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Prevalence and Determinants of Peripheral Arterial Disease in Patients with Systemic Hypertension Using the Ankle–Brachial Index: A Cross- Sectional Study

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Abstract

Background: Peripheral arterial disease (PAD) is a frequent yet underdiagnosed vascular complication of systemic hypertension, sharing common pathophysiological mechanisms related to endothelial dysfunction and arterial stiffness. Early identification of PAD in hypertensive patients is essential to prevent cardiovascular morbidity and mortality. The ankle–brachial index (ABI) provides a simple, non-invasive tool for detecting subclinical PAD. ***Objectives:*** The present study aimed to determine the prevalence of PAD among patients with systemic hypertension using ABI and to assess the influence of the duration of hypertension on ABI values. ***Methods:*** A hospital-based cross-sectional study was conducted among 164 hypertensive patients. Detailed clinical and hemodynamic assessments were performed, including blood pressure measurement and ABI determination using standard protocols. PAD was defined as ABI <0.9. Descriptive statistics were used to summarize data, and inferential analyses including chi-square tests and logistic regression were performed to identify independent predictors of PAD. ***Results:*** The mean age of the study participants was 51.21 ± 11.18 years, with a slight female predominance (52.44%). The mean duration of hypertension was 10.29 ± 5.72 years. The mean ABI was 0.94 ± 0.05, and 28.05% of patients had low ABI values consistent with PAD. PAD prevalence increased significantly with advancing age ($p < 0.001$) and longer duration of hypertension ($p = 0.033$). Patients with PAD had significantly higher systolic, diastolic, and pulse pressures ($p < 0.05$). Logistic regression analysis identified age ($p < 0.001$, OR = 1.10), duration of hypertension ($p < 0.001$, OR = 1.29), mean arterial pressure ($p < 0.001$, OR = 1.15), and Stage 2 hypertension ($p = 0.005$, OR = 1.99) as independent predictors of PAD. ***Conclusion:*** Peripheral arterial disease is highly prevalent among hypertensive individuals, particularly with advancing age, prolonged disease duration, and poorly controlled blood pressure. The ankle–brachial index serves as a valuable, non-invasive screening tool for early detection of subclinical PAD, enabling timely intervention and improved cardiovascular risk management in hypertensive patients.

Keywords: Peripheral arterial disease (PAD); Ankle–brachial index (ABI); Systemic hypertension; Duration of hypertension; Mean arterial pressure; Cardiovascular risk; Atherosclerosis; Blood pressure control

INTRODUCTION

Systemic arterial hypertension (HTN) is a major global public health challenge, recognized as one of the most prevalent chronic non-communicable diseases and a leading modifiable risk factor for cardiovascular morbidity and mortality. [1,2] The worldwide prevalence of HTN is high, with disproportionate rates in low- and middle-income countries, where it affects approximately 31.5% of adults compared to 28.5% in high-income countries, corresponding to 1.04 billion and 349 million people respectively. [3,4] In India, HTN

contributes significantly to the burden of Cardiovascular Disease (CVD) and is responsible for a substantial proportion of stroke and ischemic heart disease deaths.[5] The condition is not only highly prevalent among older adults but is also increasingly recognized in younger populations, reflecting lifestyle changes, urbanization, and associated metabolic risk factors.[6,7] The chronic elevation of blood pressure accelerates vascular aging and induces structural and functional changes in the arterial system, thereby increasing susceptibility to both macrovascular and microvascular complications.[8,9]

Peripheral Arterial Disease (PAD) is a common and serious macrovascular complication of HTN, representing a systemic manifestation of atherosclerosis characterized by narrowing or occlusion of arteries supplying the lower extremities.[10] Its pathogenesis is driven by endothelial dysfunction, lipid deposition, inflammatory activation, and arterial remodeling, processes that are exacerbated by the hemodynamic stress of uncontrolled HTN.[7] PAD often develops insidiously, with an initial asymptomatic phase that can progress to intermittent claudication, rest pain, ulceration, and even gangrene if untreated.[11] Importantly, PAD is not an isolated limb disease; it is strongly associated with generalized atherosclerosis, and its presence is a powerful predictor of future cardiovascular events such as myocardial infarction and stroke.[12] Hypertensive patients with PAD have been shown to have a significantly higher risk of Major Adverse Cardiovascular Events (MACE) compared to those without PAD, underscoring the need for early detection.[13]

The coexistence of HTN and PAD reflects the cumulative impact of vascular injury over time. Studies have demonstrated that longer duration of hypertension is associated with progressively lower Ankle-Brachial Index (ABI) values, suggesting a time-dependent deterioration of peripheral arterial health.[14,15] Even in the absence of overt symptoms, hypertensive individuals frequently harbor subclinical PAD, detectable only through targeted screening.[1] This asymptomatic stage is critical from a preventive standpoint because timely intervention—through aggressive risk factor control and lifestyle modification—can slow disease progression and reduce cardiovascular risk.[4]

The ankle-brachial index is an established, non-invasive diagnostic tool for PAD, calculated as the ratio of ankle to brachial systolic blood pressure.[16,17] It is recommended as the reference standard for PAD diagnosis in primary care settings due to its simplicity, reproducibility, and cost-effectiveness.[18] Clinically, an ABI value ≤ 0.9 is diagnostic for PAD, while values ≥ 1.40 suggest non-compressible arteries due to medial arterial calcification.[19,20] Both low and high ABI values have been independently associated with increased risk of cardiovascular morbidity and mortality, even in asymptomatic individuals.[10,21,22] Furthermore, ABI assessment is increasingly recognized as an important component in evaluating asymptomatic target organ damage in hypertensive patients, complementing other markers such as left ventricular hypertrophy and microalbuminuria.[23,24]

Despite its utility, ABI measurement remains underutilized in routine hypertension care, particularly in resource-limited settings, where PAD is often diagnosed only after the onset of severe symptoms.[25] Limitations such as reduced sensitivity in mild disease and falsely elevated readings in calcified vessels must be acknowledged; however, these can be mitigated by appropriate interpretation and, when indicated, complementary testing such as toe-brachial index.[26] In hypertensive populations, ABI measurement offers an opportunity not only for early PAD detection but also for improved cardiovascular risk stratification and preventive intervention.[27] In hypertension management, assessing asymptomatic organ damage includes evaluating ABI values.[28]Moreover, both low (≤ 0.9) and high (≥ 1.40) ABI values are linked with an increased risk of cardiovascular events.[29,30] The ABI of less <=0.9 is considered low ABI and indicates presence of peripheral arterial disease.[31] Even in asymptomatic patients of peripheral arterial disease there is increased risk for future cardiovascular events thus detecting early PAD by ABI has importance in their prevention.

Given the strong pathophysiological link between HTN and PAD, the high prevalence of asymptomatic disease, and the prognostic value of ABI, there is a compelling rationale for systematic PAD screening in hypertensive patients. The present study was conducted to determine the prevalence of PAD in individuals with systemic hypertension by measuring ABI and to assess the effect of hypertension duration on ABI values. Such data could inform clinical guidelines, enhance early detection strategies, and ultimately contribute to reducing cardiovascular morbidity and mortality in this high-risk group.

MATERIALS AND METHODS

Study Design and Setting

A cross-sectional observational study was conducted to determine the prevalence of peripheral arterial disease (PAD) among patients with systemic hypertension and to evaluate the association between the duration of hypertension and ankle–brachial index (ABI) values. The study was carried out in the Department of General Medicine at a School of medical sciences and research, Greater Noida in the year 2024-25.

Study Population

A total of 164 adult patients diagnosed with systemic hypertension were recruited consecutively from outpatient and inpatient services. Hypertension was defined according to the Joint National Committee (JNC 7) criteria. Patients with diabetes mellitus, chronic kidney disease, coronary artery disease, history of smoking, or other systemic illnesses known to affect peripheral circulation were excluded to minimize confounding.

Ethical Considerations

The study protocol was reviewed and approved by the Institutional Ethics Committee. Informed written consent was obtained from all participants prior to enrollment. Confidentiality of patient information was strictly maintained throughout the study.

Data Collection and Clinical Assessment

Detailed demographic data, medical history, and duration of hypertension were recorded for each participant using a structured proforma. Clinical parameters including systolic blood pressure (SBP), diastolic blood pressure (DBP), and pulse pressure (PP) were measured using a calibrated sphygmomanometer under standardized conditions. The mean arterial pressure (MAP) was calculated using the standard formula: MAP = DBP + 1/3(SBP - DBP)

Hypertension staging was classified as per JNC 7 guidelines into Stage 1 and Stage 2 categories.

Measurement of Ankle–Brachial Index

The ankle–brachial index (ABI) was determined for all patients using a handheld Doppler device with an 8 MHz probe. Systolic pressures were measured in both brachial arteries and in the dorsalis pedis and posterior tibial arteries of both lower limbs. The ABI was calculated separately for each leg using the following formula: ABI = Ankle Systolic Pressure/ Higher Brachial Systolic Pressure

The lower of the two limb values was used for final analysis. ABI values were interpreted as follows:

- Normal: 0.91–1.40
- Low: < 0.90 (indicative of PAD)
- High: >1.40 (suggestive of non-compressible arteries)

Statistical Analysis

All data were entered and analyzed using Statistical Package for the Social Sciences (SPSS) software version 26. Continuous variables were expressed as mean ± standard deviation (SD), while categorical variables were presented as frequencies and percentages. Associations between categorical variables were assessed using the Chi-square test, and differences in means were analyzed using the independent samples t-test. Logistic regression analysis was performed to identify independent predictors of PAD. A p-value less than 0.05 was considered statistically significant

RESULTS

The study included a total of 164 hypertensive patients with a mean age of approximately 51 years and a median age of 52 years. Most participants were in the 51–60-year age group, followed by those aged 41–50 years, indicating a predominance of middle-aged adults. The gender distribution was nearly equal, with a slight female predominance. The average duration of hypertension was around ten years, suggesting long-standing disease in most participants.

Mean systolic and diastolic blood pressures were 151.6 mmHg and 91.7 mmHg, respectively, with most patients classified under Stage 2 hypertension. The mean ankle–brachial index (ABI) was 0.94, and about one-fourth of participants had a low ABI (<0.9), consistent with the presence of peripheral arterial disease (PAD). The overall prevalence of PAD in the hypertensive population was 28.05%, emphasizing a significant burden of subclinical vascular disease among these patients. (Table 1)

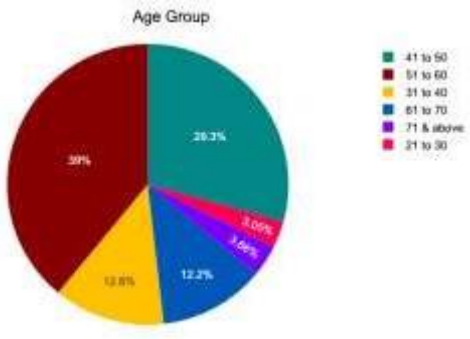

Figure 1: Age group distribution of the patients

Table 1: Baseline characteristics of the patients (n=164)

Parameter	Value
Age (years) - Mean ± SD	51.21 ± 11.18
Age Group (years)	
21–30	5 (3.05%)
31–40	21 (12.8%)
41–50	48 (29.27%)
51–60	64 (39.02%)
61–70	20 (12.2%)
≥71	6 (3.66%)
Sex	
Male	78 (47.56%)
Female	86 (52.44%)
Duration of Hypertension (years) - Mean ± SD	10.29 ± 5.72
Systolic BP (mmHg) - Mean ± SD	151.59 ± 8.14
Diastolic BP (mmHg) - Mean ± SD	91.67 ± 6.60
Pulse Pressure (mmHg) - Mean ± SD	59.91 ± 7.21
Mean Arterial Pressure (mmHg) - Mean ± SD	111.64 ± 6.29
Hypertension Stage 1	6 (3.66%)
Hypertension Stage 2	158 (96.34%)
Ankle–Brachial Index - Mean ± SD	0.94 ± 0.05
Normal ABI	118 (71.95%)
Low ABI	46 (28.05%)
PAD Present	46 (28.05%)

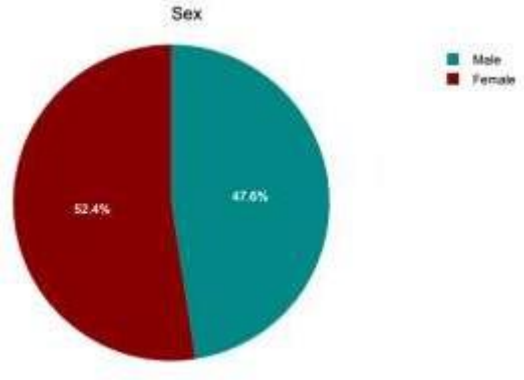

Figure 1: Gender distribution of the patients

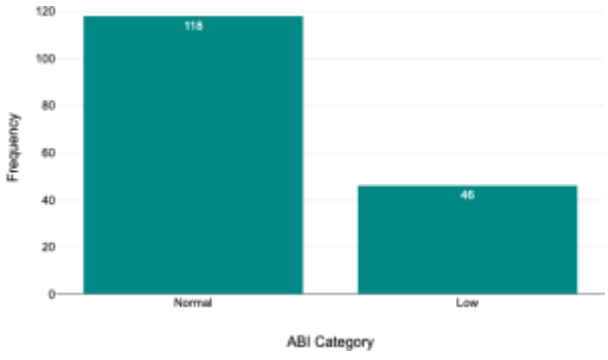

Figure 2: ABI Categorization of the patients

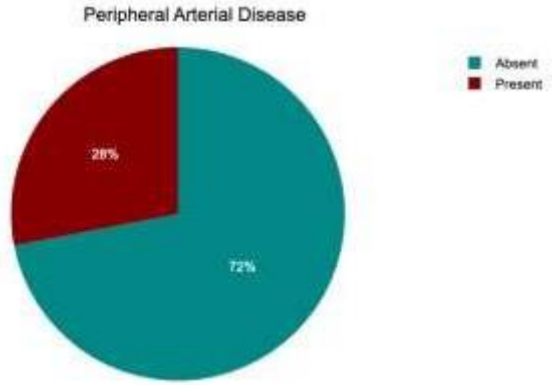

Figure 3: Prevalence of Peripheral Arterial Disease of the patients

Table 2 presents the distribution of peripheral arterial disease (PAD) across demographic and clinical parameters. A significant association was observed between PAD and age, with its prevalence increasing progressively in older age groups. Patients aged 51–60 years exhibited the highest proportion of PAD, followed by those aged 61–70 years, while no cases were found among individuals below 30 years ($p < 0.001$).

Gender distribution showed no statistically significant association with PAD ($p = 0.513$), with nearly similar proportions among males and females. Duration of hypertension demonstrated a clear relationship with PAD; those with the disease had a longer duration of hypertension compared to those without ($p = 0.033$).

Blood pressure parameters including systolic, diastolic, and pulse pressures were all significantly higher in the PAD group ($p < 0.05$), whereas mean arterial pressure did not differ significantly ($p = 0.217$). Finally, the severity of hypertension was significantly related to PAD, with Stage 2 hypertension showing a markedly higher prevalence of the disease ($p = 0.017$).

Overall, these findings indicate that advancing age, longer hypertension duration, elevated blood pressure, and higher hypertension stage are major contributors to the presence of PAD in hypertensive patients.

Table 2: Association of the presence of Peripheral Arterial Disease with the baseline variables

Parameter	PAD Absent (n, %)	PAD Present (n, %)	Mean Difference / p-value
Age			
21–30	5 (4.24%)	0 (0%)	**<0.001**
31–40	19 (16.1%)	2 (4.35%)	
41–50	41 (34.75%)	7 (15.22%)	
51–60	42 (35.59%)	22 (47.83%)	
61–70	11 (9.32%)	9 (19.57%)	
≥71	0 (0%)	6 (13.04%)	
Sex			
Male	58 (49.15%)	20 (43.48%)	0.513
Female	60 (50.85%)	26 (56.52%)	
Duration of Hypertension (years)	8.45 ± 4.59	16.91 ± 5.01	8.46 ± 0.42 / **0.033**
Systolic BP (mmHg)	149.17 ± 6.88	157.78 ± 7.91	8.61 ± 1.25 / **<0.001**
Diastolic BP (mmHg)	90.8 ± 6.17	93.91 ± 7.17	3.12 ± 1.12 / **0.006**
Pulse Pressure (mmHg)	58.37 ± 6.51	63.87 ± 7.5	5.5 ± 1.18 / **<0.001**
Mean Arterial Pressure (mmHg)	110.25 ± 5.63	115.2 ± 6.53	4.95 ± 1.02 / 0.217
Hypertension Stage 1	5 (4.24%)	1 (2.17%)	**0.017**
Hypertension Stage 2	113 (95.76%)	45 (97.83%)	

The consolidated logistic regression analysis identifies the independent predictors of peripheral arterial disease (PAD) among hypertensive patients. Age emerged as a significant predictor, indicating that the likelihood of developing PAD

increased with advancing age ($p < 0.001$, OR = 1.10, 95% CI: 1.06–1.15). Duration of hypertension also showed a strong association with PAD ($p < 0.001$, OR = 1.29, 95% CI: 1.18–1.42), suggesting that longer exposure to elevated blood pressure significantly elevates vascular risk.

Mean arterial pressure was another independent determinant ($p < 0.001$, OR = 1.15, 95% CI: 1.08–1.23), reinforcing the role of cumulative hemodynamic stress in the development of peripheral arterial disease. In contrast, sex was not a significant predictor of PAD (p = 0.514), indicating similar risk levels between males and females.

Among the hypertension stages, Stage 2 hypertension demonstrated a significant association with PAD ($p = 0.005$, OR = 1.99, 95% CI: 1.23–7.52), while Stage 1 did not show statistical significance. Collectively, these findings highlight that advancing age, prolonged hypertension duration, higher mean arterial pressure, and severe hypertension stage are independent contributors to PAD in hypertensive individuals.

Table 3: Multivariate analysis of the association of the presence of Peripheral Arterial Disease with the baseline variables

Independent Variable	Coefficient (B)	Std. Error	P value	Odds Ratio (OR)	95% Confidence Interval
Age	0.1	0.02	<0.001	1.1	1.06 – 1.15
Sex (Male)	-0.23	0.35	0.514	0.8	0.40 – 1.58
Sex (Female)	0.23	0.35	0.514	1.26	0.63 – 2.49
Duration of Hypertension (years)	0.26	0.05	<0.001	1.29	1.18 – 1.42
Mean Arterial Pressure (mmHg)	0.14	0.03	<0.001	1.15	1.08 – 1.23
Hypertension Stage 1	-0.69	1.11	0.535	0.5	0.06 – 4.42
Hypertension Stage 2	0.69	1.11	0.005	1.99	1.23 – 7.52

DISCUSSION

In the current study, the prevalence of PAD among hypertensive patients, as assessed through ABI, was approximately one-third of the study population. This finding underscores the considerable burden of subclinical atherosclerotic disease within hypertensive cohorts and reinforces the importance of incorporating PAD screening into routine hypertension care. The observation that a large proportion of hypertensive individuals exhibit impaired peripheral circulation highlights the silent nature of vascular disease and the need for early detection strategies within this high-risk group.

The prevalence observed in this study aligns closely with findings from earlier investigations. Tummala et al. (2018), in a cross-sectional study conducted among rural Indian populations, reported a similar prevalence of PAD, supporting the reliability of ABI as a diagnostic measure even in resource-limited or community-based settings. Their results, consistent with the present findings, emphasize that ABI serves as a valuable clinical and epidemiological tool for detecting PAD and guiding preventive cardiovascular care.[32] In contrast, Ushalakshmi and Avadhani (2019) reported a slightly lower PAD prevalence of 21% among hypertensive subjects. The difference may be attributed to variations in sample characteristics, as their study included a smaller cohort with a narrower age range and fewer long-term hypertensive cases.[1] Similarly, Yadav et al. (2022), who screened hypertensive patients with additional cardiovascular risk factors, documented a PAD prevalence of 26%, which again aligns closely with the findings of the present study. The consistency across these studies supports the notion that hypertension substantially increases the risk of developing PAD irrespective of geographical or demographic differences.[13]

Higher prevalence rates have been reported in studies focusing on newly diagnosed hypertensive patients. Hasan et al. (2024) found that 32.7% of newly diagnosed hypertensives exhibited low ABI values, while Pervez et al. (2024) reported a prevalence of 30.5%.[14,15] Both studies suggested that structural vascular changes begin early in the course of hypertension, and the relatively higher prevalence observed may reflect heightened endothelial vulnerability and unaddressed vascular stress in untreated individuals. Overall, the 28.05% PAD prevalence in the current study falls within the range reported by earlier research, reinforcing that hypertension remains a major determinant of peripheral arterial involvement. The relatively higher rate observed in this study may be attributed to the predominance of long-standing and Stage 2 hypertensive cases, which contribute cumulatively to vascular damage. These findings collectively highlight the need for routine PAD screening in hypertensive patients, particularly in populations with prolonged disease duration and poor blood pressure control.

In the present study, a clear and statistically significant relationship was demonstrated between advancing age and the prevalence of peripheral arterial disease (PAD). The proportion of patients affected by PAD increased steadily across higher age categories, underscoring the progressive nature of vascular degeneration with aging. Statistical analysis confirmed that this association was highly significant, while logistic regression further established age as an independent predictor of PAD. The analysis indicated that with each successive year of life, the probability of developing PAD rose substantially, reinforcing age as a major determinant of peripheral vascular compromise among hypertensive individuals. These findings highlight the cumulative impact of aging on arterial health and its pivotal role in the pathogenesis of atherosclerotic disease within this population.

The current results are consistent with the observations of Berkovitch et al. (2022), who reported that older age was significantly associated not only with a higher prevalence of PAD but also with poorer cardiovascular prognosis among patients presenting with acute coronary syndromes. Their study demonstrated that age-related endothelial dysfunction, arterial stiffness, and atheromatous plaque burden contribute to both limb ischemia and systemic vascular events. This aligns closely with the findings of the present study, which also supports the role of vascular aging as a key mechanism underlying PAD in hypertensive populations.[10] Similarly, Cicconi (2024), in a study evaluating the use of ABI for diagnosing asymptomatic lower extremity PAD, found that the disease was markedly more prevalent among elderly hospitalized patients. The increase in PAD prevalence with age was attributed to cumulative exposure to hemodynamic stress, oxidative injury, and progressive arterial calcification. The pattern observed in Cicconi's study parallels the present findings, emphasizing that the burden of PAD rises sharply in the sixth and seventh decades of life, the same age groups in which the current study noted the highest proportion of PAD-positive patients.[11]

In this study, no statistically significant association was observed between sex and the prevalence of peripheral arterial disease (PAD) ($p = 0.513$). Among the 164 hypertensive participants, PAD was present in 26 of 86 females (56.52%) and 20 of 78 males (43.48%), suggesting a slightly higher frequency among females, though the difference was not statistically meaningful. This finding indicates that, within the studied hypertensive population, both sexes were similarly susceptible to the development of PAD. Comparable observations have been made in several previous studies, though the literature presents mixed results regarding sex-related predisposition. Tummala et al. (2018), in a cross-sectional study conducted in a rural Indian population, reported a higher prevalence of PAD among females compared to males when screened using ABI.[32] The lack of a statistically significant association between sex and PAD in the current study is consistent with the growing understanding that the influence of sex on vascular disease is complex and multifactorial. Hormonal protection in premenopausal women, which diminishes after menopause, and differences in body fat distribution, endothelial function, and inflammatory response may contribute to varying susceptibility across age and sex groups. However, in populations where hypertension and metabolic risk factors are equally prevalent among both sexes, as in the present study, these physiological differences may not translate into statistically discernible variations in PAD prevalence.

In the current study, the duration of systemic hypertension demonstrated a clear and statistically significant association with the presence of peripheral arterial disease (PAD). Participants diagnosed with PAD had a notably longer history of hypertension compared to those without evidence of arterial disease, indicating that chronic exposure to elevated blood pressure plays a key role in the development of vascular dysfunction. Statistical analysis confirmed the significance of this relationship, while multivariate regression further identified the duration of hypertension as an independent determinant of PAD. The model revealed that each additional year of hypertension contributed to a progressive rise in PAD risk, highlighting the cumulative adverse effects of sustained hemodynamic stress on the peripheral vasculature. These findings reinforce the concept that long-standing hypertension accelerates arterial remodeling and atherosclerotic changes, thereby predisposing patients to peripheral vascular compromise. These findings are in agreement with those of Hasan et al. (2024), who evaluated newly diagnosed hypertensive patients and found a positive correlation between the duration of hypertension and PAD occurrence. Their study demonstrated that individuals with a longer known duration of hypertension had significantly lower ABI values and a higher prevalence of PAD. Hasan and colleagues emphasized that even within a relatively short period following the onset of hypertension, vascular endothelial dysfunction and arterial remodeling begin to manifest, underscoring the chronic cumulative effect of elevated blood pressure on peripheral arteries.[14] Similarly, Pervez et al. (2024) reported a progressive increase in PAD prevalence with the duration of hypertension. Their study found that patients with more than 10 years of hypertension had a significantly higher likelihood of having low ABI values compared to those with a shorter disease history.[15]

In the present study, a notable association was observed between various blood pressure parameters and the

occurrence of peripheral arterial disease (PAD). Individuals with PAD demonstrated consistently higher systolic, diastolic, and pulse pressure values compared to those without the condition, and these differences were found to be statistically significant. Although mean arterial pressure (MAP) did not exhibit a significant association with PAD in the initial univariate analysis, multivariate logistic regression revealed MAP as an independent predictor of disease occurrence. The analysis indicated that incremental increases in MAP were associated with a proportionate rise in PAD risk, underscoring the contribution of sustained hemodynamic load to peripheral vascular damage. These findings suggest that persistent elevations in both systolic and diastolic pressures adversely affect arterial compliance and endothelial function, thereby promoting structural alterations that culminate in peripheral arterial disease.

Comparable trends have been observed in earlier studies. Rubio-Guerra et al. (2018) investigated the relationship between blood pressure levels and ankle–brachial index (ABI) in prehypertensive and hypertensive individuals. They found that even prehypertensive subjects—those with mildly elevated blood pressure—had significantly lower ABI values compared to normotensive individuals, suggesting early subclinical arterial changes. Their findings imply that elevated blood pressure, even before it meets the diagnostic threshold for hypertension, contributes to vascular stiffness and reduced arterial compliance.[33] This observation resonates with the present study, where progressive increases in SBP, DBP, and PP were strongly associated with lower ABI values and higher PAD prevalence, underscoring the dose-dependent impact of blood pressure on arterial health.

Additionally, Zhou et al. (2025) described an L-shaped association between ABI and coronary heart disease (CHD) risk in hypertensive Chinese adults, particularly at higher blood pressure levels. Their results indicated that both very low and abnormally high ABI values were linked to increased cardiovascular risk, and that this relationship was strongly modulated by SBP and MAP. In their cohort, individuals with poorly controlled hypertension exhibited markedly lower ABI values, reflecting more advanced vascular disease.[12] This aligns with the present findings, where MAP, though not initially significant, emerged as a powerful independent predictor in multivariate analysis, reinforcing its role as an integrated measure of vascular stress and perfusion pressure.

In our study, the distribution of peripheral arterial disease (PAD) according to hypertension staging revealed a significantly higher prevalence of PAD among patients with Stage 2 hypertension. Among the 158 patients classified as Stage 2, 45 (97.83%) had PAD, while only 1 out of 6 (2.17%) patients with Stage 1 hypertension was found to have the disease. This difference was statistically significant ($p = 0.017$). Furthermore, logistic regression analysis identified Stage 2 hypertension as a significant independent predictor of PAD ($p = 0.005$), indicating that patients with more severe elevations in blood pressure are at considerably greater risk for developing peripheral arterial occlusive disease. These findings are in close agreement with the results of Ushalakshmi and Avadhani (2019), who examined the ankle–brachial index (ABI) in patients with systemic hypertension and reported a higher incidence of PAD among individuals with advanced stages of hypertension. Their study showed that as the severity of hypertension increased, ABI values progressively declined, signifying more extensive atherosclerotic involvement. The authors attributed this association to long-standing vascular stress, endothelial dysfunction, and arterial remodeling caused by persistently elevated systemic pressures.[1] Similarly, Pervez et al. (2024), in their study on newly diagnosed hypertensive patients, identified a significant relationship between hypertension severity and PAD prevalence. They observed that patients presenting with higher blood pressure readings at diagnosis were more likely to exhibit low ABI values, reflecting early but substantial vascular compromise. The authors highlighted that increased vascular wall tension and shear stress in severe hypertension accelerate the atherogenic process even before overt symptoms of PAD appear.[15] This supports the present study's findings, where a marked increase in PAD prevalence was noted with advancing hypertension stage, reinforcing the importance of early blood pressure control to prevent vascular complications.

In the present study, the mean ankle–brachial index (ABI) among hypertensive patients was 0.94 ± 0.05, with values ranging from 0.80 to 1.10. Based on the diagnostic threshold of ABI< 0.9 for peripheral arterial disease (PAD), 46 patients (28.05%) were found to have low ABI values, indicating reduced lower limb perfusion suggestive of arterial obstruction. This distribution aligns with established epidemiological data, which report a PAD prevalence of 20–30% among hypertensive cohorts when ABI is used as the primary diagnostic measure. Variability in reported prevalence across studies can often be attributed to differences in methodology and measurement techniques. Pereira Filho et al. (2022) highlighted that the method used to calculate ABI—particularly whether the higher or lower ankle systolic pressure is considered—can significantly influence the estimated prevalence of PAD. In their comparative analysis of different ABI calculation techniques, the prevalence of PAD ranged from 14% to 33%, depending on the formula applied. They emphasized the importance of methodological consistency to ensure diagnostic reliability and comparability across studies.[34] The present study utilized the higher ankle pressure for ABI computation,

a standard approach recommended for minimizing false positives due to isolated segmental disease. The mean ABI value of 0.94 obtained in this study therefore represents a robust estimate consistent with methodologically standardized findings.

Friberg et al. (2022) further expanded on the diagnostic value of ABI by demonstrating the advantages of combining it with the toe–brachial index (TBI), particularly in patients with non-compressible arteries or advanced vascular calcification. Their study showed that approximately 20% of individuals with normal ABI values were reclassified as having PAD when TBI was included, underscoring the limitations of ABI in patients with medial arterial calcification, such as those with long-standing hypertension or diabetes. Although TBI was not assessed in the present study, the authors' findings reinforce the interpretation that a subset of hypertensive patients may have underdiagnosed PAD due to arterial stiffness or calcified vessels that falsely elevate ABI readings.[26] This highlights the need for cautious interpretation of borderline ABI values and consideration of adjunctive diagnostic methods in future research.

A key methodological strength lies in the use of a standardized, validated, and reproducible ABI measurement protocol. The employment of uniform equipment and consistent procedural techniques minimized inter-observer variability and measurement error, ensuring precision and comparability of results. Moreover, the inclusion of multiple clinical and hemodynamic variables—such as age, gender, duration of hypertension, systolic and diastolic pressures, pulse pressure, mean arterial pressure, and hypertension staging—enabled a comprehensive evaluation of the multifactorial influences contributing to PAD. The subsequent application of multivariate logistic regression analysis enhanced the robustness of the findings by identifying independent predictors of PAD, thereby deepening understanding of the interplay between hypertension severity, duration, and vascular pathology.

Nevertheless, several limitations should be recognized when interpreting the results. The cross-sectional nature of the study restricts the ability to infer causality or establish temporal relationships between hypertension and the development of PAD. Although significant associations were identified, longitudinal follow-up would be necessary to determine how vascular changes evolve over time and how effective blood pressure control influences PAD progression. Additionally, the single-center design may limit the generalizability of the findings, as the sample may not fully represent the heterogeneity of broader populations with differing risk exposures, genetic profiles, or healthcare accessibility. A multicenter or community-based approach involving a larger and more diverse population would strengthen external validity and enhance representativeness.

CONCLUSION

The present study demonstrated that peripheral arterial disease (PAD) is a common comorbidity among patients with systemic hypertension, with an overall prevalence of 28.05% as determined by ankle–brachial index (ABI) measurement. The findings highlight that PAD is not confined to elderly or symptomatic individuals but is also prevalent among middle-aged hypertensive patients, underscoring the silent yet progressive nature of vascular disease in this group. The study established significant associations between PAD and several clinical parameters, including age, duration of hypertension, systolic and diastolic blood pressures, and hypertension severity. Logistic regression analysis further confirmed that advancing age, prolonged duration of hypertension, elevated mean arterial pressure, and Stage 2 hypertension were independent predictors of PAD. These observations indicate that chronic exposure to high blood pressure leads to cumulative arterial damage, endothelial dysfunction, and atherosclerotic progression, ultimately resulting in impaired peripheral circulation. The absence of a significant association with sex suggests that hypertension-related vascular injury affects both males and females similarly when other risk factors are comparable.

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