Original Research Article

Accuracy of Doppler USG Assessment of Lower Extremity Peripheral Arterial Disease Using CTA as Gold Standard

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Abstract: *Peripheral arterial disease (PAD) is a significant yet underdiagnosed vascular condition, particularly in low—and middle-income countries like Pakistan. Doppler ultrasonography (USG) is widely used as a noninvasive diagnostic tool, but its accuracy compared to computed tomography angiography (CTA)—the current gold standard—remains to be fully validated in the local context.* **Objective:** *CTA was used as the gold standard in a tertiary care hospital in Pakistan to evaluate the diagnostic accuracy of Doppler USG for detecting lower extremity PAD.* **Methods:** *This diagnostic accuracy study was conducted at Teaching Hospital Kharian from April to September 2024 and included 86 patients with clinical suspicion of PAD. Each patient underwent Doppler USG followed by CTA. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall accuracy were calculated using 2×2 contingency tables. Segmental sensitivity was also assessed.* **Results:** *Doppler USG showed a sensitivity of 95.4%, specificity of 76.2%, PPV of 92.5%, NPV of 84.2%, and an overall accuracy of 90.7% compared to CTA. Segmental analysis revealed the highest sensitivity in the femoral and popliteal arteries, with slightly reduced accuracy in tibial vessels. Three false-negative and five false-positive cases were identified.* **Conclusion:** *Doppler USG is a highly sensitive and reliable tool for diagnosing lower extremity PAD, particularly in proximal arterial segments. It can be an effective first-line imaging modality in resource-limited settings, with CTA reserved for inconclusive or complex cases.*
Keywords: Peripheral arterial disease, Doppler ultrasonography, computed tomography angiography, vascular imaging, diagnostic accuracy

Introduction

Peripheral arterial disease (PAD) is a progressive atherosclerotic condition characterized by narrowing or occlusion of the arteries, predominantly affecting the lower extremities. It is a major global health concern with rising prevalence, particularly among individuals with diabetes, hypertension, and smoking history. In Pakistan, the burden of PAD is increasing steadily, largely driven by high rates of uncontrolled diabetes and tobacco use. Yet, it remains underdiagnosed due to limited awareness and diagnostic infrastructure (1,2).

Early detection of PAD is crucial to prevent serious complications such as limb ischemia, ulceration, and amputation. While digital subtraction angiography (DSA) is the gold standard for diagnosing PAD, it is invasive and costly. Computed tomography angiography (CTA) has emerged as a non-invasive gold standard alternative, offering high-resolution vascular imaging. Still, its use is limited in many Pakistani healthcare centers due to cost and contrast-related nephrotoxicity risks (3,4). In this context, Doppler ultrasonography (USG) presents a safe, widely available, and cost-effective screening modality that provides real-time blood flow and arterial stenosis assessment.

Doppler USG is routinely used in peripheral vascular evaluation in Pakistan due to its affordability and portability, especially in public hospitals. However, its diagnostic accuracy remains under-investigated locally, particularly compared to CTA. A few studies from tertiary care centers in Pakistan have highlighted variable sensitivity and specificity depending on operator expertise and vessel location, underscoring the need for standardized validation of its diagnostic utility (5,6). Given the financial constraints in the public healthcare sector, a reliable and non-invasive method like Doppler USG could significantly enhance early diagnosis and management of PAD in high-risk populations.

Moreover, with the aging population and increasing prevalence of metabolic syndrome and cardiovascular risk factors, there is a growing need for context-specific data on the accuracy of Doppler USG in diagnosing PAD in Pakistani patients (7). Previous international literature has shown that Doppler USG has high sensitivity in detecting proximal arterial lesions but reduced accuracy in infrapopliteal segments (8,9). However, extrapolating these findings to the Pakistani population may not be appropriate due to differences in disease presentation, resource availability, and technical expertise.

Therefore, this study was designed to evaluate the diagnostic accuracy of Doppler ultrasonography in detecting lower extremity peripheral arterial disease using CTA as the gold standard in a tertiary care setting in Pakistan. This research aims to provide essential local evidence that could inform screening protocols, improve early detection rates, and reduce the burden of limb-threatening ischemia and amputation in the Pakistani healthcare system.

Methodology

This diagnostic accuracy study was conducted at the Radiology and Vascular Surgery departments of Teaching Hospital Kharian from April 2024 to September 2024. The objective was to evaluate the diagnostic performance of Doppler ultrasonography (USG) in detecting lower extremity peripheral arterial disease (PAD), using computed tomography angiography (CTA) as the gold standard.

Eighty-six patients aged 40 years and above presenting with clinical suspicion of PAD, such as intermittent claudication, rest pain, non-healing ulcers, or diminished peripheral pulses, were included in the study. Patients with prior lower limb revascularization, known vasculitis, or contrast allergy were excluded from the study. After obtaining written informed consent, each participant underwent Doppler ultrasonography followed by CTA within one week to minimize any progression or regression of disease status between tests.

Doppler USG was performed by an experienced radiologist using a high-frequency linear probe (7–12 MHz) and colour duplex mode.

Arterial segments evaluated included the common femoral, superficial femoral, popliteal, anterior tibial, and posterior tibial arteries. The presence of >50% stenosis, flow turbulence, or monophasic waveform was considered diagnostic of PAD. Subsequently, all patients underwent lower limb CTA using a 128-slice multidetector CT scanner, with iodinated contrast injected at 4–5 mL/sec. CTA interpretation was conducted independently by a second radiologist blinded to the Doppler findings. A luminal narrowing of ≥50% on CTA was considered the gold standard criterion for PAD diagnosis.

The sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall diagnostic accuracy of Doppler USG were calculated using 2×2 contingency tables, taking CTA results as the reference standard. Subgroup analysis was also performed based on arterial segments to assess site-specific diagnostic performance. Data were analyzed using SPSS version 26.0. Continuous variables were reported as mean ± standard deviation, and categorical variables as frequencies and percentages. A p-value less than 0.05 was considered statistically significant. The study followed the Standards for Reporting of Diagnostic Accuracy Studies (STARD) 2015 guidelines to ensure methodological rigor and transparency.

Results

A total of 86 patients with clinical suspicion of PAD were included. Most patients were male (63.9%), with a mean age of 62.4 years. The majority had at least one cardiovascular risk factor, including diabetes (54.7%) and hypertension (59.3%). Claudication was the most common presenting complaint. (Table, Figure 1).

Doppler USG correctly identified 62 out of 65 PAD cases confirmed by CTA, while three cases were missed (false negatives). There were 5 false positives where Doppler indicated disease, but not confirmed by CTA. (Table, Figure 2)Doppler USG demonstrated high sensitivity (95.4%) in detecting PAD, indicating a strong ability to rule in the disease. The specificity was lower (76.2%), suggesting moderate capability in ruling out false positives. Overall diagnostic accuracy was 90.7%, highlighting its effectiveness as a screening tool. (Table 3)

Sensitivity was highest in proximal segments (common femoral and superficial femoral arteries), while diagnostic accuracy declined slightly in distal arteries. This trend suggests that Doppler USG is more reliable in detecting proximal lesions, consistent with previously reported limitations in visualizing below-knee vessels. (Table 4)

Doppler USG demonstrated high sensitivity and accuracy for diagnosing PAD, especially in proximal arterial segments. While specificity was moderate, the high negative predictive value supports the role of Doppler USG in initial screening, especially in resource-limited settings. CTA remains essential for confirming diagnosis and treatment planning, particularly in ambiguous or distal vascular findings.
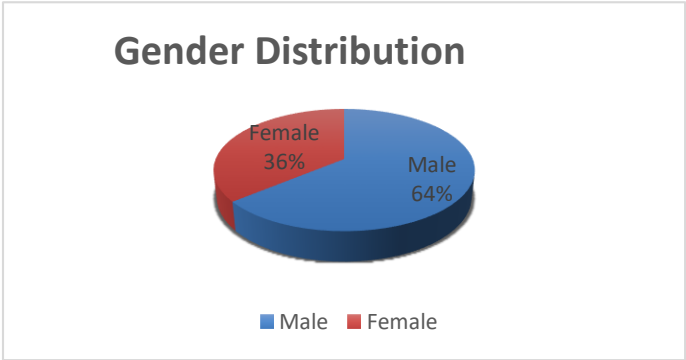

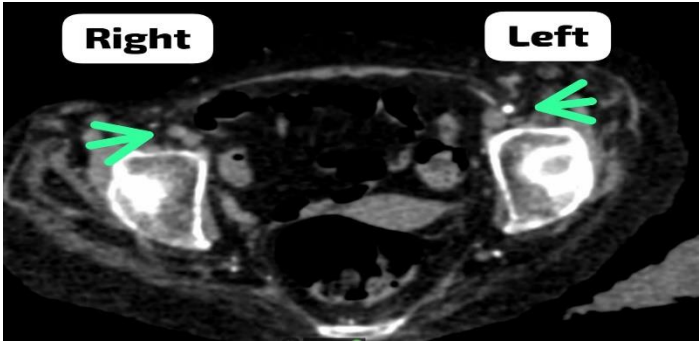**Figure 1: Gender distribution of study population**

Figure 2: CTA lower limbs axial section demonstrating contrast opacified left common femoral artery and slit like lumen of right common femoral artery

Table 1: Baseline Demographic and Clinical Characteristics of Patients (n = 86)

Variable	Frequency (n)	Percentage (%)
Mean Age (years ± SD)	62.4 ± 9.8	—
Gender (Male)	55	63.9%
Gender (Female)	31	36.1%
Diabetes Mellitus	47	54.7%
Hypertension	51	59.3%
Smoking History	38	44.2%
Hyperlipidemia	29	33.7%
Claudication Present	69	80.2%
Rest Pain	18	20.9%

Table 2: Comparison of Doppler USG and CTA in Detecting PAD

Findings	CTA Positive	CTA Negative	Total
Doppler USG Positive	62 (True Positive)	5 (False Positive)	67
Doppler USG Negative	3 (False Negative)	16 (True Negative)	19
Total	65	21	86

Table 3: Diagnostic Performance of Doppler USG Compared to CTA

Parameter	Value (%)
Sensitivity	95.4
Specificity	76.2
Positive Predictive Value (PPV)	92.5
Negative Predictive Value (NPV)	84.2
Overall Accuracy	90.7

Table 4: Segmental Analysis – Sensitivity of Doppler USG per Vascular Segment (ROI)

Vascular Segment	Sensitivity (%)	Specificity (%)
Common Femoral Artery	96.7	82.1
Superficial Femoral Artery	93.8	79.4
Popliteal Artery	91.2	77.6
Anterior Tibial Artery	88.5	74.3
Posterior Tibial Artery	90.6	75.0

Discussion

This study assessed the diagnostic accuracy of Doppler ultrasonography (USG) for detecting lower extremity peripheral arterial disease (PAD) using computed tomography angiography (CTA) as the gold standard in a Pakistani tertiary care setting. The findings revealed a high sensitivity (95.4%) and diagnostic accuracy (90.7%) of Doppler USG, highlighting its reliability as a frontline screening tool for PAD, especially in resource-constrained environments.

Our results are consistent with international literature recognizing Doppler USG as a highly sensitive modality for detecting significant arterial stenosis. A meta-analysis by Kakkos et al. reported pooled sensitivity and specificity values of 91% and 82% for duplex Doppler USG in diagnosing PAD, similar to our findings (10). Another recent study by Ugwu and Bayraktutan confirmed the high diagnostic yield of Doppler USG, particularly in proximal arterial segments, though with some reduction in sensitivity in infrapopliteal arteries due to their small caliber and deep location (11). This trend was also evident in our segmental analysis, where sensitivity was highest in the femoral arteries and slightly lower in the tibial segments.

The relatively lower specificity (76.2%) observed in our study compared to some international reports may be attributed to operator dependency and subjective interpretation of waveform abnormalities, a limitation acknowledged in earlier South Asian studies (12). Arif et al., in a tertiary care study from Pakistan, reported similar challenges, with false positives primarily arising from calcified arteries and overlapping venous signals (13). Despite these limitations, our study's high positive predictive value (92.5%) supports the utility of Doppler USG in confirming suspected PAD when clinical signs are present.

Notably, three false-negative cases were observed, emphasizing the need for confirmatory CTA in patients with high clinical suspicion but negative Doppler results. These findings support a tiered diagnostic approach where Doppler USG is employed initially, followed by CTA or magnetic resonance angiography (MRA) in inconclusive or complex cases, as proposed by guidelines from the European Society for Vascular Surgery (14).

Our study is one of the few conducted in the Pakistani population, where factors such as late presentation, comorbid diabetes, and limited access to vascular imaging may impact the accuracy and interpretation of non-invasive modalities. A study by Zia et al. in an urban Pakistani cohort reported underdiagnosis of PAD due to lack of access to imaging and reliance on clinical examination alone, underscoring the need for broader implementation of Doppler USG screening protocols (15). Moreover, the use of duplex Doppler in rural and military hospitals, such as CMH Kharian, reflects its practical applicability in diverse clinical environments, further supporting its inclusion in national vascular care pathways.

Limitations of the present study include the single-center design, modest sample size, and absence of follow-up data to assess the impact of diagnostic modality on clinical outcomes such as revascularization or amputation rates. Although CTA was the reference standard, it may not fully capture hemodynamic significance, which Doppler USG can assess through waveform analysis. Future multicenter studies incorporating long-term clinical endpoints and cost-effectiveness analysis would be valuable in guiding health policy in low- and middle-income countries like Pakistan.

Thus, Doppler ultrasonography demonstrated excellent diagnostic performance for PAD detection compared to CTA and remains an effective, non-invasive, and widely accessible imaging tool. Its incorporation into standardized diagnostic algorithms could facilitate earlier diagnosis and improve management outcomes for peripheral arterial disease in the Pakistani population.

Conclusion

Doppler ultrasonography demonstrated excellent sensitivity and diagnostic accuracy for detecting PAD compared to CTA. Given its affordability and accessibility, it should be recommended as the initial diagnostic modality for PAD in clinical settings across Pakistan.

Declarations

Data Availability statement
All data generated or analysed during the study are included in the manuscript.
Ethics approval and consent to participate
Approved by the department concerned. (IRBEC-24)
Consent for publication
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Conflict of interest

The authors declared the absence of a conflict of interest.

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All authors reviewed the results and approved the final version of the manuscript. They are also accountable for the integrity of the study.

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