Section: Radio Diagnosis

Original Research Article

COMPARATIVE DIAGNOSTIC ACCURACY OF DUPLEX ULTRASONOGRAPHY AND COMPUTED TOMOGRAPHY ANGIOGRAPHY AGAINST DIGITAL SUBTRACTION ANGIOGRAPHY IN PERIPHERAL ARTERIAL DISEASE

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ABSTRACT

Background: Accurate assessment of peripheral arterial disease (PAD) is essential for diagnosis and treatment planning. Duplex ultrasonography (DUS) is non-invasive and accessible, whereas computed tomography angiography (CTA) provides comprehensive anatomical visualization. This study compared their diagnostic performance using digital subtraction angiography (DSA) as the reference standard. **Materials and Methods:** This cross-sectional comparative study included 30 patients aged 30–80 years with clinically suspected PAD. All patients underwent DUS, CTA, and DSA. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and diagnostic accuracy were calculated for DUS and CTA against DSA. **Result:** CTA demonstrated higher sensitivity than DUS (90.0% vs 81.3%) and higher specificity (70.0% vs 64.3%). PPV was 85.7% for CTA versus 72.2% for DUS, while NPV was 77.8% and 75.0%, respectively. Overall diagnostic accuracy was higher with CTA (83.3%) than DUS (73.3%). CTA also demonstrated better performance across evaluated arterial segments, particularly in distal lower-extremity vessels. **Conclusion:** Both DUS and CTA provide useful diagnostic assessment of PAD, but CTA demonstrated superior diagnostic performance in this cohort. DUS remains appropriate as an initial non-invasive investigation, while CTA offers added value when comprehensive anatomical assessment and revascularization planning are required.

INTRODUCTION

Peripheral arterial disease (PAD) is a common manifestation of systemic atherosclerosis characterized by narrowing or occlusion of arteries supplying the lower, and less frequently upper, extremities. It is associated with substantial morbidity, impaired functional capacity, reduced quality of life, and an increased risk of cardiovascular events and mortality.[1–3] The global burden of PAD has increased with population aging and the growing prevalence of diabetes, hypertension, dyslipidemia, smoking, obesity, and chronic kidney disease.[4–6] Despite its clinical importance, PAD remains substantially underdiagnosed, particularly in low- and middle-income countries, where access to vascular imaging and specialized healthcare may be limited.[7]

The clinical presentation of PAD ranges from asymptomatic disease and intermittent claudication to chronic limb-threatening ischemia, non-healing ulcers, gangrene, and amputation. Importantly, symptoms may be atypical or absent, and their severity does not always correspond closely with the anatomical extent of arterial disease.[8] Although clinical examination and ankle–brachial index (ABI) remain important components of initial assessment, ABI may be unreliable in patients with diabetes or chronic kidney disease because of medial arterial calcification and non-compressible vessels.[9] Consequently, imaging plays a central role in confirming the diagnosis, defining the anatomical distribution and severity of disease, assessing collateral circulation and distal run-off, and guiding revascularization strategies.

Doppler ultrasound (DUS), computed tomographic angiography (CTA), and digital subtraction angiography (DSA) are the principal imaging modalities used in the evaluation of PAD. DUS is a non-invasive, radiation-free, relatively inexpensive technique that provides both anatomical and hemodynamic information through B-mode, color Doppler, and spectral Doppler assessment. It is particularly suitable as an initial investigation and for follow-up; however, its diagnostic performance may be influenced by operator expertise, patient body habitus, arterial calcification, and difficulty in evaluating distal or deeply located vessels.[10,11]

CTA provides rapid, high-resolution anatomical visualization of the peripheral arterial tree and allows assessment of stenosis, occlusion, calcification, collateral vessels, and distal run-off. Its relatively low operator dependence and ability to provide multiplanar and three-dimensional reconstructions make it valuable for pre-procedural planning. Nevertheless, CTA involves ionizing radiation and iodinated contrast administration and may be affected by blooming artifacts from extensive vascular calcification, potentially compromising assessment of severely diseased vessels.[12-14]

DSA has traditionally been regarded as the reference standard for peripheral arterial imaging because of its high spatial and temporal resolution and dynamic assessment of arterial flow. It also offers the major advantage of allowing diagnosis and endovascular treatment during the same procedure. However, DSA is invasive and requires arterial catheterization and intra-arterial contrast administration, with potential complications including bleeding, vascular injury, pseudoaneurysm, embolization, and contrast-related renal injury. Therefore, its routine use solely for diagnostic purposes has increasingly been replaced by non-invasive imaging, with DSA generally reserved for cases requiring intervention or when non-invasive findings are inconclusive.[15-17]

Although all three modalities have established roles, their relative diagnostic performance may vary according to vascular territory, lesion severity, arterial calcification, patient characteristics, and technical expertise. Existing studies have reported variable sensitivity and specificity for DUS and CTA when compared with DSA, while direct head-to-head evidence remains heterogeneous. This is particularly relevant in resource-constrained settings, where the selection of an imaging modality must balance diagnostic accuracy, safety, availability, and cost.

Therefore, comparative evaluation of these modalities is clinically important to establish an appropriate diagnostic pathway for patients with suspected or established PAD. The present study aimed to compare the findings of DUS and CTA with DSA and to determine their sensitivity, specificity, positive predictive value, and negative predictive value for the detection and assessment of peripheral arterial disease.

MATERIALS AND METHODS

Study Design and Setting: This cross-sectional comparative diagnostic accuracy study was conducted in the Department of Radiodiagnosis, National Institute of Medical Sciences and Research (NIMS), Jaipur, over a period of 18 months. The study was undertaken after obtaining approval from the Institutional Scientific and Ethics Committee. Written informed consent was obtained from all participants before enrolment and imaging.

Study Population: The study included patients aged 30–80 years of either sex who presented with clinical features suggestive of peripheral arterial disease (PAD). Patients were recruited using a convenience sampling technique, with complete enumeration of eligible patients during the study period. A minimum of 30 patients was planned for inclusion.

Patients were eligible if they presented with one or more of the following clinical features: exertional leg claudication, ischemic rest pain, abnormal lower-extremity peripheral pulses, or early signs of gangrene. Patients unwilling to participate were excluded. Pregnant women undergoing CT evaluation and patients with a known allergy to iodinated contrast media were excluded.

Clinical Assessment: All enrolled patients underwent a structured clinical evaluation using a standardized case record form. Relevant demographic and clinical information, presenting symptoms, duration of symptoms, and associated vascular risk factors were documented. A detailed physical examination, including assessment of lower-extremity peripheral pulses and other clinical features of limb ischemia, was performed. Disease severity was subsequently interpreted with reference to established clinical classifications, including the Rutherford and Fontaine classification systems.

Imaging Protocol: All patients underwent Doppler ultrasound (DUS), computed tomographic angiography (CTA), and digital subtraction angiography (DSA) of the lower-extremity arterial system.

Doppler Ultrasound: DUS was performed using high-frequency linear and, where required, curvilinear transducers. B-mode, color Doppler, and spectral Doppler examinations were used to assess the arterial lumen, wall characteristics, blood-flow pattern, stenosis, and occlusion. The major arterial segments of the lower extremity were systematically evaluated, including the common femoral, superficial femoral, profunda femoris, popliteal, anterior tibial, posterior tibial, and other visualized distal arterial segments. Findings suggestive of significant stenosis or occlusion were documented according to the imaging and hemodynamic characteristics.

Computed Tomographic Angiography: CTA was performed using a multidetector CT scanner following intravenous administration of iodinated contrast medium. Arterial-phase images were acquired to evaluate the peripheral arterial tree. Multiplanar and, where appropriate, three-dimensional reconstructions were reviewed for assessment of the location and extent of arterial stenosis or occlusion, luminal narrowing, calcified atherosclerotic plaques, collateral vessels, and distal run-off. The CTA findings were documented for each evaluated arterial segment.

Digital Subtraction Angiography: DSA was performed using a standard catheter-based angiographic technique. Selective arterial catheterization and contrast injection were performed to obtain diagnostic angiographic images of the affected lower-extremity arterial system. DSA was considered the reference standard for determining the presence, location, and extent of significant arterial stenosis or occlusion. Where clinically indicated, therapeutic endovascular procedures, including balloon angioplasty and stent placement, were performed during the same session.

Figure 1: CT angiographic demonstration of diffuse atherosclerotic disease involving the abdominal aorta and bilateral iliac and femoral arterial segments, with up to 70–80% luminal narrowing and preserved bilateral popliteal, anterior tibial, and posterior tibial arteries.

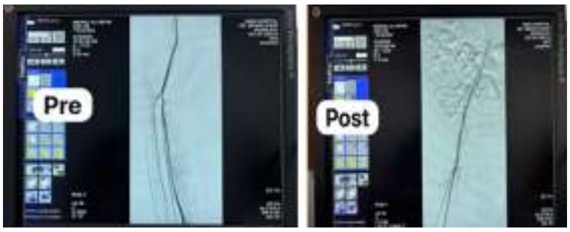

Figure 2: DSA demonstrating thrombo-stenotic disease of the right common iliac, external iliac, and superficial femoral arteries, followed by balloon angioplasty, stent deployment, and complete post-stenting recanalization.

Comparative Assessment: The arterial findings obtained with DUS and CTA were compared with the corresponding DSA findings. Assessment was performed according to individual arterial segments and included identification of normal vessels, significant stenosis, and complete occlusion. The diagnostic performance of DUS and CTA was evaluated using DSA as the reference standard.

The primary diagnostic outcomes were sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) for detection of significant peripheral arterial stenosis/occlusion. Agreement between each non-invasive imaging modality and DSA was also assessed where applicable.

Statistical Analysis: Data were entered into Microsoft Excel and analyzed using IBM SPSS Statistics. Continuous variables were summarized using mean and standard deviation or median and interquartile range, as appropriate, while categorical variables were presented as frequencies and percentages.

For diagnostic accuracy analysis, two-by-two contingency tables were constructed using DSA as the reference standard. Sensitivity, specificity, PPV, and NPV were calculated for DUS and CTA. The corresponding diagnostic performance measures were reported with appropriate 95% confidence intervals where applicable. Comparative analysis was performed to determine the diagnostic agreement of DUS and CTA with DSA. A two-sided p value <0.05 was considered statistically significant.

RESULTS

A total of 30 patients with clinically suspected peripheral arterial disease were evaluated using Doppler ultrasound and CT angiography, with digital subtraction angiography taken as the reference standard.

[Table 1] presents the demographic characteristics of the study population, including age, sex, residence, and religion. The study included 30 patients, with a predominance of males.

[Table 2] summarizes the clinical characteristics, diabetes-related variables, and major vascular risk factors, including diabetes duration, HbA1c, smoking status, general examination findings, and ABI severity.

[Table 3] shows the diagnostic findings of Doppler ultrasonography (DUS) and computed tomography angiography (CTA) compared with digital subtraction angiography (DSA), including true-positive, false-positive, false-negative, and true-negative results.

[Table 4] presents the diagnostic performance of DUS and CTA against DSA, including sensitivity, specificity, positive predictive value, negative predictive value, and overall diagnostic accuracy with corresponding 95% confidence intervals.

CTA demonstrated diffuse atherosclerotic involvement of the abdominal aorta and bilateral iliac and femoral arterial segments, with significant

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luminal narrowing of up to 70–80%. The bilateral popliteal, anterior tibial, and posterior tibial arteries were relatively preserved [Figure 1] Representative DSA demonstrated thrombo-stenotic disease involving the right common iliac, external iliac, and superficial femoral arteries. Following guidewire crossing and balloon angioplasty, residual long-segment occlusion was observed, after which stent deployment resulted in complete angiographic recanalization [Figure 2]. [Figure 3] illustrates the distribution of chief clinical complaints among the study participants, showing the frequency of leg pain, rest pain, swelling, gangrene, claudication, and absent peripheral pulses. [Figure 4] depicts the distribution of patients according to the duration and clinical course of the presenting illness, categorized as acute, subacute, or chronic. [Figure 5] compares the detection rates of peripheral arterial disease across DUS, CTA, and DSA, demonstrating the relative diagnostic performance of the three imaging modalities. [Figure 6] demonstrates the agreement of DUS and CTA findings with the DSA reference standard, with CTA showing greater overall agreement than DUS.

Figure 3: Distribution of Chief Clinical Complaints

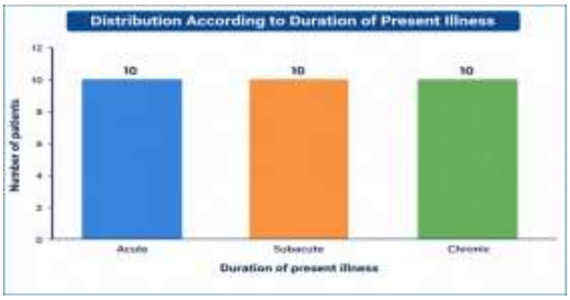

Figure 4: Distribution According to Duration of Present Illness

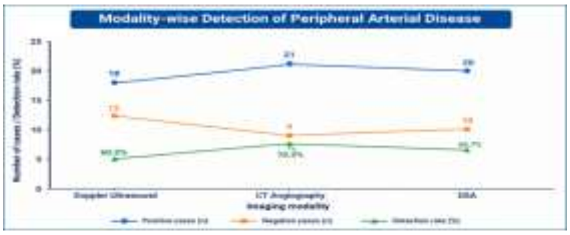

Figure 5: Modality-wise Detection of Peripheral Arterial Disease

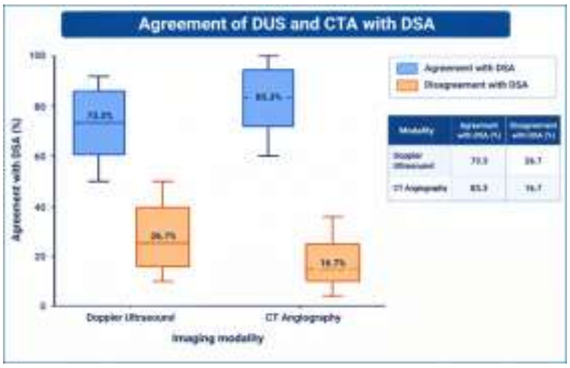

Figure 6: Agreement of DUS and CTA with DSA.

Table 1: Demographic Characteristics of the Study Population (n = 30)

Variable	Category	n (%)
Age, years	Mean ± SD	62.8 ± 5.4
	Range	54–72
Sex	Male	20 (66.7)
	Female	10 (33.3)
Residence	Urban	15 (50.0)
	Rural	15 (50.0)
Religion	Hindu	20 (66.7)
	Muslim	10 (33.3)

Table 2: Clinical Characteristics, Diabetes and Risk Profile

Variable	Category/Parameter	n (%) / Mean ± SD
Diabetes duration, years	Mean ± SD	11.6 ± 3.8
	Range	6–19
HbA1c, %	Mean ± SD	7.9 ± 1.1
	Range	6.4–9.8
HbA1c category	<7%	9 (30.0)
	≥7%	21 (70.0)
Smoking	Smoker	15 (50.0)
	Non-smoker	15 (50.0)
General examination	Pallor	15 (50.0)
	Edema	10 (33.3)
	Icterus	0 (0)
	Cyanosis	0 (0)
	Lymphadenopathy	0 (0)
ABI severity	Mild (0.8–0.9)	7 (23.3)

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	Moderate (0.5–0.7)	14 (46.7)
	Severe (<0.5)	9 (30.0)

This table will contain the clinical/risk-factor information, but chief complaints and the duration categories will be reserved for graphs, so they are not duplicated.

Table 3: Diagnostic Findings of Doppler Ultrasound and CT Angiography Compared with DSA

Diagnostic finding	Doppler Ultrasound	CT Angiography
True positive	13	18
False positive	5	3
False negative	3	2
True negative	9	7
Total	30	30

Table 4: Diagnostic Accuracy of Doppler Ultrasound and CT Angiography

Diagnostic parameter	Doppler Ultrasound, % (95% CI)	CT Angiography, % (95% CI)
Sensitivity	81.3 (54.4–96.0)	90.0 (68.3–98.8)
Specificity	64.3 (35.1–87.2)	70.0 (34.8–93.3)
PPV	72.2 (46.5–90.3)	85.7 (63.7–97.0)
NPV	75.0 (42.8–94.5)	77.8 (40.0–97.2)
Accuracy	73.3 (54.1–87.7)	83.3 (65.3–94.4)

DISCUSSION

Principal Findings: This cross-sectional comparative diagnostic study evaluated the performance of duplex ultrasonography (DUS) and computed tomography angiography (CTA), using digital subtraction angiography (DSA) as the reference standard, in patients with clinically suspected peripheral arterial disease (PAD). The principal finding was that both non-invasive modalities demonstrated clinically useful diagnostic performance, although CTA showed consistently higher diagnostic accuracy than DUS. In the present cohort, CTA demonstrated a sensitivity of 90.0%, specificity of 70.0%, positive predictive value (PPV) of 85.7%, negative predictive value (NPV) of 77.8%, and overall accuracy of 83.3%, compared with 81.3%, 64.3%, 72.2%, 75.0%, and 73.3%, respectively, for DUS. These findings support the contemporary diagnostic paradigm in which non-invasive vascular imaging is central to the evaluation and treatment planning of symptomatic lower-extremity PAD, while DSA remains primarily an invasive reference and therapeutic modality rather than a routine first-line diagnostic investigation.[14–16]

The superiority of CTA observed in the present study is biologically and technically plausible. CTA provides high-resolution cross-sectional visualization of the arterial lumen, vessel wall, calcified plaque, occlusive segments, collateral pathways, and distal runoff within a relatively short acquisition time. Shwaiki et al. highlighted the continuing importance of lower-extremity CTA for comprehensive anatomical assessment and treatment planning in PAD, while also describing technical developments aimed at improving image quality and reducing artifacts.[7] Similarly, Kim et al. demonstrated that advanced CT reconstruction approaches, including virtual monoenergetic imaging, can improve visualization of lower-extremity arterial pathology and potentially mitigate some of the limitations associated with conventional CT angiography.[8] The 83.3% accuracy of CTA in the present cohort is therefore consistent with the broader evidence supporting CTA as a robust anatomical imaging technique when detailed delineation of stenotic and occlusive disease is required.

Performance of Duplex Ultrasonography: DUS demonstrated a sensitivity of 81.3% and specificity of 64.3% in the present study, with an overall accuracy of 73.3%. These findings reinforce the role of DUS as an effective, non-invasive first-line investigation for PAD, although its diagnostic performance was lower than that of CTA in this cohort. Importantly, DUS offers several practical advantages that are not captured by diagnostic accuracy alone, including absence of ionizing radiation, avoidance of iodinated contrast, relatively low cost, bedside accessibility, and the ability to provide both anatomical and haemodynamic information.

These observations are broadly compatible with the findings of Martinelli et al., who reported that DUS can provide sufficiently reliable anatomical information for PAD treatment planning and may represent an alternative to CTA in appropriately selected patients.[4] García-Rivera et al. similarly evaluated DUS as a stand-alone diagnostic test and supported its clinical utility in the diagnosis of peripheral arterial disease.[5] More recently, Dias et al., in a systematic review and meta-analysis, concluded that duplex ultrasound has good diagnostic performance for lower-extremity PAD, while emphasizing heterogeneity between studies and the influence of technical and methodological factors.[6] Thus, the 81.3% sensitivity observed in the current study is consistent with the established ability of DUS to detect clinically important arterial disease, although the relatively modest specificity suggests that positive DUS findings may require anatomical confirmation when intervention is being considered.

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The lower performance of DUS compared with CTA may partly reflect the inherent technical limitations of ultrasound. Image quality can be affected by arterial calcification, obesity, deep vascular location, bowel gas, extensive multilevel disease, and operator experience. These limitations become particularly relevant in distal and infrapopliteal arterial segments. The present study similarly observed relatively lower DUS performance in distal vessels such as the anterior tibial, posterior tibial, and dorsalis pedis arteries, whereas CTA demonstrated better visualization across these segments. This finding is clinically relevant because accurate delineation of distal runoff may influence revascularization planning, particularly in patients with chronic limb-threatening ischemia.

Comparative Advantage of CTA: CTA demonstrated a higher sensitivity than DUS (90.0% vs 81.3%) and a higher overall diagnostic accuracy (83.3% vs 73.3%). The higher PPV of CTA (85.7% vs 72.2%) is particularly important in patients being evaluated for possible revascularization because false-positive findings can result in unnecessary additional investigations or inappropriate procedural planning. The relatively higher NPV of CTA (77.8%) also indicates useful exclusionary capability, although neither modality should be interpreted independently of the clinical presentation and pre-test probability.

The present results are consistent with the contemporary imaging pathway described by Malangu and Kotev, who emphasized the complementary roles of DUS and CTA and the importance of selecting imaging according to clinical circumstances, anatomical requirements, and resource availability.[3] The findings also align with the ACR Appropriateness Criteria, which recognize DUS, CTA, magnetic resonance angiography, and catheter angiography as different components of the imaging pathway depending on the clinical question and whether revascularization is contemplated.[16] The 2024 ACC/AHA multisociety PAD guideline similarly places non-invasive physiological and anatomical testing within a structured diagnostic pathway, with imaging selected according to clinical presentation and the need for treatment planning [15] However, the higher diagnostic accuracy of CTA in this study should not be interpreted as meaning that CTA should replace DUS in all patients. Rather, the findings support a complementary imaging strategy. DUS may be particularly attractive as an initial investigation in patients with suspected PAD because it is safe, repeatable, inexpensive, and widely available. CTA can subsequently be used when detailed anatomical mapping is required, when DUS findings are equivocal, or when intervention is being planned. This sequential approach may be particularly valuable in resource-constrained healthcare systems, where indiscriminate use of advanced imaging may not be feasible.

Relationship with ABI and Clinical Assessment: The distribution of ankle-brachial index (ABI) values in the present study demonstrated predominantly moderate disease, with 14 patients (46.7%) having an ABI of 0.5–0.7 and nine (30.0%) having an ABI below 0.5. This reinforces the importance of integrating physiological assessment with anatomical imaging. ABI remains an established and accessible diagnostic test; however, its performance may be compromised in patients with medial arterial calcification, particularly those with diabetes or chronic kidney disease.

Fu et al. demonstrated the diagnostic utility of automated oscillometric ABI measurement while emphasizing the importance of appropriate methodology when ABI is used for PAD detection [9] Herraiz-Adillo et al., in a systematic review and meta-analysis, further demonstrated that ABI and toe-brachial index have important roles in the diagnosis of lower-extremity PAD, while highlighting differences in diagnostic performance across patient populations and disease contexts [10] Forsythe et al. similarly showed that bedside diagnostic investigations have variable performance in people with diabetes, in whom arterial calcification can complicate physiological testing [11] These observations support the use of ABI as an important component of the diagnostic pathway but not necessarily as a substitute for anatomical imaging when the extent and location of disease must be defined.

The high prevalence of diabetes in the study population is particularly relevant. Seventy percent of participants had HbA1c ≥7%, and the subgroup analysis demonstrated higher sensitivity for CTA than DUS in both glycaemic categories. CTA sensitivity was 88% among participants with HbA1c <7% and 92% among those with HbA1c ≥7%, compared with 82% and 80%, respectively, for DUS. Although these subgroup findings should be interpreted cautiously because of the small sample size, they suggest that CTA may retain an anatomical diagnostic advantage in patients with poorer glycaemic control, potentially reflecting the greater frequency of diffuse atherosclerotic disease and arterial calcification in this population.

This interpretation is supported by the broader literature linking diabetes to PAD risk. Chase-Vilchez et al. demonstrated a significant association between diabetes and incident PAD and emphasized the substantial vascular burden associated with diabetes.[12] Brouwers et al. also reported that bedside tests may be less reliable in populations prone to medial arterial calcification, emphasizing the diagnostic challenges posed by diabetes and other conditions associated with arterial calcification.[13]

Influence of Disease Duration and Clinical Presentation: The present study also demonstrated higher CTA sensitivity across diabetes-duration subgroups. CTA sensitivity was 89% in patients with diabetes duration <10 years and 93% in those with duration ≥10 years, whereas DUS sensitivity was 84% and 79%, respectively. Although these subgroup analyses are exploratory, the progressively greater

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advantage of CTA with longer diabetes duration may reflect the increasing complexity, multilevel distribution, and calcific burden of arterial disease in patients with longstanding diabetes.

Clinical presentation also appeared to influence the relative performance of the two modalities. CTA demonstrated superior performance in patients presenting with claudication, rest pain, and gangrene/chronic limb-threatening ischemia (CLTI), with the greatest relative advantage observed in more severe clinical presentations. This is clinically plausible because patients with rest pain or tissue loss frequently have extensive multilevel disease in which precise characterization of inflow, femoropopliteal disease, and distal runoff is essential. Current PAD guidelines emphasize that imaging should be directed by clinical severity and the anticipated need for revascularization rather than being performed in isolation.[15] The ACR recommendations likewise support anatomical imaging when the objective is to define disease distribution for potential revascularization.[16]

Segment-Specific Considerations: An important finding of the present study was the apparent difference between DUS and CTA across arterial segments. CTA demonstrated better performance for the common iliac and superficial femoral arteries and maintained an advantage in the anterior tibial, posterior tibial, and dorsalis pedis arteries. The relative reduction in DUS performance in infrapopliteal vessels is clinically meaningful because these segments can be technically challenging to assess using ultrasound, particularly when there is diffuse calcification or extensive multilevel occlusive disease.

The ability of CTA to provide a continuous anatomical overview from the aortoiliac segment to the pedal arteries represents one of its principal advantages over DUS. Shwaiki et al. described the value of CTA for evaluating the complete lower-extremity arterial tree and for characterizing lesion morphology and runoff.[7] Kim et al. further demonstrated the potential of advanced CT techniques to improve arterial visualization in lower-extremity PAD.[8] Therefore, the segment-level findings of the present study support the use of CTA when comprehensive vascular mapping is required, particularly before endovascular or surgical revascularization.

Role of DSA as the Reference Standard: In this study, DSA was used as the reference standard against which DUS and CTA were compared. DSA remains highly valuable because of its excellent spatial and temporal resolution and its ability to demonstrate dynamic arterial flow while simultaneously permitting endovascular treatment. The representative angiographic intervention in the present study illustrates this dual diagnostic and therapeutic role. Nevertheless, DSA is invasive and carries risks related to arterial access, contrast administration, embolization, bleeding, and other procedure-related complications. Consequently, contemporary practice has increasingly shifted toward non-invasive imaging for initial diagnosis and anatomical assessment, reserving catheter angiography primarily for cases in which revascularization is being considered or when non-invasive imaging is inconclusive.[14–16]

This distinction is important when interpreting the present findings. The study does not demonstrate that CTA or DUS can replace the therapeutic capabilities of DSA. Instead, it demonstrates that both modalities can provide clinically meaningful diagnostic information before invasive angiography, with CTA offering greater diagnostic accuracy in the present cohort.

Clinical Implications: The findings have practical implications for diagnostic pathways in PAD. A reasonable approach is to use clinical assessment and ABI as the initial evaluation, followed by DUS as a readily accessible non-invasive anatomical and haemodynamic investigation. CTA may be preferred when DUS is inconclusive, when extensive multilevel disease is suspected, when distal runoff needs to be mapped, or when revascularization planning requires detailed anatomical information. DSA can then be reserved for patients in whom endovascular treatment is planned or when non-invasive imaging does not adequately resolve the anatomical question.

This strategy is consistent with current guideline-based recommendations. Gornik et al. emphasize a structured approach to PAD diagnosis and management incorporating clinical assessment, physiological testing, and appropriate imaging according to the clinical scenario.[15] Bates et al. similarly highlight the importance of contemporary guideline-directed diagnostic and therapeutic pathways.[14] The systematic review by Uyagu et al. further demonstrated that although recommendations across PAD guidelines are broadly concordant, differences exist in specific diagnostic pathways and implementation strategies.[17] In this context, the present findings provide additional comparative evidence supporting the complementary use of DUS and CTA rather than an exclusive reliance on a single imaging modality.

Comparison with Previous Evidence: Overall, the diagnostic hierarchy observed in the present study—CTA performing better than DUS, while both remain clinically useful—is broadly consistent with contemporary literature. The sensitivity of DUS in this study (81.3%) supports previous evidence that duplex imaging provides reliable detection of PAD [4–6], while the higher CTA sensitivity (90.0%) and accuracy (83.3%) are compatible with the established role of CTA for high-resolution anatomical assessment.[3,7,8] The results also reinforce the limitations of physiological testing and bedside assessment in selected populations, particularly patients with diabetes or arterial calcification.[9–13]

At the same time, the present study adds value by directly comparing both modalities against DSA within the same patient cohort rather than interpreting their diagnostic characteristics across separate study populations. Such within-cohort comparison reduces some of the variability introduced by differences in disease spectrum, imaging protocols, and reference standards between independent studies. Nevertheless, the modest sample size means that the results should be considered preliminary and hypothesis-generating rather than definitive estimates applicable to all PAD populations.

Limitations: This study has several limitations. First, the sample size was relatively small (n=30), resulting in wide confidence intervals around several diagnostic estimates and limiting the statistical power of subgroup analyses. Second, the cross-sectional design does not permit assessment of long-term clinical outcomes, limb salvage, reintervention, or cost-effectiveness. Third, DUS is operator dependent, and interobserver variability was not formally assessed. Fourth, CTA image quality may be influenced by extensive vascular calcification, contrast timing, and renal function, although these factors were not quantitatively evaluated. Fifth, the study was conducted at a single institution, which may limit generalizability to other healthcare settings and patient populations. Larger prospective multicentre studies using standardized segment-level diagnostic criteria and blinded image interpretation are warranted to validate these findings and establish clinically meaningful imaging algorithms for PAD.

CONCLUSION

In patients with clinically suspected peripheral arterial disease, both duplex ultrasonography (DUS) and computed tomography angiography (CTA) demonstrated clinically useful diagnostic performance when compared with digital subtraction angiography (DSA), although CTA showed superior overall diagnostic accuracy. CTA achieved higher sensitivity (90.0% vs 81.3%), specificity (70.0% vs 64.3%), PPV (85.7% vs 72.2%), and accuracy (83.3% vs 73.3%) than DUS. DUS nevertheless remains an important first-line modality because of its non-invasive nature, absence of ionizing radiation, lower cost, and ability to provide haemodynamic information. CTA may be particularly advantageous when detailed anatomical mapping, multilevel disease assessment, distal runoff evaluation, or revascularization planning is required. These findings support a complementary, clinically guided imaging strategy in which DUS serves as an accessible initial investigation and CTA provides additional anatomical characterization when indicated, with DSA primarily reserved for definitive angiographic assessment and endovascular intervention. Larger prospective multicentre studies are warranted to validate these findings and establish optimized imaging pathways for different PAD presentations.

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