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EVALUATING DUPLEX SCAN VERSUS ANKLE-BRACHIAL PRESSURE INDEX IN THE ASSESSMENT OF PERIPHERAL VASCULAR DISEASE AMONG PATIENTS WITH DIABETIC FOOT ULCERS

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ABSTRACT

Background: Diabetic foot ulcer (DFU) is a significant consequence of diabetes mellitus, frequently linked to underlying peripheral vascular disease (PVD), which impedes wound healing and elevates the risk of amputation. Consequently, the early identification of PVD is essential for prompt intervention and preservation of the limb. Duplex ultrasonography as well as Ankle-Brachial Pressure Index (ABPI) are two prevalent non-invasive techniques for evaluating lower limb arterial insufficiency, although their diagnostic precision differs in diabetic individuals.

Aims: The study aims to compare the diagnostic efficacy of Duplex scan and Ankle-Brachial Pressure Index measurements in detecting peripheral vascular disease among patients with diabetic foot ulcers.

Materials and Methods: This prospective comparative study was conducted over a period of eight months at the Department of General Surgery in a tertiary care centre in South India. A total of 45 patients with clinically diagnosed DDUs were included based on defined inclusion and exclusion criteria. Detailed history, clinical examination, and laboratory evaluation were performed. Each participant underwent ABPI measurement using a handheld Doppler device. Subsequently, Duplex Doppler Ultrasonography of both lower limbs was carried out to assess arterial flow characteristics, stenosis, and occlusions. The findings were correlated with ABPI values to determine the sensitivity and specificity of ABPI against Duplex as the reference standard.

Results: Of the 45 patients, 31 (68.9%) were male and 14 (31.1%) were female, predominantly within the age range of 51–70 years. A duplex scan identified PVD in 28 (62.2%) individuals, whereas the ABPI revealed abnormal values in 24 (53.3%) patients. The average ABPI in those with PVD was 0.62 ± 0.15 , whereas it was 0.96 ± 0.08 in individuals with normal Duplex results. The relationship between the Duplex scan and ABPI was statistically significant ($p < 0.001$). The sensitivity and specificity of the ABPI for identifying PVD were determined to be 85.7% and 90.0%, respectively, yielding an overall diagnostic accuracy of 86.6% in comparison to Duplex ultrasonography.

Conclusion: Both Duplex scan as well as ABPI are essential non-invasive methods for identifying PVD in patients with DFUs. Although ABPI functions as a swift and economical screening technique, Duplex ultrasonography provides enhanced diagnostic accuracy and anatomical specificity.

Keywords: Ankle-Brachial Pressure Index, Doppler Study, Diabetic Foot Ulcer, Duplex Ultrasonography, Peripheral Vascular Disease.

INTRODUCTION

Diabetes mellitus is a chronic metabolic condition marked by sustained hyperglycemia resulting from impairments in insulin production, insulin action, or both. It is linked to several long-term issues impacting the eyes, kidneys, nerves, and peripheral blood vessels.¹

Diabetic foot ulcer (DFU) is one of the most prevalent and debilitating consequences, resulting in considerable morbidity, extended hospitalization, and amputation.²

The World Health Organization (WHO) predicts that around 15–25% of diabetes people may experience a foot ulcer at some stage in their lives, with peripheral vascular disease (PVD) being a significant contributing factor in many of these instances.³

PVD caused by atherosclerotic narrowing as well as occlusion of lower limb arteries results in ischemia, tissue hypoxia, and compromised wound healing. In diabetic patients, PVD is typically more distant,



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diffuse, and silent due to accompanying neuropathy that obscures pain sensation.^{4,5} As a result, a postponed diagnosis of vascular insufficiency frequently leads to persistent non-healing ulcers, infections, and gangrene, ultimately resulting in limb amputation. Consequently, the prompt identification of PVD in individuals with DFUs is crucial for enhancing therapy and increasing limb preservation results.⁶

Conventional clinical assessment techniques, such as palpating peripheral pulses or assessing ulcer features, may not consistently reflect the degree of vascular compromise. Consequently, the utilization of non-invasive diagnostic instruments such as the Ankle-Brachial Pressure Index (ABPI) and Duplex ultrasonography has become increasingly significant.⁷

The ABPI determined by the ratio of ankle systolic pressure to brachial systolic pressure, serves as a straightforward, rapid, and economical screening technique for peripheral artery disease. In diabetic patients, medial arterial calcification can cause arteries to become incompressible, resulting in inaccurately high ABPI values and an underassessment of ischemia.⁸

Conversely, Duplex Doppler ultrasonography offers a comprehensive assessment of artery structure and hemodynamic patterns.⁹ It integrates B-mode imaging for structural evaluation with Doppler analysis to measure flow velocity, turbulence, and the extent of stenosis. This technique enables direct observation of arterial blockages and collateral circulation, providing a more thorough evaluation of vascular impairment.¹⁰ Although Duplex scanning has enhanced diagnostic capabilities, it is more reliant on the operator, requires more time, and is less accessible in primary care environments than ABPI.¹¹

The necessity to assess the diagnostic utility and relative accuracy of these two non-invasive methods in identifying PVD in patients with DFUs serves as the justification for the present study. The precise identification of vascular insufficiency impacts clinical decision-making, encompassing the necessity for revascularization interventions, selection of wound management approaches, and forecasting of healing potential. Although numerous studies have assessed each modality independently, few have simultaneously examined their diagnostic connection within the same group of DFU patients under uniform conditions.

Aims and Objectives

- To compare the diagnostic efficacy of Duplex scan and Ankle-Brachial Pressure Index measurements in detecting peripheral vascular disease among patients with diabetic foot ulcers.

MATERIALS AND METHODS

This prospective comparative study was conducted in the Department of General Surgery, Sree Mookambika Institute of Medical Sciences, over a period of eight months from December 2024 to July 2025. A total of 45 patients who presented to the surgical outpatient and inpatient departments with clinically diagnosed DFUs were included in the study.

Inclusion Criteria

- Patients with clinically diagnosed DFUs.
- Age above 30 years.
- Both male and female patients.
- Willingness to participate and provide informed consent.

Exclusion Criteria

- Patients with non-DFUs.
- Patients with acute limb ischemia or previous vascular surgery.
- Patients with ulcers of traumatic, venous, or malignant origin.
- Patients with severe edema or infection precluding ABPI measurement.
- Uncooperative patients or those unwilling to participate in the study.

The diagnosis of diabetes mellitus was established based on clinical history, fasting and postprandial blood glucose levels, and HbA1c measurements. Each patient underwent a detailed clinical evaluation, including age, gender, duration of diabetes, ulcer characteristics, presence of neuropathy, and previous history of vascular disease or foot ulceration.

After obtaining informed written consent, all patients underwent ABPI measurement using a handheld Doppler device with an 8 MHz probe. The systolic blood pressures were measured at both the brachial and ankle levels (dorsalis pedis and posterior tibial arteries). The ABPI was calculated by dividing the higher of the ankle systolic pressures by the higher of the brachial systolic pressures. The results were interpreted as follows:

- Normal: >0.9
- Mild ischemia: $0.7-0.9$
- Moderate ischemia: $0.4-0.69$
- Severe ischemia: <0.4

Following ABPI measurement, each patient underwent Duplex Doppler ultrasonography of both lower limbs using a high-frequency linear probe. The Duplex scan assessed arterial flow characteristics, waveform patterns, peak systolic velocity, and the presence of stenosis or occlusion in the femoral, popliteal, and tibial arteries. The degree of vascular compromise was classified as normal flow, mild, moderate, or severe arterial disease. Duplex findings were considered the reference

standard against which ABPI results were compared.

The data obtained were tabulated and analyzed using appropriate statistical methods. The correlation between ABPI and Duplex findings was determined, and sensitivity, specificity, and diagnostic accuracy of ABPI were calculated. A *p*-value of less than 0.05 was considered statistically significant.

OBSERVATION AND RESULTS

The majority of patients were between 51 and 70 years of age, suggesting that peripheral vascular complications occur more frequently among middle-aged and elderly diabetics. The mean age was 59.4 ± 8.2 years. Among the 45 participants, 31 (68.9%) were males and 14 (31.1%) were females, indicating a male predominance. (Table 1)

Table 1: Age and Gender Distribution of Patients

Age Group (years)	Male n (%)	Female n (%)	Total n (%)
31–40	3 (9.7%)	2 (14.3%)	5 (11.1%)
41–50	6 (19.4%)	2 (14.3%)	8 (17.8%)
51–60	10 (32.3%)	4 (28.6%)	14 (31.1%)
61–70	9 (29.0%)	5 (35.7%)	14 (31.1%)
>70	3 (9.7%)	1 (7.1%)	4 (8.9%)
Total	31 (68.9%)	14 (31.1%)	45 (100%)

More than half of the patients (55.6%) presented with Grade 2 or Grade 3 ulcers, suggesting delayed

medical attention and advanced local disease at presentation. (Table 2)

Table 2: Distribution of Patients According to Wagner's Grade

Wagner's Grade	Description	N(%)
Grade 1	Superficial ulcer	8 (17.8%)
Grade 2	Ulcer involving tendon/joint	13 (28.9%)
Grade 3	Ulcer with abscess/osteomyelitis	12 (26.7%)
Grade 4	Local gangrene (forefoot/heel)	8 (17.8%)
Grade 5	Extensive gangrene	4 (8.8%)

ABPI revealed abnormal values in 24 (53.3%) patients, suggesting that more than half of the cases had some degree of arterial insufficiency. (Table 3)

Table 3: Distribution of Patients according to Wagner's Grade

ABPI Range	Interpretation	N(%)
>0.9	Normal	21 (46.7%)
0.7–0.9	Mild ischemia	10 (22.2%)
0.4–0.69	Moderate ischemia	8 (17.8%)
<0.4	Severe ischemia	6 (13.3%)

The duration of diabetes among the study population ranged from 4 to 22 years. Patients with a longer history of diabetes showed a higher prevalence of

PVD on Duplex scan, establishing a significant association between disease duration and vascular compromise ($p < 0.05$). (Table 4).

Table 4: Duration of Diabetes and Presence of PVD

Duration of Diabetes (years)	No. of Patients	PVD Present n (%)	PVD Absent n (%)	p Value
<5	8	2 (25.0%)	6 (75.0%)	<0.05
5–10	12	6 (50.0%)	6 (50.0%)	
>10	25	20 (80.0%)	5 (20.0%)	

Higher Wagner grades were significantly associated with the presence of PVD ($p < 0.05$). Patients with severe ulcers were more likely to have vascular

compromise, underscoring the importance of vascular assessment in advanced DFU cases. (Table 5)

Table 5: Correlation between Wagner's Grade and Presence of PVD (By Duplex Scan)

Wagner's Grade	No. of Patients	PVD Present n (%)	PVD Absent n (%)	p Value
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Grade 1–2	21	9 (42.9%)	12 (57.1%)	<0.05
Grade 3–5	24	19 (79.2%)	5 (20.8%)	

A strong and statistically significant correlation ($p < 0.001$) was observed between ABPI and Duplex findings. ABPI successfully detected the majority of

cases identified by Duplex, confirming its validity as a screening tool. (Table 6).

Table 6: Correlation between ABPI and Duplex Scan Findings

Duplex Finding	ABPI Abnormal n (%)	ABPI Normal n (%)	p Value
PVD Present	24 (85.7%)	4 (14.3%)	<0.001
PVD Absent	3 (10.0%)	14 (90.0%)	
Total	27 (60.0%)	18 (40.0%)	

ABPI demonstrated a high level of sensitivity and specificity, though Duplex ultrasonography provided greater anatomical precision and detection of segmental lesions. The scoring system demonstrated strong diagnostic performance, with sensitivity of 85.7% and specificity of 90%. The positive predictive value was 88.9% and the negative predictive value was 82.3%, with an overall diagnostic accuracy of 86.6%

DISCUSSION

In the evaluation of 45 patients with DFUs, males were the majority (31, 68.9%), and the predominant age group was 51–70 years (28, 62.2%), indicating the heightened vulnerability of middle-aged and elderly diabetics to peripheral vascular problems. A significant percentage of patients (25, 55.6%) had diabetes for over 10 years, and among these, 20 (80%) exhibited PVD on Duplex ultrasonography, highlighting the robust correlation between prolonged diabetes and vascular insufficiency. George R et al.¹² reported similar demographic patterns, identifying the age group of 51–60 years as the most commonly affected, whereas Murari K et al.¹³ noted a predominance of middle-aged individuals and a significant prevalence of diabetes duration beyond 10 years. Shabhay A et al.¹⁴ observed that more than fifty percent of their study cohort had diabetes for over five years, hence underscoring chronicity as a significant risk factor. Ugwu E et al.¹⁵ emphasized the diagnostic precision of vascular evaluations, demonstrating a strong correlation between Ankle–Brachial Index (ABI) and Duplex ultrasonography (DUS), with sensitivity increasing in accordance with the severity of stenosis.

The current study indicated that ABPI measures showed 24 patients (53.3%) with aberrant values signifying mild to severe ischemia, whereas Duplex ultrasonography identified PVD in 28 patients (62.2%). In patients with PVD, 24 (85.7%) exhibited aberrant ABPI values, indicating a statistically substantial connection ($p < 0.001$) between the two

diagnostic modalities. ABPI demonstrated efficacy as a practical and swift screening instrument, but Duplex scan offered supplementary anatomical information regarding the location and severity of stenosis, which ABPI was unable to identify.

Similar results have been published by Ramaswami B et al.¹⁶ who indicated a high sensitivity and predictive value of ABPI, and by Babu M et al.¹⁷ who showed that exclusive dependence on ABPI could lead to overlooked diagnoses, hence endorsing the adjunctive use of Duplex scanning.

Assessment of ulcer severity indicated that over fifty percent of the patients (25, 55.6%) presented with Wagner Grade 2–3 ulcers, whereas 12 (26.7%) exhibited Grade 4–5 ulcers. The prevalence of PVD was markedly elevated in patients with advanced ulcer grades, with 19 of 24 (79.2%) Grade 3–5 ulcers linked to vascular compromise, in contrast to 9 of 21 (42.9%) Grade 1–2 ulcers ($p < 0.05$). This connection highlights the pivotal role of ischemia in ulcer advancement and protracted healing. Similar distributions of Wagner grades have been documented by Cervantes-García E et al.¹⁸ further substantiating the relationship between ulcer depth and perfusion state.

Limb involvement exhibited a marginal majority of left-sided ulcers (26, 57.7%), with the forefoot identified as the most commonly affected area (21, 46.7%), succeeded by the midfoot (10, 22.2%) and heel (9, 20%). These findings indicate that regions exposed to elevated pressure and comparatively inadequate perfusion are more susceptible to ulcer formation in diabetes patients.

The current study showed that PVD was common in DFU patients, especially in those with advanced ulcer grades and prolonged diabetes duration. Both ABPI and Duplex ultrasonography are significant non-invasive diagnostic modalities, with ABPI showing abnormalities in 24 cases (53.3%) and Duplex identifying PVD in 28 cases (62.2%). Although ABPI functions as an efficient screening tool, Duplex offers comprehensive vascular

mapping, facilitating management and enhancing limb salvage results.

This was comparable to the findings of Ragghianti B et al.¹⁹ who highlighted Duplex ultrasonography as the gold standard while admitting that test combinations, particularly ABI may be useful first-line substitutes in situations with limited settings.

CONCLUSION

PVD was identified in 28 individuals via Duplex scan and in 24 patients through ABPI, demonstrating a significant correlation. Patients exhibiting advanced Wagner grades of ulcers demonstrated a higher likelihood of vascular compromise. ABPI exhibited elevated sensitivity and specificity for identifying peripheral arterial disease, whereas Duplex ultrasonography offered comprehensive anatomical evaluation. Both procedures are valuable non-invasive instruments, with ABPI appropriate for rapid screening and Duplex critical for accurate assessment and management strategy formulation.

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Conflicts of Interest:

There are no conflicts of interest

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