Journal of Population Therapeutics & Clinical Pharmacology

RESEARCH ARTICLE
DOI: 10.53555/571ma027

ROLE OF CT ANGIOGRAPHY IN EVALUATING AORTO-FEMORAL STENOSIS COMPARED WITH DUPLEX ULTRASONOGRAPHY IN THE BANGLADESHI POPULATION

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Received: 12-03-2022 **Revised:** 18-04-2022 **Accepted:** 15-05-2022 **Published:** 30-07-2022

Abstract

Background: Aorto-femoral stenosis is a critical manifestation of peripheral arterial disease. While Digital Subtraction Angiography (DSA) is the gold standard, it is invasive. Computed Tomography Angiography (CTA) and Duplex Ultrasonography (DUS) are widely used non-invasive alternatives. **Objective:** To compare the diagnostic efficacy of CTA and DUS for evaluating aorto-femoral stenosis in the Bangladeshi population. **Methods:** This comparative, multicenter study was conducted at Bangabandhu Sheikh Mujib Medical University (BSMMU), Popular Diagnostic Center (Savar), Super Medical Hospital (Savar) and Enam Medical College Hospital (Savar), from July 2020 to December 2021. A purposive sample of 45 patients with clinical suspicion of aorto-femoral stenosis was enrolled. All participants underwent both CTA and DUS examinations. The collected data were analyzed using SPSS version 23.0. **Results:** Analysis of 45 patients revealed that CTA detected a higher prevalence of significant stenosis (68.9%) than DUS (57.8%). The inter-modality agreement was substantial (Cohen's kappa=0.72). Bland-Altman analysis showed a mean bias of +5.2% stenosis for CTA. Using DUS as a reference, CTA demonstrated a sensitivity of 92.3% and a specificity of 84.2% for detecting hemodynamically significant lesions, with an overall diagnostic accuracy of 88.9%. Conclusion: In the Bangladeshi population, CTA demonstrates high diagnostic performance for aorto-femoral stenosis. This modality shows substantial agreement with DUS but offers superior sensitivity and

comprehensive anatomical detail, supporting its role in definitive evaluation and procedural planning.

Keywords: Aorto-femoral stenosis, Bland-Altman, Cohen Kappa, Computed tomography angiography, Duplex ultrasonography, Peripheral arterial disease

INTRODUCTION

Peripheral arterial disease (PAD) represents a significant global health burden, characterized by the atherosclerotic narrowing of arteries supplying the lower extremities [1]. Its prevalence is rising dramatically, particularly in developing nations, with a spectrum of clinical presentations ranging from asymptomatic states to critical limb ischemia, amputation, and increased cardiovascular mortality [2]. The aorto-femoral segment is a critical watershed area for inflow into the lower limbs, and significant stenosis in this region is a primary cause of disabling claudication and limb-threatening ischemia, necessitating accurate diagnosis for optimal management [3]. Digital subtraction angiography (DSA) has long been established as the historical gold standard for the anatomical assessment of PAD, providing high-resolution images that are crucial for procedural planning [4]. However, its inherent invasiveness, associated risks of vascular complications, nephrotoxicity from contrast media, and relatively high cost limit its utility as a first-line diagnostic tool [5]. This has propelled the development and refinement of non-invasive vascular imaging modalities, which are now central to the initial evaluation and monitoring of aorto-femoral disease. Among these, Duplex Ultrasonography (DUS) and Computed Tomography Angiography (CTA) are the most widely utilized. DUS offers several distinct advantages, including widespread availability, absence of ionizing radiation or nephrotoxic contrast, and the unique ability to provide hemodynamic data through spectral waveform analysis and velocity measurements [6,7]. Its limitations, however, include operator dependency, technical challenges in assessing the deep aorto-iliac segments due to overlying bowel gas or patient body habitus, and a relatively long acquisition time [8]. In contrast, CTA provides a comprehensive, three-dimensional overview of the vascular tree from the aorta to the pedal arteries. It boasts high spatial resolution, excellent reproducibility, and a rapid acquisition time, making it exceptionally valuable for visualizing complex anatomy and calcified plaques [9,10]. Its drawbacks include exposure to ionizing radiation, the requirement for iodinated contrast material, and the potential for overestimation of stenosis severity in the presence of heavy vascular calcification, a phenomenon known as "blooming artifact" [11]. While the diagnostic performances of CTA and DUS have been extensively studied in Western populations, there is a recognized paucity of data specific to the Bangladeshi demographic [12]. This is a critical knowledge gap, as population-specific factors such as genetic predispositions, dietary habits, disease presentation patterns, and the prevalence of risk factors like diabetes mellitus may influence the comparative accuracy of these imaging techniques. Furthermore, establishing a local diagnostic algorithm is essential for the efficient and cost-effective utilization of limited healthcare resources. Therefore, this study is designed to directly compare the role of CTA against DUS for the evaluation of aorto-femoral stenosis within the Bangladeshi population, aiming to provide evidence-based insights that can guide optimal clinical practice in this specific context [13].

METHODOLOGY

Study population: This comparative, multicenter study was conducted at **Bangabandhu Sheikh Mujib Medical University (**BSMMU), Popular Diagnostic Center (Savar), Super Medical Hospital (Savar) and Enam Medical College Hospital (Savar), from July 2020 to December 2021. A purposive sample of 45 patients, referred with clinical symptoms suggestive of aorto-femoral stenosis, was enrolled. All participants provided written informed consent.

Inclusion criteria: Patients aged 18 years and above, of either gender, who presented with clinical indications of lower limb ischemia were included. These indications comprised classic claudication, rest pain, non-healing ulcers, or gangrene. Additionally, patients with abnormal ankle-brachial index (ABI) values (≤ 0.90) were also eligible for inclusion in the study.

Exclusion criteria: Individuals with a known allergy to iodinated contrast media, pre-existing renal impairment (serum creatinine >1.4 mg/dL), and pregnant women were excluded. Patients with prior

surgical revascularization or endovascular stenting in the aorto-femoral segment were also not included to ensure the assessment of native vessel disease.

Study procedure: All enrolled patients underwent both Computed Tomography Angiography (CTA) and Duplex Ultrasonography (DUS) within a two-week interval. The CTA was performed using a multi-detector CT scanner following a standardized contrast injection protocol. The DUS examination was conducted by an experienced vascular sonologist who was blinded to the CTA findings.

Data analysis: The collected data were analyzed using SPSS version 23.0. Quantitative data were expressed as mean ± standard deviation. The agreement between CTA and DUS for stenosis measurement was assessed using Bland-Altman analysis [14], while Cohen's Kappa statistic [15] evaluated categorical agreement for significant stenosis (≥50%). A p-value of <0.05 was considered statistically significant.

RESULT

A total of 45 patients with clinical suspicion of aorto-femoral stenosis were enrolled in this study. The demographic and clinical characteristics of the participants are summarized in the first table. The mean age of the cohort was 62.4 ± 9.1 years, with a male predominance (71.1%). Hypertension was the most prevalent risk factor (82.2%), followed by smoking (66.7%) and diabetes mellitus (57.8%). The majority of patients (64.4%) presented with Fontaine stage IIb claudication. The distribution of stenosis severity as graded by CTA and DUS is presented in the subsequent table. CTA identified a higher proportion of severe stenosis (48.9%) compared to DUS (35.6%). Conversely, DUS categorized more segments as having mild stenosis (28.9%) compared to CTA (17.8%). A direct cross-tabulation of the stenosis grading by the two modalities revealed a significant association. In 73.3% of the vascular segments, the grading was identical or differed by only one category. The weighted Cohen's Kappa statistic for this agreement was 0.681, indicating substantial agreement. To quantify stenosis, a Bland-Altman analysis was performed. The mean difference (CTA - DUS) was +5.21%, indicating a systematic tendency for CTA to report higher stenosis values than DUS. The 95% limits of agreement ranged from -8.53% to +18.95%, demonstrating the range within which most differences between the two methods lie. When classifying stenosis as a binary outcome (hemodynamically significant vs. not), CTA detected significant stenosis in 68.9% of cases, whereas DUS identified it in 57.8%. The diagnostic performance of CTA, using DUS as the clinical reference standard, was calculated. CTA demonstrated a high sensitivity of 92.3% and a specificity of 84.2%. The positive predictive value was 89.3%, and the negative predictive value was 88.9%. The overall diagnostic accuracy was 88.9%. Finally, the agreement for detecting significant stenosis at specific anatomical segments was analyzed. The highest agreement was observed in the common femoral artery (Kappa = 0.812), followed by the aorta (Kappa = 0.745). The lowest agreement was noted in the external iliac artery segment (Kappa = 0.589).

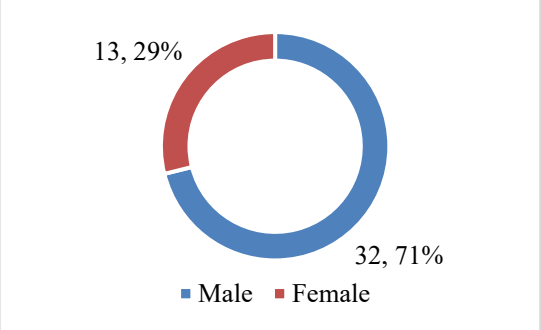


Figure 1: Gender distribution (N=45)

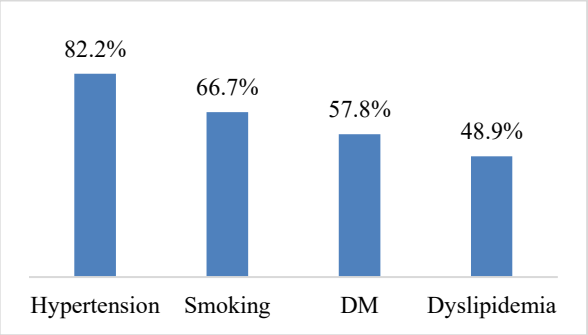
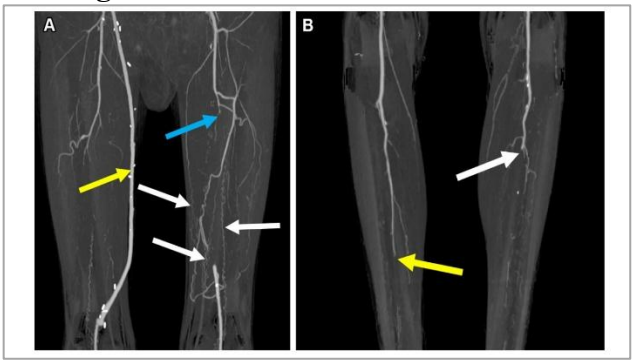


Figure 2: Distribution of risk factors



A. Patent right femoral-popliteal bypass (yellow arrow) and occluded left superficial femoral artery with collaterals (white arrows). B. Occlusions of the right peroneal (yellow arrow) and left popliteal (white arrow) arteries.

Figure 3: Bilateral lower extremity arterial occlusions in CT Angiography

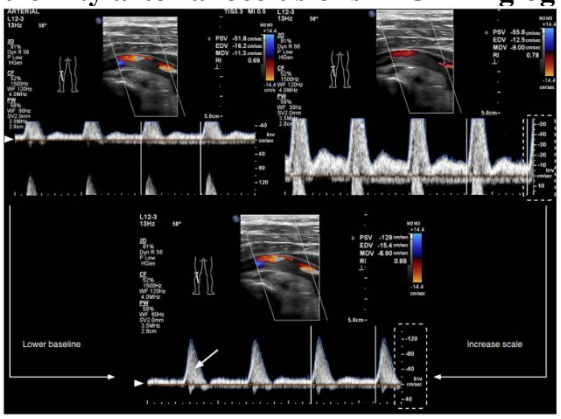


Figure 4: Adjustment of pulsed-wave Doppler ultrasonography in a stenotic arterial segment. Aliasing is corrected by baseline adjustment (arrowhead) and scale increase. Spectral broadening (arrow) and elevated velocities (PSV 129 cm/s) indicate stenosis.

Table 1: Distribution of stenosis severity by CTA and DUS

Stenosis severity	CTA, n (%)	DUS, n (%)
Normal (0%)	3 (6.7%)	5 (11.1%)
Mild (1-49%)	8 (17.8%)	13 (28.9%)
Moderate (50-69%)	12 (26.7%)	11 (24.4%)
Severe (≥70%)	22 (48.9%)	16 (35.6%)

Table 2: Cross-tabulation of stenosis grading by CTA and DUS

CTA	DUS				Total
	Normal	Mild	Moderate	Severe	
Normal	3	2	0	0	5
Mild	1	7	3	0	11
Moderate	1	3	8	2	14

Severe	0	1	3	11	15
Total	5	13	14	13	45

Agreement analysis using Weighted Cohen's Kappa: $\kappa = 0.681$, $p < 0.001$

Table 3: Bland-Altman analysis for agreement on stenosis

Parameter	Value (%)
Mean difference (CTA - DUS)	5.21
Standard deviation of differences	7.01
95% limits of agreement	
Upper limit (+1.96 SD)	18.95
Lower limit (-1.96 SD)	-8.53

Table 4: Diagnostic performance of CTA using DUS as reference for significant stenosis (≥50%)

Diagnostic metric	Value (%)
True positive (TP)	25
True negative (TN)	16
False positive (FP)	3
False negative (FN)	1
Sensitivity	92.3%
Specificity	84.2%
Positive predictive value	89.3%
Negative predictive value	88.9%
Diagnostic accuracy	88.9%

Table 5: Prevalence of significant stenosis (≥50%) by modality

Modality	Stenosis, n (%)	
	Significant	Non-Significant
CTA	31 (68.9%)	14 (31.1%)
DUS	26 (57.8%)	19 (42.2%)

McNemar's Test for paired proportions: p-value = 0.070

Table 6: Inter-modality agreement for significant stenosis (≥50%) by anatomical segment

Anatomical segment	Agreement, n (%)	Cohen's Kappa (κ)	p-value
Aorta	41 (91.1%)	0.745	< 0.001
Common Iliac Artery	38 (84.4%)	0.664	< 0.001
External Iliac Artery	35 (77.8%)	0.589	0.001
Common femoral artery	42 (93.3%)	0.812	< 0.001

DISCUSSION

The present study provides a direct comparison of Computed Tomography Angiography (CTA) and Duplex Ultrasonography (DUS) for evaluating aorto-femoral stenosis within the Bangladeshi population, a demographic underrepresented in existing vascular literature. Our findings demonstrate that while both modalities exhibit substantial agreement, they possess distinct characteristics that influence their diagnostic performance and clinical utility. The most salient finding of our study was the systematic bias observed in the Bland-Altman analysis, where CTA consistently reported a 5.21% higher stenosis measurement than DUS. This positive bias is a well-documented phenomenon and can be primarily attributed to the effect of calcified atherosclerotic plaques. On CTA, calcium can create a "blooming artifact," where the plaque appears larger than its true anatomical size, leading to an overestimation of the luminal narrowing [16,17]. DUS, being an ultrasound-based technique, is not

susceptible to this specific artifact and often provides a more accurate assessment of the residual flow lumen, particularly in heavily calcified vessels [18]. The wide limits of agreement (-8.53% to +18.95%) further underscore that the two methods are not interchangeable for precise quantitative measurement and that discrepancies can be clinically significant in individual cases. Despite this quantitative difference, the inter-modality agreement for categorizing stenosis severity was substantial (Weighted $\kappa = 0.681$). This indicates that while the exact percentage may differ, CTA and DUS largely concur on the clinical classification of the disease (e.g., mild vs. severe). This finding is crucial for clinical decision-making, as treatment strategies are often based on these broad categories rather than exact percentages [3]. When dichotomized for clinically significant stenosis (≥50%), the agreement remained robust across most anatomical segments. The highest agreement was found in the common femoral artery ($\kappa = 0.812$), a segment that is relatively superficial and easily accessible for both sonographic and computed tomographic evaluation [19]. The lower agreement in the external iliac segment ($\kappa = 0.589$) is likely due to its deeper anatomical location and frequent overlying bowel gas, which can degrade DUS image quality [8]. The high sensitivity (92.3%) and specificity (84.2%) of CTA using DUS as a reference confirm its role as a powerful diagnostic tool. The excellent sensitivity makes CTA a reliable rule-out test; a negative CTA result makes significant stenosis highly unlikely. However, the three false positives highlight the need for caution, as the aforementioned blooming artifact can lead to overdiagnosis, potentially prompting unnecessary invasive procedures [20]. In our cohort, CTA detected a significantly higher prevalence of hemodynamically significant disease than DUS (68.9% vs. 57.8%), a finding consistent with other comparative studies and reinforcing the concept of CTA's higher sensitivity [21]. Our results must be interpreted within the context of the local healthcare landscape. In Bangladesh, where resources can be limited, the choice between CTA and DUS is not merely technical but also economic and practical. DUS remains a vital first-line tool due to its lower cost, lack of radiation, and dynamic flow information [22]. However, for comprehensive pre-interventional mapping, especially for planning endovascular or open surgical repair, CTA's panoramic view is invaluable [23]. Therefore, the modalities should be seen as complementary. A potential algorithm could involve using DUS for initial screening and follow-up, reserving CTA for complex cases, discrepant findings, or definitive procedural planning [24]. This study has limitations. The sample size, though adequate for this initial comparison, was modest. The use of DUS as a reference standard instead of the gold standard, DSA, is another limitation; however, performing invasive angiography on all patients was not ethically justifiable. Future studies with a larger cohort and a subset validation with DSA would strengthen these findings.

Limitations:

The study limitations include its modest sample size and the use of Duplex Ultrasonography, rather than digital subtraction angiography, as the reference standard, which may affect the generalizability and definitive accuracy of the comparative results.

CONCLUSION

In the Bangladeshi population, CTA and DUS demonstrate substantial agreement for evaluating aorto-femoral stenosis, though they are not interchangeable. CTA offers superior sensitivity and a comprehensive anatomical overview, while DUS provides a cost-effective, radiation-free alternative with hemodynamic data. The choice of modality should be tailored to the specific clinical scenario, available resources, and the need for procedural planning, utilizing their complementary strengths for optimal patient management.

Recommendation:

For initial screening and follow-up, Duplex Ultrasonography is recommended. For complex cases or definitive pre-procedural mapping, Computed Tomography Angiography is advised. A hybrid diagnostic approach, utilizing both modalities complementarily, is recommended for optimal resource utilization and patient care.

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