Original Article
DOI: https://doi.org/10.70749/ijbr.v3i5.2734

INDUS JOURNAL OF BIOSCIENCE RESEARCH
https://ijbr.com.pk
ISSN: 2960-2793/ 2960-2807

Validity of Carotid Intima-Media Thickness on B-Mode Ultrasonography in the Diagnosis of Coronary Artery Disease Keeping Coronary Angiography as Gold Standard

Ramisa Saleem[1], Alia Mir[2], Sadia Anjum[3], Ayesha Ghafoor[4]

[1-4]Department of Diagnostic Radiology, Islamabad Medical Complex, Islamabad, Pakistan.

ARTICLE INFO

Keywords: Coronary Artery Disease, Carotid intima–media Thickness, B-mode Ultrasonography, Diagnostic Validity, Risk Stratification.

Correspondence to: Ramisa Saleem, Department of Diagnostic Radiology, Islamabad Medical Complex, Islamabad, Pakistan.
Email: ramisasaleem@gmail.com

Declaration
Authors' Contribution
All authors equally contributed to the study and approved the final manuscript

Conflict of Interest: No conflict of interest.

Funding: No funding received by the authors.

Article History
Received: 15-03-2025 Revised: 03-05-2025
Accepted: 17-05-2025 Published: 30-05-2025

ABSTRACT

Background: Carotid intima–media thickness (CIMT) measured by B-mode ultrasonography is a non-invasive marker of systemic atherosclerosis and has been proposed as a surrogate indicator for coronary artery disease (CAD), particularly in resource-limited settings. **Objective:** To evaluate the diagnostic validity of carotid intima–media thickness (CIMT) for detecting angiographically confirmed coronary artery disease (CAD) in an angiography-referred population at a tertiary care hospital in Islamabad, Pakistan. **Methods:** The study was conducted in the Department of Radiology at Islamabad Medical Complex in collaboration with the Cardiology Department. It was designed as a cross-sectional diagnostic accuracy (validation) study and was carried out from December 2024 to Feb 2025. Participants were recruited using consecutive (non-probability) sampling from patients scheduled for coronary angiography, either through the outpatient clinic or as admitted ward patients. **Results:** At a CIMT cutoff of ≥0.9 mm, sensitivity was 80.6%, specificity 80.8%, positive predictive value 56.8%, negative predictive value 93.0%, and overall diagnostic accuracy 80.8%. The positive likelihood ratio was 4.2 and the negative likelihood ratio was 0.24, indicating that a negative CIMT result meaningfully reduced the post-test probability of angiographically significant CAD. The observed prevalence of angiographically confirmed CAD in this study population was 23.8%. **Conclusion:** CIMT demonstrates good diagnostic performance with a high negative predictive value in this angiography-referred population, supporting its use as a non-invasive adjunct for CAD risk stratification and exclusion. CIMT does not replace coronary angiography but may assist clinical decision-making and triage, particularly in resource-constrained settings. Further multicenter studies are warranted to validate these findings.

1. INTRODUCTION

Coronary artery disease (CAD) is one of the leading causes of morbidity and mortality worldwide and is commonly associated with risk factors such as hypertension, diabetes mellitus, elevated fibrinogen levels, low-density lipoprotein cholesterol, and smoking. However, evidence suggests that these conventional risk factors alone have limited predictive value for accurately identifying individuals with significant CAD [1,2]. Several clinical studies have shown that the structures and mechanisms of the atherosclerosis lesions in both the carotid and coronary arteries are pathophysiological remarkably similar. However, the carotid arteries are often affected earlier in the course of atherosclerosis [2]. The carotid artery, due to its more accessible and surface-level anatomy, allows for easier non-invasive assessments when compared to the coronary arteries. While coronary angiography (CAG) is the most accurate way to diagnose coronary atherosclerosis, it is an invasive, expensive, and time-consuming procedure that requires a lot of medical resources. Because of this, it is not commonly used in low-resource areas as a routine screening procedure for atherosclerosis [3]. Carotid ultrasonography is a repeatable, low-cost, and protective method to examine subclinical atherosclerosis. Between the parameters of carotid ultrasound, carotid plaque burden and carotid intima-media thickness (CIMT) are recognized as potential cardiovascular risk factors. With the AHA Prevention Conference in the year 2000, indicated that the measure of CIMT, if performed by competent laboratories, may be accepted to the physician upon request to clarify the risk of coronary heart disease. Increased CIMT and cardiovascular related disease such as transient ischemic attack, myocardial infarction have been explained in several researches which provide the justification of CIMT as a marker of target-organ vascular damage in the

presence or risk of CAD. Studies have reported a positive correlation indicating that vascular target-organ damage is increased with transient ischemic attacks and myocardial infarctions [3]. Along with AHA, B-mode ultrasonography is a non-invasive method with positive findings, indicated the presence of atherosclerotic carotid changes and to reinforce the risk for cardiovascular disease, as citations from other works indicate sensitivity of the method were found to be a minimum of 78% to a maximum 91% with a specificity of 72% to 85% [2,6]. A CIMT value of more than 1.0 mm has been illustrated by a meta-analysis to provide a moderate predictive accuracy for CAD which is explained by a global sensitivity and specificity of 72% and 77% [5]. Furthermore, the burden of coronary artery disease (CAD) continues to rise especially as local studies identify prevalence data of 37.5% [7].

There are limited resources in Pakistani hospitals, so access to coronary angiography is restricted. For this reason, B-mode ultrasonography for CIMT assessment is widely accepted to screen for this condition, as it is low-cost, easy, and reproducible. Local evidence also supports the comparison of carotid Doppler ultrasonography with computed tomography to determine clinically significant carotid stenosis [9]. This reinforces the use of carotid imaging in vascular risk assessment. Given the global incidence of coronary heart disease and acute coronary syndromes, there is a need for the affordable, accessible, and non-invasive ways to aid in the early detection and risk assessment of patients, particularly in low-resource settings [10]. CAD and carotid artery disease have the same atherosclerotic mechanisms and significant CIMT and stenosis (≥ 0.9 mm and > 50%, respectively) increase the risk of stroke and other serious cardiovascular issues. Therefore, early identification of carotid atherosclerosis is crucial and will assist in more aggressive preventative measures. Therefore, this study aims to determine the validity of carotid intima–media thickness on B-mode ultrasonography in diagnosing coronary artery disease, keeping coronary angiography as the gold standard.

2. MATERIAL AND METHODS

The study was conducted in the Department of Radiology at Islamabad Medical Complex in collaboration with the Cardiology Department. It was designed as a cross-sectional diagnostic accuracy (validation) study and was carried out from December 2024 to Feb 2025. Participants were recruited using consecutive (non-probability) sampling from patients scheduled for coronary angiography, either through the outpatient clinic or as admitted ward patients.

The sample size was calculated using a sensitivity- and specificity-based approach for diagnostic studies. A total sample of 130 participants was required based on an assumed sensitivity of 85.7% and specificity of 85.1%, an expected CAD prevalence of 37.5%, a 95% confidence level, and 10% precision. This sample was selected to ensure an adequate number of disease-positive cases for reliable estimation of sensitivity while maintaining acceptable precision for specificity.

Patients of either gender aged 35–60 years scheduled for coronary angiography were included. Patients with a documented previous myocardial infarction (based on history, ECG, or medical records), a history of coronary artery bypass graft surgery, or a history of stroke were excluded. Written informed consent was obtained from all participants, and demographic and clinical information was recorded using a structured proforma. Ethical approval was obtained from the hospital ethical review committee. All participants underwent carotid Doppler/B-mode ultrasonography prior to coronary angiography. Scans were performed using a LOGIQ™ P7 (GE) ultrasound system with a 10 MHz linear probe under the supervision of a consultant radiologist. Participants were examined in the supine position with the neck extended and rotated slightly away from the side being assessed. CIMT was measured bilaterally at three segments: the distal 1 cm of the common carotid artery proximal to the bifurcation, the carotid bifurcation, and the proximal 1 cm of the internal carotid artery. Measurements were obtained on longitudinal views, and the maximum CIMT value for each side was recorded. The final CIMT value was calculated as the mean of the right and left carotid measurements. A mean CIMT of ≥0.9 mm was considered a positive ultrasonographic finding suggestive of CAD. Coronary angiography served as the reference standard. Significant CAD was defined as luminal narrowing of ≥50% in at least one main coronary artery branch. Angiography findings were interpreted by a consultant cardiologist who was blinded to CIMT results to reduce interpretation bias.

All analyses were conducted at the individual patient level using SPSS version 24. Continuous variables (e.g., age, CIMT) are presented as mean ± standard deviation, and categorical variables (e.g., gender, angiography outcome) as frequencies and percentages. Diagnostic validity was evaluated using a 2×2 contingency table to calculate sensitivity, specificity, positive predictive value, negative predictive value, and overall accuracy using standard formulas.

3. RESULTS

This study evaluated the diagnostic validity of carotid intima–media thickness (CIMT) measured by B-mode ultrasonography for the detection of coronary artery disease (CAD), using coronary angiography as the reference standard. All analyses were conducted at the individual patient level in accordance with the prespecified methodology.

1. Demographic and clinical characteristics

A total of 130 patients aged 35–60 years who were referred for coronary angiography were included in the study. The mean age of participants was 48.6 ± 6.9 years. Males constituted 60.0% (n = 78) of the study population, while 40.0% (n = 52) were females. The mean carotid intima–media thickness was 0.98 ± 0.21 mm. Baseline demographic and clinical characteristics are summarized in Table 1.

Table 1

Demographic and clinical characteristics of the study participants (N = 130)

Variable	Mean ± SD / n (%)
Age (years)	48.6 ± 6.9
Gender	
Male	78 (60.0)
Female	52 (40.0)

CIMT (mm)	0.98 ± 0.21

2. Coronary angiography findings

On coronary angiography, 31 participants (23.8%) were found to have significant CAD, defined as ≥50% luminal stenosis in at least one major coronary artery. The remaining 99 participants (76.2%) had no significant coronary artery disease (<50% stenosis). The distribution of angiographic findings is shown in Table 2.

Table 2

Distribution of coronary angiography findings (N = 130)

Coronary angiography result	n (%)
Significant CAD (≥50% stenosis)	31 (23.8)
No significant CAD (<50% stenosis)	99 (76.2)

3. CIMT classification and agreement with coronary angiography

Using the predefined cutoff value of CIMT ≥0.9 mm, ultrasonographic findings were classified as positive in 44 participants (33.8%) and negative in 86 participants (66.2%). When compared with coronary angiography, CIMT correctly identified 25 true-positive cases and 80 true-negative cases. There were 19 false-positive and 6 false-negative results. The cross-tabulation between CIMT findings and coronary angiography is presented in Table 3.

Table 3

Comparison of CIMT category with coronary angiography findings (N = 130)

CIMT category	CAD present (≥50%)	CAD absent (<50%)	Total
≥ 0.9 mm	25	19	44
< 0.9 mm	6	80	86
Total	**31**	**99**	**130**

4. Diagnostic performance of CIMT

When evaluated against coronary angiography, CIMT ≥0.9 mm demonstrated a sensitivity of 80.6% (95% CI: 63.7–90.8) and a specificity of 80.8% (95% CI: 72.0–87.4). The positive predictive value was 56.8% (95% CI: 42.2–70.3), while the negative predictive value was 93.0% (95% CI: 85.6–96.8). The overall diagnostic accuracy of CIMT was 80.8% (95% CI: 73.2–86.6). Diagnostic performance indices are detailed in Table 4.

Table 4

Diagnostic performance of CIMT ≥0.9 mm for detection of CAD (N = 130)

Diagnostic parameter	Value % (95% CI)
Sensitivity	80.6 (63.7–90.8)
Specificity	80.8 (72.0–87.4)
Positive predictive value	56.8 (42.2–70.3)
Negative predictive value	93.0 (85.6–96.8)
Diagnostic accuracy	80.8 (73.2–86.6)

The positive likelihood ratio was 4.2, while the negative likelihood ratio was 0.24, indicating that a negative CIMT result substantially reduced the post-test probability of significant CAD.

5. Summary of diagnostic implications

Overall, CIMT measured by B-mode ultrasonography demonstrated good sensitivity (80.6%) and strong rule-out performance, reflected by a high negative predictive value (93.0%), for detecting angiographically significant coronary artery disease in this angiography-referred population. Although the observed CAD prevalence (23.8%) was lower than that assumed during sample size estimation, this primarily influences predictive values; sensitivity and specificity are not mathematically determined by prevalence and are therefore generally more comparable across settings. These findings suggest that CIMT may be most useful as a practical, non-invasive adjunct to rule out CAD, while the moderate positive predictive value likely reflects the underlying disease prevalence in this clinical context.

4. DISCUSSION

This study assessed the diagnostic validity of carotid intima–media thickness (CIMT) measured by B-mode ultrasonography for detecting coronary artery disease (CAD), using coronary angiography as the reference standard in an angiography-referred population at a tertiary care hospital in Islamabad. At a CIMT cut-off of ≥0.9 mm, CIMT demonstrated good diagnostic performance with an accuracy of 80.8%, a sensitivity of 80.6%, and a specificity of 80.8%. This authenticates CIMT as a viable candidate for supplying CAD screening and risk stratification in resource-limited areas. The performance metrics correlate with regional and global studies that indicate CIMT based CAD detection sensitivity and specificity to be in the range of 70-85% [1,6]. Given the relationship of CIMT to angiography-confirmed CAD and future cardiovascular risk in meta-analyses, CIMT reflects systemic atherosclerosis [5,11]. Carotid and coronary atherosclerosis share similar pathophysiological mechanisms, including endothelial dysfunction, lipid deposition, inflammation, and plaque formation [12,13]. For this study, while CIMT showed a negative predictive value this high (93.0\%) and a moderate positive predictive value of 56.8\%, it is more useful to rule out significant CAD. This is consistent with studies where CIMT has been shown to serve more as a CAD screening tool and CAD triage, rather than a direct substitute for coronary angiography. In practice, a low/normal CIMT may provide added value in identifying patients where the likelihood of obstructive CAD is low, and may help in determining selective referral for invasive testing in conjunction with symptoms and risk factors [3,14]. The referral sample indicates CAD prevalence (23.8%) and should not be extrapolated to the general population. The mean age being relatively young mirrors concerns of South Asian populations with earlier atherosclerosis, attesting to the demand for low-cost vascular risk screening. From a health-systems perspective, CIMT assessment is particularly relevant in Pakistan, where access to coronary angiography may be limited by cost, infrastructure constraints, and the availability of trained specialists [15]. Carotid ultrasonography is widely available, cost-effective, repeatable, and free of ionizing radiation, making it suitable for initial assessment and follow-up risk evaluation [16,17]. CIMT can enhance a clinical assessment by serving as an additional risk indicator and should be considered for those who may profit from earlier interventions and more extensive cardiac workups [18]. These results are in line with the increase in prevalence of coronary heart disease and acute coronary syndromes, particularly in lower and middle-income countries [19]. This study evaluated the diagnostic validity of carotid

intima–media thickness (CIMT) measured by B-mode ultrasonography for identifying angiographically significant coronary artery disease (CAD). Because atherosclerosis is a systemic process, carotid arterial wall changes may reflect coronary atherosclerotic burden. In this angiography-referred population, CIMT demonstrated good diagnostic performance, supporting its potential role as a non-invasive adjunct for risk stratification and triage rather than a substitute for coronary angiography. [20].

This study has limitations. First, it was a single-center, cross-sectional diagnostic study in an angiography-referred population, which may limit generalizability to lower-risk or community settings. Second, CIMT is operator-dependent; although standardized measurement procedures were used, formal inter-observer or intra-observer reliability testing was not performed and should be addressed in future studies. Finally, longitudinal follow-up was not available; therefore, the prognostic value of CIMT for future cardiovascular outcomes could not be assessed.

5. CONCLUSION

CIMT measured by B-mode ultrasonography demonstrated good diagnostic accuracy for detecting angiographically significant CAD in this angiography-referred sample, with strong rule-out utility reflected by a high negative predictive value and low negative likelihood ratio. Although CIMT cannot replace coronary angiography, it may serve as a practical, non-invasive adjunct for CAD risk stratification and triage, particularly in resource-constrained settings. Larger multicenter studies are warranted to confirm these findings and to evaluate the prognostic value of CIMT for future cardiovascular outcomes.

6. REFERENCES

1. Liu, D., Du, C., Shao, W., & Ma, G. (2020). Diagnostic role of carotid intima-media thickness for coronary artery disease: A meta-analysis. *BioMed Research International*, *2020*(1). https://doi.org/10.1155/2020/9879463
2. Rehana, K., Shuaib, I., Khan, J., Gul, H., Khattak, N., & Nawab, K. (2022). Validity of carotid Doppler ultrasound for detection of carotid artery plaque keeping computed tomography sensitivity as reference standard. *Pakistan Journal of Medical and Health Sciences*, *16*(7), 971-973. https://doi.org/10.53350/pjmhs22167971
3. Yu, J., Xl, W., An, Z., Zhu, D., Xu, L., Xu, T., Wang, D., Qu, Y., N, L., & Li, L. (2023). Predicting coronary artery disease by carotid color doppler ultrasonography. *PubMed*, *27*(24), 11713–11721. https://doi.org/10.26355/eurrev_202312_34768
4. Zaidi, N., Gilani, S., Mehboob, R., Waseem, H., & Hassan, A. (2020). Diagnostic accuracy of carotid intima media thickness by B-mode ultrasonography in coronary artery disease patients. *Archives of Medical Science – Atherosclerotic Diseases*, *5*(1), 79-84. https://doi.org/10.5114/amsad.2020.95651
5. Bytyçi, I., Shenouda, R., Wester, P., & Henein, M. Y. (2021). Carotid atherosclerosis in predicting coronary artery disease. *Arteriosclerosis, Thrombosis, and Vascular Biology*, *41*(4). https://doi.org/10.1161/atvbaha.120.315747
6. Coskun, U., Yildiz, A., Esen, O. B., Baskurt, M., Cakar, M. A., Kilickesmez, K. O., Orhan, L. A., & Yildiz, S. (2009). Relationship between carotid intima-media thickness and coronary angiographic findings: A prospective study. *Cardiovascular Ultrasound*, *7*(1). https://doi.org/10.1186/1476-7120-7-59
7. Jafar, T. H., Jafary, F. H., Jessani, S., & Chaturvedi, N. (2005). Heart disease epidemic in Pakistan: Women and men at equal risk. *American Heart Journal*, *150*(2), 221-226. https://doi.org/10.1016/j.ahj.2004.09.025
8. Biswas, M., Saba, L., Chakrabartty, S., Khanna, N. N., Song, H., Suri, H. S., Sfikakis, P. P., Mavrogeni, S., Viskovic, K., Laird, J. R., Cuadrado-Godia, E., Nicolaides, A., Sharma, A., Viswanathan, V., Protogerou, A., Kitas, G., Pareek, G., Miner, M., & Suri, J. S. (2020). Two-stage artificial intelligence model for jointly measurement of atherosclerotic wall thickness and plaque burden in carotid ultrasound: A screening tool for cardiovascular/stroke risk assessment. *Computers in Biology and Medicine*, *123*, 103847. https://doi.org/10.1016/j.compbiomed.2020.103847
9. Ahmad, S., Khatra Wahid, Gulsanga Ayub, Parkha Jabbar Khan, Muhammad Sajjad Ali Khan, & Owais Ali. (2022). Validity of carotid Doppler ultrasound for detection of Caroted stenosis keeping computed tomography sensitivity as gold standard. *Journal of Saidu Medical College, Swat*, *12*(2), 62-65. https://doi.org/10.52206/jsmc.2022.12.2.571
10. Sanchis-Gomar, F., Perez-Quilis, C., Leischik, R., & Lucia, A. (2016). Epidemiology of coronary heart disease and acute coronary syndrome. *Annals of Translational Medicine*, *4*(13), 256-256. https://doi.org/10.21037/atm.2016.06.33
11. Ling, Y., Wan, Y., Barinas-Mitchell, E., Fujiyoshi, A., Cui, H., Maimaiti, A., Xu, R., Li, J., Suo, C., & Zaid, M. (2023). Varying definitions of carotid intima-media thickness and future cardiovascular disease: A systematic review and meta-analysis. *Journal of the American Heart Association*, *12*(23). https://doi.org/10.1161/jaha.123.031217
12. Patial, S., Sharma, A., Raj, K., & Shukla, G. (2024). Atherosclerosis: Progression, risk factors, diagnosis, treatment, probiotics and synbiotics as a new prophylactic hope. *The Microbe*, *5*, 100212. https://doi.org/10.1016/j.microb.2024.100212
13. Dabravolski, S. A., Churov, A. V., Elizova, N. V., Ravani, A. L., Karimova, A. E., Sukhorukov, V. N., & Orekhov, A. N. (2024). Association between atherosclerosis and the development of multi-organ pathologies. *SAGE Open Medicine*, *12*. https://doi.org/10.1177/20503121241310013
14. Bolognese, L., & Reccia, M. R. (2022). Computed tomography to replace invasive coronary angiography? The discharge trial. *European Heart Journal Supplements*, *24*(Supplement_I), I25-I28. https://doi.org/10.1093/eurheartjsupp/suac067
15. Wang, L. W. (2025). Non-invasive screening for coronary artery disease: Current perspectives, patient, public health and ethical considerations in evaluating symptomatic and asymptomatic individuals. *Internal Medicine Journal*, *55*(4), 555-563. https://doi.org/10.1111/imj.16585
16. Nezu, T., & Hosomi, N. (2020). Usefulness of carotid ultrasonography for risk stratification of cerebral and cardiovascular disease. *Journal of Atherosclerosis and Thrombosis*, *27*(10), 1023-1035.

https://doi.org/10.5551/jat.rv17044
17. Mohammadkarim, A., Mokhtari-Dizaji, M., Kazemian, A., Saberi, H., Yazdi, N. A., & Esfehani, M. (2022). Assessing the short-term effects of radiotherapy on the shear modulus of the common carotid artery as a new biomarker of radiation-induced atherosclerosis. *Ultrasonography*, *41*(1), 114-123. https://doi.org/10.14366/usg.21032
18. Zyriax, B., Dransfeld, K., & Windler, E. (2021). Carotid intima–media thickness and cardiovascular risk factors in healthy volunteers. *The Ultrasound Journal*, *13*(1). https://doi.org/10.1186/s13089-021-00218-6
19. Qamar, N., Sial, J. A., Sagir, T., Hussain, Z., Shah, A. Z., Khan, K., Shah, J. A., Karim, M., Kumari, S., Khan, S., Bhatti, S., & Hakeem, A. (2024). Advancing acute MI care in densely populated low- and middle-income countries (LMICs): Innovative stand-alone chest pain units for expedited triage and timely management. *The Lancet Regional Health - Southeast Asia*, *30*, 100488. https://doi.org/10.1016/j.lansea.2024.100488
20. Jeon, M. H., DiSipio, T., Wilson, L., Garvey, G., & Diaz, A. (2025). Assessment and stratification of cardiovascular disease risk in people diagnosed with breast cancer: A scoping review. *Cancer Treatment Reviews*, *135*, 102903. https://doi.org/10.1016/j.ctrv.2025.102903