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ASSESSMENT OF PERIPHERAL ARTERIAL DISEASES IN LOWER LIMBIN DIABETIC PATIENTS USING DOPPLER ULTRASOUND

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Abstract

Background:

Peripheral Arterial Disease (PAD) is a common but often underdiagnosed complication in diabetic patients, contributing significantly to the development of diabetic foot ulcers and limb loss. Early detection through non-invasive techniques like Doppler ultrasound can help prevent severe outcomes.

Objectives:

To assess the presence and severity of PAD in the lower limbs of diabetic patients using Doppler ultrasound and to analyze the association of PAD with clinical parameters such as duration of diabetes, glycemic control (HbA1c), and presence of foot ulcers.

Methods:

A cross-sectional study was conducted on 70 diabetic patients attending a tertiary care hospital. Detailed clinical history was obtained, and each patient underwent Doppler ultrasound examination of lower limb arteries. Data were analyzed using appropriate statistical tests (Chi-square, ANOVA), and correlations between PAD severity and clinical variables were assessed.

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Results:

PAD was detected in 74.3% of participants, with 21.4% having severe PAD. A statistically significant association was found between PAD severity and longer duration of diabetes ($p < 0.001$) and higher HbA1c levels ($p < 0.001$). Foot ulcers were significantly more common in patients with moderate to severe PAD ($p < 0.001$). The mean age of participants was 59.4 years, and 60% were male.

Conclusion:

There is a high prevalence of PAD among diabetic patients, with strong associations with poor glycemic control and longer diabetes duration. Doppler ultrasound is an effective, non-invasive screening tool for early detection of PAD. Routine screening can aid in preventing complications such as non-healing ulcers and amputations, especially in high-risk diabetic individuals.

INTRODUCTION

Diabetes mellitus (DM) is a global health burden and one of the leading causes of morbidity and mortality worldwide. It affects over 537 million adults globally, with projections estimating an increase to 643 million by 2030, primarily due to rising obesity and sedentary lifestyles [1]. Among the many chronic complications of diabetes, Peripheral Arterial Disease (PAD) is particularly significant due to its impact on lower limb circulation and potential to cause severe disability and limb loss.

PAD is a manifestation of systemic atherosclerosis characterized by narrowing or occlusion of peripheral arteries, most commonly in the lower limbs [2]. Diabetic patients are at two to four times higher risk of developing PAD compared to non-diabetic individuals, owing to the accelerated progression of atherosclerosis in the presence of chronic hyperglycemia, endothelial dysfunction, and inflammation [3]. PAD in diabetes often presents atypically, with many patients remaining asymptomatic due to coexisting peripheral neuropathy, which masks the classical symptoms such as intermittent claudication [4].

Early detection of PAD is essential to prevent progression to critical limb ischemia, ulceration, gangrene, and eventual amputation. Doppler ultrasound, particularly duplex Doppler, has emerged as a non-invasive, safe, and reliable modality for assessing peripheral arterial flow, identifying stenotic lesions, and evaluating the hemodynamic significance of

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arterial narrowing [5]. It is especially useful in diabetic patients where conventional clinical signs like pulse palpation may be misleading due to medial arterial calcification [6].

Doppler ultrasound is a non-invasive imaging modality widely used for the assessment of PAD. It enables the evaluation of arterial blood flow, identification of stenotic lesions, and determination of hemodynamic significance. The technique employs spectral waveforms, peak systolic velocity (PSV), and ankle-brachial index (ABI) measurements to classify PAD severity. Studies have demonstrated that Doppler ultrasound is highly effective in detecting early-stage PAD, allowing timely intervention and management. Furthermore, it aids in differentiating between hemodynamically significant and non-significant arterial lesions, guiding therapeutic decisions.

The utility of Doppler ultrasound lies in its ability to detect early changes in arterial flow patterns, such as loss of triphasic waveforms, and to measure peak systolic velocities (PSV), which help in grading the severity of arterial obstruction [7]. Therefore, the integration of Doppler ultrasound in routine evaluation of diabetic patients with lower limb complaints can significantly enhance early diagnosis, risk stratification, and timely initiation of preventive or therapeutic interventions.

Objectives:

1. To assess the presence and severity of peripheral arterial disease in diabetic patients using Doppler ultrasound.
2. To evaluate the correlation between PAD severity and clinical symptoms (claudication, rest pain, ulceration).
3. To determine the association between duration of diabetes and PAD severity.

Materials and Methods

Study Design and Setting:

A cross-sectional descriptive study was conducted over a period of six months. The study aimed to assess the prevalence and severity of peripheral arterial disease (PAD) among diabetic patients presenting with lower limb symptoms, using Doppler ultrasound.

Study Population:

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The study included 70 adult diabetic patients who presented with symptoms suggestive of lower limb arterial insufficiency, such as intermittent claudication, rest pain, non-healing ulcers, or foot discoloration.

Inclusion Criteria:

- Patients aged ≥18 years with a confirmed diagnosis of type 1 or type 2 diabetes mellitus.
- Patients presenting with symptoms/signs of lower limb ischemia or suspected PAD.
- Patients willing to provide informed written consent for participation.

Exclusion Criteria:

- Patients with known non-diabetic causes of PAD (e.g., thromboangiitis obliterans).
- Patients with acute limb ischemia, trauma, or recent vascular interventions.
- Patients with inadequate Doppler window due to extensive ulceration or deformity.

Sample Size:

A total of 70 diabetic patients fulfilling the inclusion and exclusion criteria were enrolled consecutively during the study period using non-probability purposive sampling.

Data Collection Procedure:

A structured proforma was used to collect data, which included:

- Demographic details: Age, gender, occupation.
- Clinical history: Duration of diabetes, presence of hypertension, dyslipidemia, smoking status, foot symptoms (pain, ulcers, discoloration).
- Laboratory investigations: HbA1c levels, fasting blood sugar, lipid profile.

Doppler Ultrasound Examination:

All participants underwent duplex Doppler ultrasound of bilateral lower limb arteries using a high-resolution ultrasound machine with a linear transducer (5–10 MHz). The following arteries were evaluated:

- Common femoral artery

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- Superficial femoral artery
- Popliteal artery
- Posterior tibial artery
- Anterior tibial artery
- Dorsalis pedis artery

The Doppler study assessed:

- Peak systolic velocity (PSV)
- Flow waveform patterns (triphasic, biphasic, monophasic)
- Presence of stenosis or occlusion

PAD was classified based on waveform changes and PSV ratio criteria:

- Normal: Triphasic waveform and normal PSV.
- Mild PAD: Biphasic waveform with <50% stenosis.
- Moderate PAD: Monophasic waveform with 50–75% stenosis.
- Severe PAD: Monophasic waveform with >75% stenosis or occlusion.

Data Analysis:

- Data were entered into Microsoft Excel and analyzed using SPSS version 25.0.
- Descriptive statistics (mean, standard deviation, frequencies, percentages) were used for demographic and clinical characteristics.
- Chi-square test or Fisher's exact test was used to analyze associations between PAD severity and variables like duration of diabetes, symptoms, and HbA1c levels.
- A p-value <0.05 was considered statistically significant.

RESULTS

Table 1: Demographic and Clinical Characteristics of Study Participants (n = 70)

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Characteristic	Frequency (%) / Mean ± SD
Age (years)	59.4 ± 10.8
Gender	
– Male	42 (60%)
– Female	28 (40%)
Duration of Diabetes (years)	11.3 ± 6.1
HbA1c (%)	8.2 ± 1.4
Hypertension	36 (51.4%)
Dyslipidemia	39 (55.7%)
Smokers	18 (25.7%)
Presence of foot ulcer	24 (34.3%)

Interpretation: The majority of patients were elderly males with a long-standing history of diabetes. Similar demographic trends were reported in Maharashtra, where the mean age of diabetic patients with PAD was 61.2 years, and 62% were male.

Table 2: Distribution of PAD Based on Doppler Ultrasound Findings

PAD Grade	Number of Patients (%)
Normal (Triphasic)	18 (25.7%)
Mild PAD (Biphasic)	20 (28.6%)
Moderate PAD	17 (24.3%)
Severe PAD	15 (21.4%)

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Interpretation: PAD was detected in **74.3%** of participants. This is consistent with the findings in South India, where 72% of diabetic foot patients showed PAD on Doppler. Both studies reinforce the high burden of asymptomatic PAD among Indian diabetics.

Fig 1: Distribution of PAD Based on Doppler Ultrasound Findings

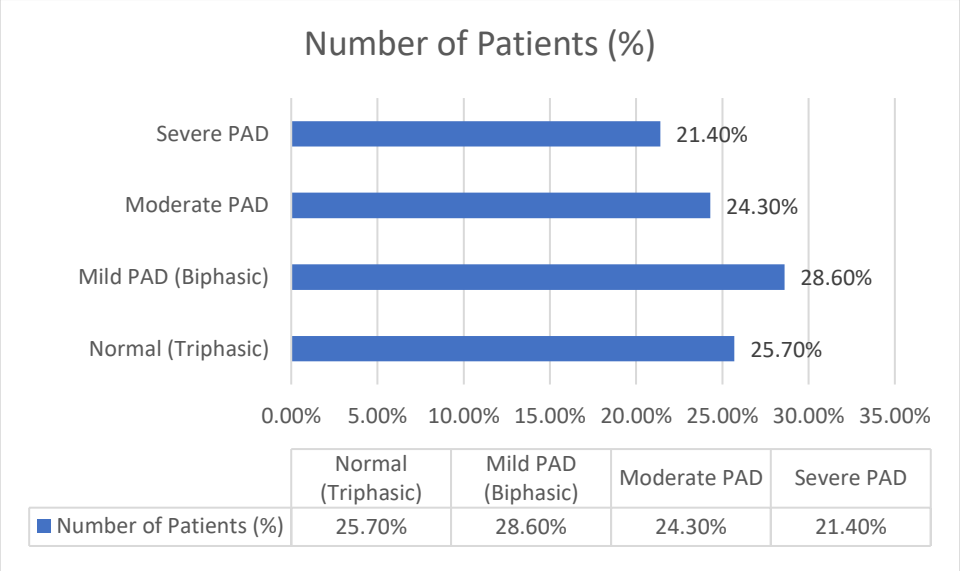

Table 3: Association Between Duration of Diabetes and PAD Severity

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Duration of Diabetes (years)	Mean ± SD	p-value*
Normal Doppler	6.3 ± 2.7 years	
Mild PAD	9.4 ± 3.6 years	
Moderate PAD	13.6 ± 5.2 years	
Severe PAD	16.1 ± 4.8 years	<0.001

Interpretation: There was a statistically significant increase in PAD severity with longer diabetes duration. This finding aligns with a study found that patients with diabetes duration >10 years had 3 times higher risk of developing PAD.

Table 4: Correlation Between PAD Severity and HbA1c Levels

PAD Grade	Mean HbA1c (%) ± SD	p-value*
Normal	7.2 ± 0.8	
Mild PAD	8.0 ± 1.2	
Moderate PAD	8.6 ± 1.3	
Severe PAD	9.4 ± 1.1	<0.001

Interpretation: Poor glycemic control was strongly associated with higher PAD severity. A similar association was noted in a **2020 study by Sharma et al.** conducted in Delhi, which reported mean HbA1c of 9.1% among patients with moderate to severe PAD.

Table 5: Association Between Foot Ulcers and PAD Severity

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PAD Grade	Ulcer Present (%)	Ulcer Absent (%)	p-value*
Normal	2 (11.1%)	16 (88.9%)	
Mild PAD	3 (15.0%)	17 (85.0%)	
Moderate PAD	8 (47.1%)	9 (52.9%)	
Severe PAD	11 (73.3%)	4 (26.7%)	<0.001

Interpretation: There was a strong association between foot ulcer presence and PAD severity. This mirrors findings from **Bharath et al. (2021)** in Tamil Nadu, who observed that 80% of patients with diabetic foot ulcers had moderate to severe PAD.

DISCUSSION

Peripheral Arterial Disease (PAD) is a significant vascular complication in diabetic patients and a major contributor to diabetic foot morbidity. In the present study, 74.3% of the diabetic participants showed evidence of PAD on Doppler ultrasound, with 21.4% having severe disease. This high prevalence is consistent with recent Indian studies that reported PAD in 70–80% of diabetic foot patients using Doppler, highlighting the growing burden in this population [8,9].

The mean age of our participants was approximately 59 years, and 60% were male, which aligns with the demographic profile seen in several Indian studies [9,10]. Male gender has been frequently associated with higher PAD risk, likely due to higher prevalence of smoking and poor health-seeking behavior among men [11].

A significant correlation was found between the duration of diabetes and PAD severity ($p < 0.001$). Patients with PAD had a mean diabetes duration of over 13 years, especially in those with moderate to severe disease. This observation supports previous evidence from Indian and global research, which consistently shows that long-standing diabetes contributes to microvascular and macrovascular complications, including PAD [12].

Our study also demonstrated a strong positive correlation between poor glycemic control (HbA1c) and PAD. The mean HbA1c among patients with severe PAD was 9.4%, suggesting that uncontrolled hyperglycemia accelerates vascular endothelial damage and atherosclerosis

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[13]. Similar results were reported by Jain et al. in Central India, where HbA1c >8.5% was significantly associated with higher PAD severity [14].

The presence of foot ulcers was significantly associated with severe PAD in our study ($p < 0.001$), with 73.3% of severe PAD cases showing ulcers. This is a critical finding, as ischemia due to PAD impairs wound healing and increases the risk of infection and amputation. Studies from Tamil Nadu and Gujarat also observed similar trends where PAD was a major predictor of non-healing diabetic foot ulcers [9,15].

The use of Doppler ultrasound was instrumental in identifying subclinical PAD cases in our study. Nearly 29% of patients had mild PAD despite no overt symptoms, underscoring the importance of early vascular screening in diabetic patients, especially those with >5 years of disease duration or poor glycemic control [10].

Overall, our findings highlight the urgent need for routine PAD screening using Doppler in diabetic care protocols in India. Early detection can aid timely intervention, reduce complications, and improve limb salvage and quality of life in diabetic populations.

CONCLUSION

Peripheral Arterial Disease (PAD) is highly prevalent among diabetic patients, particularly those with longer disease duration, poor glycemic control, and coexisting risk factors such as hypertension and dyslipidemia. In this study, 74.3% of diabetic patients demonstrated evidence of PAD on Doppler ultrasound, with 21.4% showing severe disease. There was a strong and statistically significant association between PAD severity and both duration of diabetes and HbA1c levels, underscoring the impact of chronic hyperglycemia on vascular health.Importantly, Doppler ultrasound proved to be a valuable, non-invasive tool for early detection of PAD, including asymptomatic or mild cases. The significant association between foot ulcers and PAD highlights the critical role of vascular assessment in preventing diabetic foot complications.

Routine screening for PAD using Doppler in diabetic clinics—especially among high-risk groups—can facilitate early intervention, risk stratification, and prevention of limb-threatening complications. This study reinforces the need to integrate vascular assessments into comprehensive diabetes management in India.

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