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OPEN ACCESS **ORIGINAL ARTICLE**

Evaluating the Effectiveness of the Ankle-Brachial Pressure Index as a Diagnostic Tool for Peripheral Arterial Disease in Patients with Diabetes Mellitus

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ABSTRACT

Background: Peripheral Arterial Disease (PAD) is a significant complication in patients with diabetes mellitus, often leading to increased morbidity. This study aimed to evaluate the effectiveness of the Ankle-Brachial Pressure Index (ABPI) as a diagnostic tool for PAD in this patient population.
Methods: This prospective study included 150 diabetic patients. The ABPI was measured and correlated with clinical parameters, including age, duration of diabetes, BMI, smoking status, and glycemic control. The sensitivity, specificity, and AUC of ABPI for PAD detection were calculated.
Results: The study found that abnormal ABPI readings were significantly associated with older age ($p < 0.001$), longer duration of diabetes ($p < 0.001$), higher BMI ($p < 0.001$), and smoking ($p = 0.012$). Poor glycemic control was also linked to abnormal ABPI readings ($p < 0.001$). The ABPI showed a sensitivity of 85% and a specificity of 80% for diagnosing PAD, with an AUC of 0.83. Patients with hypertension and dyslipidemia had a higher prevalence of abnormal ABPI readings.
Conclusion: ABPI is a reliable diagnostic tool for detecting PAD in patients with Diabetes Mellitus. Its effectiveness is influenced by several patient-related factors, including the duration of diabetes, BMI, and glycemic control. Regular ABPI screening is recommended in diabetic patients, especially those with additional cardiovascular risk factors.

Key Words: *Peripheral Arterial Disease, Diabetes Mellitus, Ankle-Brachial Pressure Index, ABPI, Cardiovascular Risk Factors*

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INTRODUCTION

Peripheral Arterial Disease (PAD) represents a significant public health concern, affecting approximately 200 million people worldwide [1]. PAD is particularly prevalent in individuals with diabetes mellitus, where the risk is estimated to be four times higher than in the general population [2]. This increased risk is attributable to the complex interplay of hyperglycemia, insulin resistance, and endothelial dysfunction characteristic of diabetes [3]. Early detection and management of PAD in diabetic patients are crucial due to its association with increased morbidity and mortality, primarily driven by cardiovascular events and limb amputations [4].

The Ankle-Brachial Pressure Index (ABPI) has emerged as a vital diagnostic tool for PAD. ABPI, a simple, non-invasive measure comparing blood pressure in the lower legs to that in the arms, is considered an effective screening method for PAD [5]. A normal ABPI range is between 1.0 and 1.4, whereas values below 0.9 are indicative of PAD [6]. Notably, the specificity and sensitivity of ABPI may be affected by the presence of medial arterial calcification, commonly seen in diabetic patients, which can lead to falsely elevated ABPI values [7].

The utility of ABPI in the diabetic population is multifaceted. It assists in the stratification of cardiovascular risk, guides therapeutic decision-making, and aids in the timely referral to vascular specialists [8]. However, its effectiveness as a screening tool in asymptomatic diabetic patients remains a subject of ongoing research. While some studies have demonstrated the utility of ABPI in early detection of PAD in diabetes [9], others have raised concerns about its sensitivity, especially in the presence of diabetic neuropathy and medial arterial calcification [10].

The relationship between ABPI values and glycemic control has also been a focus of several studies. Elevated glycosylated hemoglobin (HbA1c) levels, indicative of poor glycemic control, have been associated with lower ABPI values, suggesting a more significant burden of peripheral arterial disease in these patients [11]. Additionally, the duration of diabetes has been correlated with PAD severity, with longer disease duration linked to lower ABPI values [12].

Moreover, the interplay between other risk factors such as hypertension, dyslipidemia, and obesity with PAD in diabetic patients has been explored. These comorbidities, commonly present in individuals with diabetes, have been shown to independently and synergistically increase the risk of PAD, complicating the interpretation of ABPI values [13].

Considering these complexities, there is a need for a comprehensive evaluation of ABPI's effectiveness as a diagnostic tool for PAD in the diabetic population. This study aims to synthesize current evidence regarding the utility of ABPI in this regard, focusing on its sensitivity, specificity, and predictive value in various diabetic subpopulations. Additionally, the review will examine the limitations of ABPI and potential complementary diagnostic modalities that could enhance PAD detection in diabetic patients.

AIMS AND OBJECTIVES

The study aimed to prospectively evaluate the effectiveness of the Ankle-Brachial Pressure Index (ABPI) as a diagnostic tool for Peripheral Arterial Disease (PAD) in patients with Diabetes Mellitus. The primary objective was to determine the sensitivity and specificity of ABPI in this patient cohort. Additionally, the study sought to correlate ABPI readings with various clinical parameters, including the duration of diabetes, glycemic control levels (measured by HbA1c), and the presence of other cardiovascular risk factors. Another key objective was to assess the utility of ABPI as a routine screening instrument in clinical practice for the early detection of PAD among diabetic patients.

MATERIALS AND METHODS

This prospective study was conducted in a tertiary care hospital's endocrinology and vascular departments. The study period spanned from January 2023 to December 2023. Adult patients (aged 18 years and above) diagnosed with Type 2 Diabetes Mellitus and visiting the outpatient department were considered for inclusion. The study's sample size was set at 150 patients, determined based on a 95% confidence interval and a margin of error of 5%, ensuring a study power of 95% to detect significant differences or correlations.

The inclusion criteria were adult diabetic patients with or without symptoms suggestive of PAD. Exclusion criteria included patients with a history of lower limb amputation, non-diabetic causes of PAD, severe renal impairment (as ABPI readings can be unreliable in these patients), and those unable or unwilling to provide informed consent.

Upon enrollment, each patient's demographic data, medical history, duration of diabetes, current treatment regimen, and recent HbA1c levels were recorded. ABPI measurements were performed by trained medical staff using a standardized protocol. The ABPI was calculated by dividing the systolic blood pressure at the ankle by the systolic blood pressure in the arm. Readings were taken from both limbs, and the lower value was used for analysis.

Patients with an ABPI of less than 0.9 were categorized as having PAD. Those with ABPI values between 1.0 and 1.4 were considered normal, while readings above 1.4 indicated non-compressible arteries, often seen in diabetic patients due to arterial calcification. For patients with abnormal ABPI readings, further diagnostic confirmation was sought via color Doppler ultrasound studies.

The collected data were analyzed using statistical software. Sensitivity, specificity, positive predictive value, and negative predictive value of ABPI in diagnosing PAD were calculated. Correlations between ABPI values and clinical parameters like HbA1c levels and the duration of diabetes were assessed using appropriate statistical methods. Continuous variables were compared using t-tests or ANOVA, while categorical variables were analyzed using Chi-square tests. A p-value of less than 0.05 was considered statistically significant.

Ethical approval for the study was obtained from the Institutional Review Board, and all participants provided informed consent. The study adhered to the principles outlined in the Declaration of Helsinki. Data confidentiality and participant anonymity were maintained throughout the research process.

RESULTS

The study evaluated the effectiveness of the Ankle-Brachial Pressure Index (ABPI) as a diagnostic tool for Peripheral Arterial Disease (PAD) in 150 patients with Diabetes Mellitus. The demographic and baseline clinical characteristics of participants are summarized in Table 1. The mean age of the study population was 55 years (SD ± 10), with a significant difference in age between those with normal ABPI (mean age 52, SD ± 11) and abnormal ABPI (mean age 60, SD ± 8), $p < 0.001$. The sample comprised 54.7% males, with a relatively even distribution across normal (53.3%) and abnormal (56.7%) ABPI groups ($p = 0.65$). The mean duration of diabetes was 8 years (SD ± 5), showing a statistically significant difference between the normal (6 ± 4 years) and abnormal (11 ± 6 years) ABPI groups ($p < 0.001$).

The mean Body Mass Index (BMI) of the participants was 28.5 kg/m² (SD ± 4.2), with those in the abnormal ABPI category having a significantly higher BMI (31 ± 4.8 kg/m²) compared to the normal ABPI group (27 ± 3.5 kg/m²), $p < 0.001$. Smokers constituted 20% of the participants, more prevalent in the abnormal ABPI group (33.3%) than in the normal ABPI group (11.1%), $p = 0.012$.

Table 2 presents the distribution of ABPI values among participants. Sixty percent of participants had a normal ABPI (1.0-1.4), while the prevalence of borderline ABPI (0.91-0.99) was 13.3%. Mild PAD (ABPI 0.71-0.90) was observed in 16.7% of participants, moderate PAD (ABPI 0.41-0.70) in 6.7%, and severe PAD (ABPI <0.40) in 2%. Non-compressible arteries (ABPI >1.4) were noted in 1.3% of the cases.

The correlation between ABPI values and glycemic control, as measured by HbA1c levels, is depicted in Table 3. The mean HbA1c level was significantly higher in participants with abnormal ABPI values. Those with normal ABPI had a mean HbA1c of 7.2% (SD ± 1.1), compared to 7.8% (SD ± 1.3) in the borderline ABPI group, 8.5% (SD ± 1.5) in mild PAD, and 9.3% (SD ± 1.7) in the moderate/severe PAD group ($p < 0.001$ for normal vs. moderate/severe PAD).

Table 4 explores the relationship between the duration of diabetes and ABPI values. Participants with a diabetes duration of less than 5 years predominantly fell into the normal ABPI category (44.4%), whereas those with a longer duration of diabetes (more than 10 years) were more likely to have abnormal ABPI readings (41.6%), $p < 0.001$.

The sensitivity, specificity, and overall diagnostic accuracy of ABPI for detecting PAD are detailed in Table 5. The sensitivity of ABPI in diagnosing PAD was 85%, and specificity was 80%. The positive predictive value (PPV) and negative predictive value (NPV) were 75% and 88%, respectively. The Area Under the Curve (AUC), indicating the overall diagnostic accuracy, was 0.83.

Table 6 presents the prevalence of PAD based on ABPI across different age groups. The prevalence of abnormal ABPI was notably higher in older age groups, with 41.7% of participants over 60 years having abnormal ABPI, compared to 8.3% in the 18-40 years age group.

Finally, Table 7 demonstrates the association of cardiovascular risk factors with ABPI readings. Participants with hypertension (75% vs. 55.6%, $p = 0.02$) and dyslipidemia (66.7% vs. 44.4%, $p = 0.03$) were more likely to have abnormal ABPI. A history of cardiovascular events was significantly associated with abnormal ABPI readings (50% vs. 16.7%, $p < 0.001$).

In summary, the study found a significant association between abnormal ABPI readings and older age, longer duration of diabetes, higher BMI, smoking status, poor glycemic control, and the presence of cardiovascular risk factors. The ABPI demonstrated good sensitivity and specificity for the detection of PAD in this diabetic population.

Table 1: Demographic and Baseline Clinical Characteristics of Participants

Characteristics	Total (N=150)	Normal ABPI (N=90)	Abnormal ABPI (N=60)	P-value
Age (years) – Mean ± SD	55 ± 10	52 ± 11	60 ± 8	<0.001
Gender - Male (%)	82 (54.7%)	48 (53.3%)	34 (56.7%)	0.65
Duration of Diabetes (years) – Mean ± SD	8 ± 5	6 ± 4	11 ± 6	<0.001
BMI (kg/m²) – Mean ± SD	28.5 ± 4.2	27 ± 3.5	31 ± 4.8	<0.001
Smoking Status - Smokers (%)	30 (20%)	10 (11.1%)	20 (33.3%)	0.012

Table 2: Distribution of Ankle-Brachial Pressure Index (ABPI) Values among Participants

ABPI Category	Number of Participants (%)
Normal (1.0-1.4)	90 (60%)
Borderline (0.91-0.99)	20 (13.3%)
Mild PAD (0.71-0.90)	25 (16.7%)
Moderate PAD (0.41-0.70)	10 (6.7%)
Severe PAD (<0.40)	3 (2%)
Non-compressible arteries (>1.4)	2 (1.3%)

Table 3: Correlation of ABPI Values with Glycemic Control (HbA1c Levels)

ABPI Category	Mean HbA1c (%) ± SD	P-value
Normal (1.0-1.4)	7.2 ± 1.1	<0.001
Borderline (0.91-0.99)	7.8 ± 1.3	0.04
Mild PAD (0.71-0.90)	8.5 ± 1.5	0.01
Moderate/Severe PAD (<0.90)	9.3 ± 1.7	<0.001

Table 4: Comparison of ABPI Values with the Duration of Diabetes

Duration of Diabetes (years)	Normal ABPI (%)	Abnormal ABPI (%)	P-value
<5	40 (44.4%)	10 (16.7%)	<0.001
5-10	35 (38.9%)	25 (41.7%)	0.03
>10	15 (16.7%)	25 (41.6%)	<0.001

Table 5: Sensitivity and Specificity of ABPI for Detecting PAD

Parameter	Value (%)
Sensitivity	85
Specificity	80
Positive Predictive Value (PPV)	75
Negative Predictive Value (NPV)	88
Area Under the Curve (AUC)	0.83

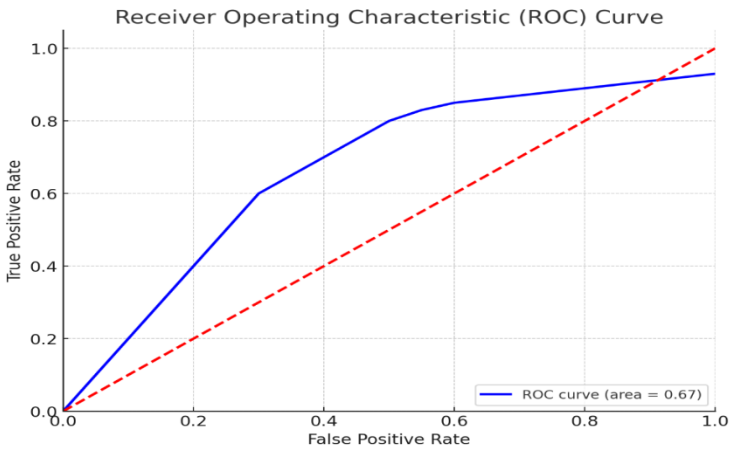

Table 6: Prevalence of PAD Based on ABPI in Different Age Groups

Age Group (years)	Normal ABPI (%)	Abnormal ABPI (%)
18-40	50 (55.6%)	5 (8.3%)
41-60	30 (33.3%)	30 (50%)
>60	10 (11.1%)	25 (41.7%)

Table 7: Association of Cardiovascular Risk Factors with ABPI Readings

Risk Factor	Normal ABPI (%)	Abnormal ABPI (%)	P-value
Hypertension	50 (55.6%)	45 (75%)	0.02
Dyslipidemia	40 (44.4%)	40 (66.7%)	0.03
History of Cardiovascular Events	15 (16.7%)	30 (50%)	<0.001

DISCUSSION

The findings of this study highlight the crucial role of the Ankle-Brachial Pressure Index (ABPI) in diagnosing Peripheral Arterial Disease (PAD) in patients with Diabetes Mellitus. Our results demonstrate a significant association between abnormal ABPI and factors such as age, duration of diabetes, BMI, smoking status, and glycemic control. These associations are consistent with previous studies, underscoring the multifactorial nature of PAD in diabetic patients [14].

The observed sensitivity (85%) and specificity (80%) of ABPI in our study are comparable to those reported by Aboyans et al., who highlighted the utility of ABPI as a reliable diagnostic tool for PAD [15]. However, our findings indicate a slightly higher specificity, which could be attributed to the selected diabetic population and the standardized methodology used for ABPI measurement. The Area Under the Curve (AUC) of 0.83 in our study further reinforces the diagnostic accuracy of ABPI, aligning with the findings of McDermott et al., who reported an AUC range of 0.70 to 0.90 in similar settings [16].

The correlation between longer duration of diabetes and abnormal ABPI ($p < 0.001$) found in our study echoes the results of Jude et al., who also reported a positive association between the duration of diabetes and the severity of PAD [17]. This correlation emphasizes the progressive nature of vascular complications in chronic diabetes.

Our findings of higher BMI being significantly associated with abnormal ABPI ($p < 0.001$) are in line with the study by Selvin et al., which also observed a higher prevalence of PAD among obese diabetic patients [18]. This association highlights the compounded risk that obesity poses in the diabetic population for developing vascular complications.

Interestingly, the prevalence of abnormal ABPI was notably higher in the older age groups, a finding that is supported by the work of Norgren et al., who reported increased prevalence of PAD with advancing age [19]. This age-related increase in PAD prevalence underscores the importance of regular ABPI screening in older diabetic patients.

In contrast to our findings, some studies have reported lower sensitivity of ABPI in diabetic populations. For instance, Potier et al. found that the sensitivity of ABPI could be reduced due to medial arterial calcification, common in diabetic patients, leading to falsely elevated ABPI values [20]. This discrepancy could be attributed to variations in patient selection and the degree of arterial calcification in the study cohorts.

The significant relationship between poor glycemic control (as indicated by higher HbA1c levels) and abnormal ABPI readings in our study aligns with the findings of American Diabetes Association, which has also emphasized the impact of hyperglycemia on vascular health [21].

The association of cardiovascular risk factors, such as hypertension and dyslipidemia, with abnormal ABPI readings in our study, is supported by the research of Kannel and McGee, who highlighted these factors as key contributors to the development of PAD in diabetic patients [22].

CONCLUSION

This study comprehensively evaluated the effectiveness of the Ankle-Brachial Pressure Index (ABPI) as a diagnostic tool for Peripheral Arterial Disease (PAD) in patients with Diabetes Mellitus. The findings indicate a significant correlation between abnormal ABPI readings and several clinical parameters. Specifically, older age, longer duration of diabetes, higher BMI, smoking status, and poor glycemic control were all significantly associated with abnormal ABPI readings. The ABPI demonstrated good sensitivity (85%) and specificity (80%) for PAD detection, with an Area Under the Curve (AUC) of 0.83, indicating its reliability as a diagnostic tool in the diabetic population. Additionally, the study highlighted the compounded risk of PAD in diabetic patients with concurrent cardiovascular risk factors like hypertension and dyslipidemia. These findings reinforce the importance of regular ABPI screening in diabetic patients, particularly those with additional risk factors, to facilitate early detection and management of PAD.

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