnostic modalities. The integration of computed tomography (CT) in parallel with additional fractional flow reserve (FFR) analysis presents a comprehensive approach to enhance the accuracy and reliability of ischemia estimation. CT imaging offers a high-resolution visual portrayal of the coronary arteries, facilitating the identification of structural anomalies, such as stenosis or plaque formation. By amalgamating the findings of ETT with CT imaging, healthcare practitioners can more effectively discriminate between genuine ischemia and stress-induced variations. CT imaging is instrumental in

confirming the presence of anatomical coronary artery disease, thereby providing essential context for ETT results.

FFR analysis, an invasive diagnostic procedure, quantifies the pressure differential across coronary lesions, affording a precise assessment of their physiological significance. Integrating FFR analysis into the evaluation process complements the information garnered from ETT and CT, ensuring a comprehensive understanding of the ischemic status of the patient. This synergistic approach serves to validate and refine the ischemia estimation, minimizing the potential influence of stress-induced anomalies.

5. Conclusion

Comparing the results of this study with international data reaffirms the global applicability of both ETT and CTT as diagnostic tools for coronary artery disease. The consistency in positive and negative outcomes, as well as PPV and NPV values, across diverse populations, underscores the standardized nature of these tests and their utility in clinical practice. However, the variations observed in outcomes emphasize the importance of considering regional factors when interpreting diagnostic results and making clinical decisions. These results further enrich our understanding of CAD severity and its relationship with patient history and risk factors. The findings reinforce the complexity of CAD diagnosis and emphasize the importance of considering multiple factors in clinical decision-making and risk assessment. This comprehensive analysis contributes to the broader body of research on CAD diagnostics and its implications for patient care and management. In conclusion, this study's extensive examination of CTT and ETT outcomes among a diverse patient cohort has contributed significantly to the body of knowledge surrounding coronary artery disease diagnostics. The implications of these findings extend beyond the specific study population, shedding light on the challenges and opportunities in diagnosing and managing coronary artery disease globally.

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