

Research Article

A STUDY TO EVALUATE PERIPHERAL VASCULAR DISEASE USING PULSE OXIMETER, ANKLE BRACHIAL PRESSURE INDEX AND HAND HELD VASCULAR COLOUR DOPPLER AS A SCREENING TEST IN SURGERY OUT PATIENT DEPARTMENT

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Abstract: Introduction: Peripheral Vascular Disease (PVD) is a manifestation of systemic atherosclerosis associated with global burden of around 230–240 million people worldwide. The prevalence has increased by over 70% since 1990, mainly due to population aging, diabetes, smoking, hypertension, and obesity. More than 70% of cases occur in low- and middle-income countries, including India. It is associated with a 2–6 times higher risk of cardiovascular death. Increased risk of myocardial infarction, stroke, and limb amputation. Significant disability, reduced quality of life, and healthcare costs, significant morbidity and cardiovascular complications. Early diagnosis is essential to prevent progression to critical limb ischemia and tissue loss. **Aim:** To evaluate the diagnostic utility of pulse oximetry and ABPI using hand held colour doppler compared with vascular colour Doppler ultrasonography in patients with suspected peripheral vascular disease. **Materials and Methods:** This prospective observational cross-sectional study was conducted in the Department of General Surgery, Gandhi Medical College and Associated Hamidia Hospital from May 2023 to October 2024. A total of 150 patients with symptoms suggestive of PVD were included. All patients underwent clinical examination, pulse oximetry, ABPI measurement using hand held colour doppler device, and vascular colour Doppler ultrasonography. Statistical analysis included sensitivity, specificity, chi-square test, and p-value assessment. **Results:** The majority of patients were above 60 years of age (48.7%), with a mean age of 57.95 ± 12.72 years. Diabetes mellitus was present in 48.7% and hyperlipidemia in 58.0% of patients. Smoking showed a highly significant association with PVD ($\chi^2 = 28.6$, $p < 0.001$). Pulse oximetry demonstrated lower toe oxygen saturation (85–97%) compared to finger saturation (93–99%), indicating impaired distal perfusion. The mean ABPI was 0.79 ± 0.26 , suggestive of mild peripheral arterial disease. Colour Doppler ultrasonography identified abnormal vascular findings in 69.3% of patients. ABPI showed 90% concordance with Doppler findings, demonstrating high diagnostic reliability. **Conclusion:** ABPI is a reliable, inexpensive, and effective screening tool for peripheral vascular disease, while pulse oximetry serves as a useful adjunctive bedside test. Combined use of these modalities may facilitate early diagnosis and timely referral, especially in resource-limited outpatient settings.

Keywords: Peripheral Vascular Disease, Ankle-Brachial Pressure Index, Pulse Oximetry, Colour Doppler Ultrasonography, Peripheral Arterial Disease, Screening Test.

INTRODUCTION

Peripheral arterial disease (PVD), a clinical manifestation of systemic atherosclerosis, is characterized by progressive stenosis or occlusion of the lower extremity arteries, resulting in impaired tissue perfusion and limb ischemia. Beyond its impact on limb function, PVD is an independent predictor of major adverse cardiovascular events, including myocardial infarction, stroke, and cardiovascular mortality. Recent estimates from the Global Burden of Disease Study indicate that more than 230 million people worldwide are affected by PVD, with the greatest increase occurring in

low- and middle-income countries owing to population ageing and the growing prevalence of diabetes mellitus, hypertension, dyslipidaemia, tobacco use, and obesity. Despite its substantial clinical and socioeconomic burden, PVD remains markedly underdiagnosed because a significant proportion of patients are asymptomatic or present with atypical symptoms.

Early diagnosis is essential to prevent disease progression and reduce cardiovascular and limb-related complications. Although vascular colour Doppler ultrasonography provides accurate anatomical and

haemodynamic assessment of peripheral arterial disease, its routine application as a screening modality is limited by cost, operator dependence, and availability in resource-constrained settings. Consequently, there is increasing interest in simple, inexpensive, and reliable bedside screening tools.

The ankle-brachial pressure index (ABPI) is the recommended first-line non-invasive test for PVD, with an ABPI <0.90 demonstrating high diagnostic accuracy for haemodynamically significant arterial disease. However, its diagnostic performance may be reduced in patients with medial arterial calcification, particularly those with diabetes mellitus and chronic kidney disease. Pulse oximetry, an inexpensive and widely available technique, has recently been investigated as an adjunctive screening tool based on its ability to detect reduced distal tissue oxygenation secondary to impaired arterial perfusion, although evidence regarding its diagnostic utility remains limited.

The present study aimed to compare the diagnostic performance of pulse oximetry and ABPI using vascular colour Doppler ultrasonography as the reference standard and to evaluate their association with established cardiovascular risk factors in patients with suspected peripheral arterial disease.

MATERIALS AND METHODS

Study Design

The present study was designed as a prospective observational cross-sectional study aimed at evaluating the diagnostic accuracy of pulse oximetry and ankle-brachial pressure index (ABPI) in comparison with vascular colour Doppler ultrasonography for the detection of peripheral vascular disease in patients attending the surgery outpatient department.

Study Setting

The study was conducted in the Department of General Surgery at Gandhi Medical College and Associated Hamidia Hospital Hospital, Bhopal, Madhya Pradesh. These tertiary care teaching hospitals cater to a large population of urban and rural patients and provide specialized surgical and vascular diagnostic services.

Study Duration

The study was carried out over a period of 18 months from May 2023 to October 2024. This duration allowed sufficient time for patient recruitment, clinical evaluation, investigations, data collection, and statistical analysis.

Study Population

The study population consisted of adult patients presenting to the surgery outpatient department with symptoms suggestive of peripheral vascular disease. Patients were enrolled consecutively after fulfilling

eligibility criteria and providing informed written consent.

Sample Size Calculation

The sample size was calculated using the standard formula for prevalence-based cross-sectional studies:

$$n = \frac{Z^2pq}{d^2}$$

Where:

- ($Z = 1.96$) at 95% confidence interval
- ($p = 3.79\%$) (prevalence of PVD in Indian population)
- ($q = 100 - p = 96.21\%$)
- ($d = 3\%$) allowable error

The calculated sample size was 156 patients. This sample size was considered adequate to evaluate sensitivity, specificity, and diagnostic accuracy of the screening tests.

Inclusion Criteria

Patients fulfilling all the following criteria were included in the study:

- Patients above 18 years of age of either gender.
- Patients willing to provide written informed consent.
- Patients presenting with symptoms suggestive of peripheral vascular disease such as intermittent claudication, rest pain, cold extremities, or non-healing ulcers.
- Patients able to comply with study procedures and investigations.
- Patients able to provide reliable medical and personal history.

Exclusion Criteria

The following patients were excluded from the study:

- Patients with collagen vascular diseases or arteritis.
- Patients with chronic venous insufficiency or lymphedema.
- Patients on oxygen supplementation or severe chronic obstructive pulmonary disease.
- Patients with acute limb ischemia requiring emergency intervention.
- Patients with previous vascular surgeries or angioplasty.
- Patients with severe cardiac failure or recent myocardial infarction.
- Patients with severe anemia (Hb <7 g/dL).
- Patients unwilling or unable to provide informed consent.

Ethical Considerations

Approval for the study was obtained from the Institutional Ethics Committee of Gandhi Medical College, Bhopal prior to commencement of research. All participants received detailed explanation regarding study objectives, procedures, risks, and benefits in English or Hindi. Written informed consent was obtained from each participant before enrollment. Confidentiality of patient data was strictly maintained throughout the

study. The study was conducted according to the ethical principles of the Declaration of Helsinki and ICMR ethical guidelines.

Patient Enrollment and Clinical Evaluation

All patients attending the surgery outpatient department were screened for eligibility. A detailed clinical history was obtained including age, gender, presenting complaints, duration of symptoms, smoking history, alcohol intake, diabetes mellitus, hypertension, dyslipidaemia, coronary artery disease, and family history of vascular disorders.

Comprehensive general and systemic examination was performed in all patients. Peripheral arterial examination included inspection for skin discoloration, ulceration, trophic changes, muscle wasting, and gangrene. Palpation of femoral, popliteal, posterior tibial, and dorsalis pedis pulses was carried out systematically and graded appropriately. Auscultation for femoral bruits was also performed.

Laboratory Investigations

The following investigations were performed in all enrolled patients:

- Complete blood count
- Random blood sugar
- Glycated hemoglobin (HbA1c)
- Lipid profile
- Urine albumin-creatinine ratio
- Serum creatinine

All investigations were conducted in the institutional central laboratory using standardized methods.

Pulse Oximetry Assessment

Pulse oximetry was performed using a standard handheld digital pulse oximeter. Patients were examined in a supine position after 10 minutes of rest. Oxygen saturation was measured sequentially from the index finger and great toe of both limbs.

Additional readings were obtained after elevating the lower limbs to approximately 30 degrees. A reduction of toe oxygen saturation by $\geq 2\%$ compared with finger saturation or a $\geq 2\%$ reduction during limb elevation was considered suggestive of peripheral vascular disease.

Ankle-Brachial Pressure Index Measurement

ABPI was measured using a sphygmomanometer and handheld vascular Doppler device with probe frequency ranging from 2–5 MHz. Systolic blood pressure was recorded in both brachial arteries, and the higher reading was used as reference pressure. Ankle systolic pressure was measured from dorsalis pedis and posterior tibial arteries in both lower limbs. ABPI was calculated using the formula:

$$ABPI = \frac{\text{Ankle Systolic Pressure}}{\text{Highest Brachial Systolic Pressure}}$$

An ABPI value less than 0.9 was considered diagnostic of peripheral vascular disease.

ABPI values were classified as:

- Normal: 1.0–1.4
- Borderline: 0.91–0.99
- Mild to moderate PAD: 0.41–0.90
- Severe PAD: < 0.40
- Non-compressible vessels: > 1.4



HAND HELD COLOUR DOPPLER DEVICE used and measurement of ABPI done in surgical opd

Vascular Colour Doppler Ultrasonography

Colour Doppler ultrasonography was used as the reference standard diagnostic modality. The examination was performed using a high-resolution ultrasound machine with linear array transducer frequency ranging from 7.5–12 MHz.

The arterial tree from common femoral artery to distal leg arteries was examined systematically. Bmode imaging assessed plaque morphology and vessel wall

changes, while colour Doppler and spectral Doppler evaluated blood flow characteristics.

Triphasic flow patterns were considered normal, whereas biphasic or monophasic waveforms indicated hemodynamically significant peripheral arterial disease. Presence, location, and severity of stenotic lesions were documented.

Data Collection and Management

Data from all patients were entered into a predesigned case record proforma. Each participant was assigned a unique identification number to maintain confidentiality. The collected data included demographic variables, clinical findings, laboratory parameters, pulse oximetry readings, ABPI values, and Doppler findings. The master chart was prepared using Microsoft Excel with appropriate data validation measures. Data backup and secure storage were maintained throughout the study period.

Statistical Analysis

Statistical analysis was performed using SPSS software version 25.0 and EPI Info 7.0. Continuous variables were expressed as mean \pm standard deviation, while categorical variables were expressed as frequencies and percentages.

Diagnostic performance of pulse oximetry and ABPI was evaluated by calculating:

- Sensitivity
- Specificity
- Positive Predictive Value (PPV)
- Negative Predictive Value (NPV)
- Overall diagnostic accuracy

Two-by-two contingency tables were used for analysis. Chi-square test and Fisher's exact test were applied for categorical variables. Student's t-test and paired t-test were used for comparison of continuous variables where appropriate. Correlation between variables was assessed using Pearson's correlation coefficient. A p-value less than 0.05 was considered statistically significant.

RESULTS

A total of 150 patients with clinically suspected peripheral vascular disease (PVD) attending the Surgery Outpatient Department were included in the present study. Detailed demographic evaluation, assessment of comorbid conditions, clinical examination findings, pulse oximetry measurements, anklebrachial pressure index (ABPI), and vascular colour Doppler ultrasonography findings were analyzed systematically. Statistical analysis was performed using descriptive and inferential methods to evaluate the diagnostic utility of pulse oximetry and ABPI in comparison with colour Doppler ultrasonography.

Demographic Characteristics

The age distribution of the study population revealed that peripheral vascular disease was predominantly observed among elderly individuals. Nearly half of the study participants (48.7%) belonged to the age group above 60 years, while 21.3% were between 41–50 years and 18.0% belonged to the 51–60 years age group. Only 12.0% of patients were aged between 31–40 years, and no patient was younger than 30 years. The mean age of participants was 57.95 ± 12.72 years, with ages ranging from 35 to 80 years. These findings indicate that increasing age is strongly associated with peripheral arterial disease and support the established concept that atherosclerotic vascular changes progress with advancing age.

Table 1: Demographic Characteristics of Study Participants

Parameter	Frequency (n)	Percentage (%)
Age >60 years	73	48.7
Age 41–50 years	32	21.3
Age 51–60 years	27	18.0
Age 31–40 years	18	12.0
Male	68	45.3
Female	82	54.7

The table showed slight female predominance, with females constituting 54.7% and males 45.3% of participants, indicating that peripheral vascular disease affects both genders significantly.

Diabetes mellitus was present in 48.7% of patients, and the mean HbA1c of $7.36 \pm 1.94\%$ suggested poor glycemic control among many participants. Hyperlipidemia was the most common risk factor, observed in 58.0% of cases, while 26.0% had a previous history of cerebrovascular accident, reflecting the systemic nature of atherosclerotic disease.

Smoking showed a strong association with peripheral vascular disease, with 64.0% of smokers affected compared to 18.9% of non-smokers. This association was statistically highly significant ($\chi^2 = 28.6$, $p < 0.001$).

Table 2: Association of Major Risk Factors with Peripheral Vascular Disease

Risk Factor	PVD Present n (%)	PVD Absent n (%)	p-value
Diabetes Mellitus	60 (80.0%)	15 (20.0%)	<0.05
Hyperlipidemia	87 (58.0%)	63 (42.0%)	<0.05

Smoking	32 (64.0%)	18 (36.0%)	<0.001
Risk Factor	PVD Present n (%)	PVD Absent n (%)	p-value
Previous CVA	39 (26.0%)	111 (74.0%)	<0.05

Diabetic patients showed higher proportions of moderate and severe peripheral arterial disease compared to non-diabetic patients, and the association was statistically significant ($p < 0.05$), indicating that diabetes increases both the risk and severity of PVD.

Clinical examination revealed significant arterial compromise in most patients. Absent pulses were the most common finding (24.7%), followed by weak pulses (21.3%) and gangrenous changes (18.0%), suggesting advanced ischemic disease in a considerable proportion of patients.

Pulse oximetry showed normal finger oxygen saturation (93–99%) but reduced toe saturation (85–97%), indicating impaired lower limb perfusion. Greater finger-to-toe saturation differences were observed in patients with abnormal colour Doppler findings, supporting the usefulness of pulse oximetry as a simple screening tool for peripheral vascular disease.

Table 3: Diagnostic Findings of Pulse Oximetry and ABPI

Diagnostic Parameter	Observation
Finger SpO ₂ Range	93–99%
Toe SpO ₂ Range	85–97%
Mean ABPI	0.79 ± 0.26
Minimum ABPI	0.30
Maximum ABPI	1.19
Mean Arterial Occlusion	45.77 ± 24.98%

The mean ABPI was 0.79 ± 0.26, indicating overall mild peripheral arterial disease, although values ranged from normal perfusion to severe ischemia. Lower ABPI values were associated with greater disease severity on colour Doppler examination, showing a strong correlation between ABPI and arterial compromise.

Colour Doppler ultrasonography revealed significant vascular pathology in 69.3% of patients, including 35.3% with abnormal flow patterns and 34.0% with critical ischemia. The mean arterial occlusion was 45.77 ± 24.98%, indicating variable disease severity among patients.

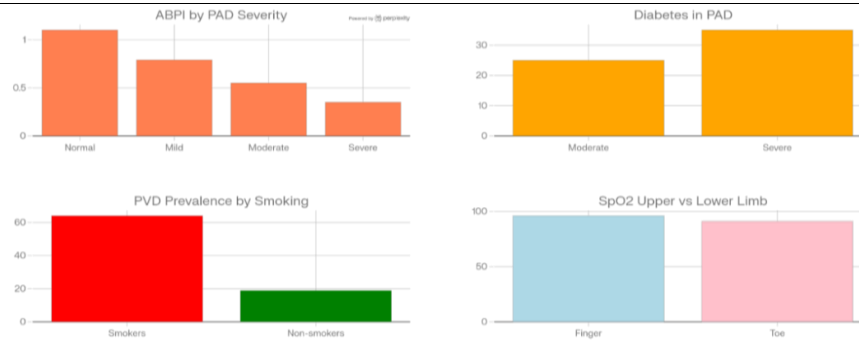
ABPI showed high agreement with colour Doppler findings, with 90% concordance between the two modalities. Discordant findings were seen in 10% of cases, mainly among diabetic and elderly patients with arterial calcification causing falsely elevated ABPI values.

Table 4: Comparison of ABPI with Colour Doppler Findings

ABPI Interpretation	Colour Doppler Normal	Colour Doppler Abnormal	Total
Normal ABPI	70	10	80
ABPI Interpretation	Colour Doppler Normal	Colour Doppler Abnormal	Total
Abnormal ABPI	5	65	70
Total	75	75	150

Sensitivity, specificity, and overall diagnostic accuracy calculations demonstrated that ABPI possessed superior diagnostic performance compared with pulse oximetry. Nevertheless, pulse oximetry proved to be a valuable adjunctive screening tool because of its simplicity, rapidity, and low cost.

The combined analysis of pulse oximetry, ABPI, and colour Doppler findings indicates that both noninvasive bedside tests are useful in the early screening of peripheral vascular disease. ABPI showed particularly strong diagnostic correlation with Doppler findings, while pulse oximetry provided additional supportive evidence regarding distal limb perfusion abnormalities.



DISCUSSION

Peripheral vascular disease (PVD) is an important manifestation of systemic atherosclerosis associated with significant morbidity and cardiovascular complications. Early detection is essential to prevent progression to critical limb ischemia and tissue loss. The present study evaluated the usefulness of pulse oximetry and ankle-brachial pressure index (ABPI) as screening tools compared with colour Doppler ultrasonography in suspected PVD patients.

The study population predominantly consisted of elderly individuals, with 48.7% of patients aged above 60 years and a mean age of 57.95 ± 12.72 years. These findings are consistent with studies by Criqui and Tao Kou et al.¹ and Fowkes et al.², who reported increasing prevalence of peripheral arterial disease with advancing age due to progressive atherosclerosis and vascular calcification.

A slight female predominance (54.7%) was observed in the present study. Although earlier studies showed male predominance, recent epidemiological evidence suggests increasing disease burden among females, especially in postmenopausal women with metabolic risk factors.³

Diabetes mellitus was present in 48.7% of participants and showed a significant association with moderate and severe disease ($p < 0.05$). The mean HbA1c of $7.36 \pm 1.94\%$ indicated suboptimal glycemic control. Similar observations were reported by Singh MV et al.⁴, who described accelerated atherosclerosis and endothelial dysfunction among diabetic patients leading to severe distal arterial disease.

Hyperlipidemia was the most common risk factor, present in 58.0% of patients. Dyslipidemia contributes to plaque formation and progressive arterial stenosis, increasing the risk of peripheral arterial disease and cardiovascular events.⁵

Smoking demonstrated a highly significant association with PVD ($\chi^2 = 28.6$, $p < 0.001$), with 64.0% of smokers affected compared to 18.9% of non-smokers. These findings correlate with studies by Behrooz L et al.⁶, who identified smoking as a major independent risk factor for peripheral arterial disease.

Clinical examination revealed absent or weak peripheral pulses in most patients, while gangrenous changes were present in 18.0%, suggesting advanced ischemic disease. Similar findings were reported by Norgren et al.⁷, emphasizing the importance of careful peripheral vascular examination in early diagnosis. Pulse oximetry demonstrated lower toe oxygen saturation compared to finger saturation, indicating impaired distal perfusion. Finger oxygen saturation ranged from 93–99%, whereas toe saturation ranged from 85–97%. Previous studies by Siao RM et al.⁸ also supported the utility of pulse oximetry as a simple adjunctive screening tool for lower limb ischemia.

The mean ABPI in the present study was 0.79 ± 0.26 , corresponding to mild peripheral arterial disease. ABPI showed 90% concordance with colour Doppler findings, demonstrating strong diagnostic reliability. Similar results were reported, ABPI to have high sensitivity and specificity for detecting peripheral arterial disease.⁹

Discordant or grey-zone cases were mainly observed among diabetic and elderly patients with arterial calcification causing falsely elevated ABPI values. Aboyan et al.¹⁰ emphasized cautious interpretation of ABPI in such patients because vessel incompressibility may mask significant stenosis.

Colour Doppler ultrasonography identified abnormal vascular findings in 69.3% of patients, including 34.0% with critical ischemia. Doppler imaging effectively assessed stenosis severity and blood flow abnormalities, supporting findings reported by Collins et al.¹¹ regarding its high diagnostic accuracy.

Overall, the present study demonstrates that ABPI is a reliable, inexpensive, and effective screening tool for peripheral vascular disease, while pulse oximetry serves as a useful supplementary bedside test. Combined use of these modalities may facilitate early diagnosis and timely referral, particularly in resource-limited outpatient settings.

CONCLUSION

PAD predominantly affects elderly individuals and is strongly associated with major cardiovascular risk factors such as diabetes mellitus, smoking, hyperlipidemia, and previous cerebrovascular disease. ABPI showed high diagnostic concordance with vascular colour Doppler ultrasonography and proved to be a reliable, inexpensive, and non-invasive screening modality for peripheral vascular disease in outpatient settings. Pulse oximetry also demonstrated clinical utility by identifying reduced distal perfusion through lower toe oxygen saturation values.

Although colour Doppler ultrasonography remains the definitive diagnostic modality, routine screening using ABPI and pulse oximetry may facilitate early identification of patients requiring further vascular evaluation and intervention. Early detection and management of modifiable risk factors can significantly reduce disease progression, critical limb ischemia, and associated cardiovascular morbidity.

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