

## Assessing the Diagnostic Role of Doppler Ultrasonography in Peripheral Vascular Disease

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### Abstract:

**Background:** Peripheral vascular disease (PVD) is a widespread circulatory condition in which there is a diminished circulation to the extremities, which is mainly as a result of atherosclerotic alterations. Timely diagnosis is needed to avoid complications like ischemia and amputation. Doppler ultrasonography has become a non-invasive and useful imaging modality to evaluate the vascularity.

**Aim:** To assess the accuracy of diagnostic and clinical utility of Doppler ultrasonography in the diagnosis of PVD.

**Methodology:** This was a retrospective observational study which was done on a Department of Radio-Diagnosis, ICARE Institute of Medical Sciences and Research & Dr. Bidhan Chandra Roy Hospital, Haldia, West Bengal, India in a period of one year. 180 patients suspected of having PVD and subjected to Doppler ultrasonography were used. Appropriate statistical analysis was used to analyze the demographic data, clinical risk factors and Doppler findings.

**Results:** Most of the patients were of age 50-69 years (45%), mostly men (60%). The most prevalent risk factors were diabetes mellitus (50%), hypertension (40%), and smoking (35%). Arterial stenosis was detected in 53.9% and total occlusion was detected in 26.1% by Doppler ultrasonography. The disease severity was strongly correlated with abnormal patterns in the waveforms (especially, biphasic and monophasic flows).

**Conclusion:** Doppler ultrasound is a useful, non-invasive diagnostic system of peripheral vascular disease. It gives very useful information about the structure of the vascularity and hemodynamics which helps to make an early diagnosis and proper treatment.

**Keywords:** Peripheral Vascular Disease, Doppler Ultrasonography, Arterial Stenosis, Vascular Imaging, Hemodynamics.

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### Introduction

PVD is a wide range of disorders in which blood vessels (those outside the heart and brain) are involved, the most common of which is the arterial system of the lower extremities. Atherosclerosis is a chronic inflammatory disease that involves the deposition of lipids, fibrous elements and inflammatory cells in the arterial wall that is the major pathological process of PVD [1]. With time, this causes a progressive constriction of the vessel lumen, loss of arterial elasticity and eventual blockage of the blood flow. The defective perfusion results in various clinical symptomatic effects such as intermittent claudication, rest pain, non-healing ulcers, and in severe cases, critical limb ischemia, that can require amputation of the limb in the event of delay [2]. The early detection and monitoring of the disease is especially important in clinical prac-

tice because of the chronic and progressive nature of the disease [3].

The prevalence of PVD in the world has been steadily increasing, much like the more general epidemiological changes linked with non-communicable diseases [4]. The rising life expectancy, urbanization, sedentary living, and change in nutrition have all led to an increased prevalence of diseases like diabetes mellitus, hypertension, dyslipidemia, and obesity, all known risk factors of PVD [5]. Moreover, tobacco consumption is an important problematic factor that can be changed to cause vascular damage, which leads to faster atherosclerotic processes and dysfunction of endothelium [6]. There is an unequal distribution of the disease among older populations but younger people

with multiple risk factors are increasingly being diagnosed. In addition to its physical effects, PVD has a serious functional and independence effects on patients and has a significant overall quality of life, which subjects it to a significant socioeconomic burden on healthcare systems all over the world [7].

Proper diagnosis of PVD is critical to manage the disease effectively, stratify risk, and prevent complications [8]. Conventional contrast angiography has been considered the gold standard in vascular imaging because it offers high spatial resolution and accurately represents the vascular anatomy [9]. Nonetheless, its invasive quality, related complications like contrast induced nephropathy and radiation exposure, and increased cost restrict its regular application, especially in resource capped environments. Consequently, increased focus has been on non-invasive diagnostic modalities that are capable of yielding reliable and reproducible results without exposing patients to unwarranted risks [10]. The ankle-brachial index measurement, computed tomography angiography and magnetic resonance angiography techniques have been used but they all have limitations in accessibility, cost, or contraindications [11].

Doppler ultrasonography has been developed as the foundation in the assessment of PVD among the non-invasive approaches because of its ubiquity, safety, and diagnostic capabilities [12]. This is a method that is a blend of the traditional ultrasonography and Doppler categories to evaluate the anatomy of blood vessels as well as the kinetics of the blood circulation. Doppler ultrasonography is capable of detecting hemodynamic alterations related to arterial constriction, occlusion or collateral circulation by measuring the velocity of flow and the patterns of waveforms [13]. Severity of vascular compromise: the categorization of waveforms such as triphasic, biphasic and monophasic gives useful information on the degree of vascular compromise. Moreover, it facilitates real-time evaluation, repeat evaluation, and applicability at the bedside, which is especially applicable in the outpatient and emergency care. Its affordability and lack of ionizing radiations also makes it more suitable to be used by a large number of clinics [14].

Against this background of benefits, this research aims to assess in detail the role of Doppler ultrasonography in the diagnosis of patients with suspected peripheral vascular disease. The study will examine how effective it is at identifying vascular anomalies, its association with clinical manifestations, and how useful it is as a first line diagnostic tool in clinical practice [15]. This study aims to add to the current literature and facilitate evidence-based clinical practice when dealing with PVD by systematically reviewing patient data and the Doppler results.

## Methodology

Before defining the particular methodological elements, it is necessary to stress that the current study was designed in such a way that the diagnostic value of Doppler ultrasonography in suspected patients with PVD is assessed by means of a systematic review of the pre-existing clinical and imaging data. The retrospective design of the study enabled the evaluation of real life clinical situations to be able to identify the trends in diagnosis, the association of risk factors, and imaging pattern without affecting the management of the patients. This strategy was also effective in ensuring effective use of the available hospital records and at the same time respecting ethical practices and confidentiality of data.

**Study Design:** This was a retrospective observational study that intended to examine the Doppler ultrasonography results of patients who are presenting with clinical suspicion of peripheral vascular disease. The study attempted to determine the correlation between clinical presentation and imaging outcomes by the review of the already recorded medical records. This design was especially appropriate to assess diagnostic performance because it meant it was possible to include a mixed group of patients over a specific time and thus increasing generalizability of the results. Also, the retrospective method reduced selection bias relating to prospective enrollment and made available a more comprehensive dataset that was representative of routine clinical practice.

**Study Area:** The study was carried out in the Department of Radiodiagnosis, ICARE Institute of Medical Sciences and Research and Dr. Bidhan Chandra Roy Hospital, Haldia, West Bengal, India

**Study Duration:** The research was conducted in a one year.

**Study Participants:** The population of the study included patients with a clinical suspicion of having PVD and who were referred to Doppler ultrasonography. The participants were selected according to the clearly-defined inclusion and exclusion criteria to guarantee the reliability and relevance of data.

### Inclusion Criteria:

- Patients who come with symptoms indicative of PVD e.g. limb pain claudication or non-healing ulcers.
- Patients who had Doppler ultrasonography of peripheral arteries.
- Those who are 18 years and over.
- Access to full clinical history, exams, and imaging reports.

**Exclusion Criteria:**

- Patients whose medical records are not complete or missing.
- Patients with a history of prior vascular surgical procedures, which might distort normal vascular anatomy and vascular flow patterns.
- Patients with known congenital vascular anomalies with potential to misinterpret Doppler data.

**Sample Size:** The study included 180 records of patients who fit the inclusion criteria. The sample size was found to be sufficient to provide meaningful statistical interpretation and to reflect different clinical presentations and severity of disease. The use of a fairly big sample strengthened the validity and dependability of the study results.

**Procedure:** The hospital medical records department was accessed and patient records were retrieved and reviewed in a systematic and organized way. It employed a standardized form of data collection to achieve some uniformity in data extraction. The demographic information (age, gender), presenting symptoms, related medical history, and comorbid conditions (diabetes mellitus, hypertension, and smoking status) were recorded.

The results of doppler ultrasonography were examined in detail to determine the status of the vessel. The analysis was aimed to determine vessel patency, presence and severity of arterial stenosis/occlusion, and atherosclerotic plaques or thrombotic lesions. Vital signs, such as the velocity and direction of blood flow, were attentively measured.

Special emphasis was made on the analysis of waveforms, which is crucial regarding the degree of vascular impairment. Patterns of flow were divided into:

- **Triphasic waveform**, a pointer of normal arterial flow with preserved elasticity.
- **Biphasic waveform**, implicating mild to mod-

erate arterial disease in partial loss of elasticity.

- **Monophasic waveform**, an indicator of serious arterial inadequacy of greatly diminished flow.

**Statistical Analysis:** The data collected were inputted and analyzed with Statistical Package of the Social Sciences (SPSS) version 27.0. The data were summarised using descriptive statistical techniques. The variables (age) were in the form of continuous variables (mean and standard deviation) and the categorical variables (gender, risk factors, and Doppler findings) were in the form of frequencies and percentages.

Inferential statistics was used to analyze the relationships between clinical variables and Doppler findings. To measure the relationships between categorical variables (e.g., risk factors and severity of vascular disease), the chi-square test was used. The p-value of below 0.05 was set as statistically significant and this implies that there is a significant relationship between the variables. The findings were clarified within the framework of clinical significance to make evidence-based conclusions.

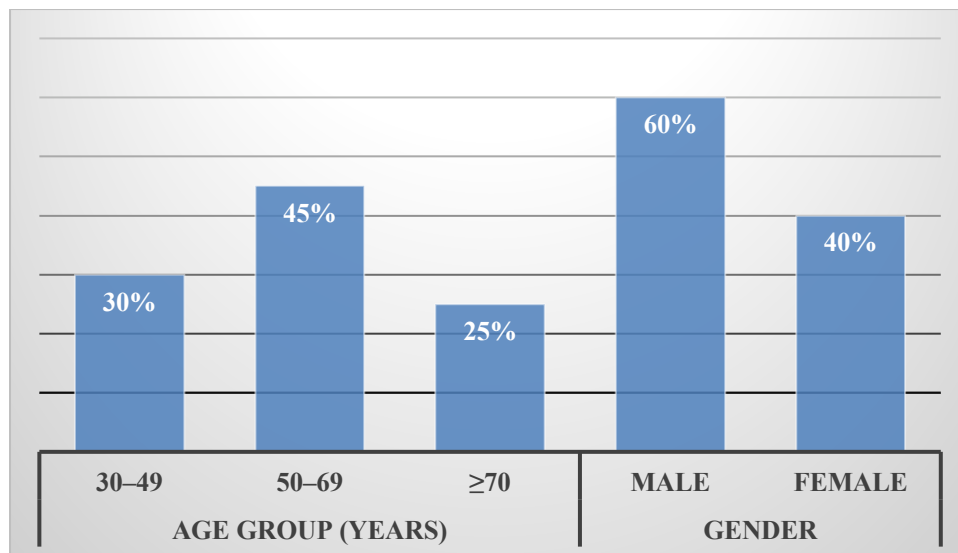
**Results**

The sample size used was 180 patients. In the analysis, demographic factors, risk factors involved, and Doppler ultrasonography were looked into to assess the prevalence and the extent of PVD in the study population.

The age brackets as indicated in Table 1 indicate that most patients were aged 50-69 years old (45%), 30-49 years old (30%), and 70 years and above (25%), which means that the prevalence is higher in older age. Also, the proportion of males (60%) was larger than that of females (40%); this is possibly explained by the fact that males are more exposed to risk factors associated with lifestyle; this ratio is also clearly presented in Figure 1 that gives a visual picture of the demographic situation.

**Table 1: Demographic Profile (n = 180)**

Parameter	Category	Frequency	Percentage
Age Group (years)	30-49	54	30%
	50-69	81	45%
	≥70	45	25%
Gender	Male	108	60%
	Female	72	40%

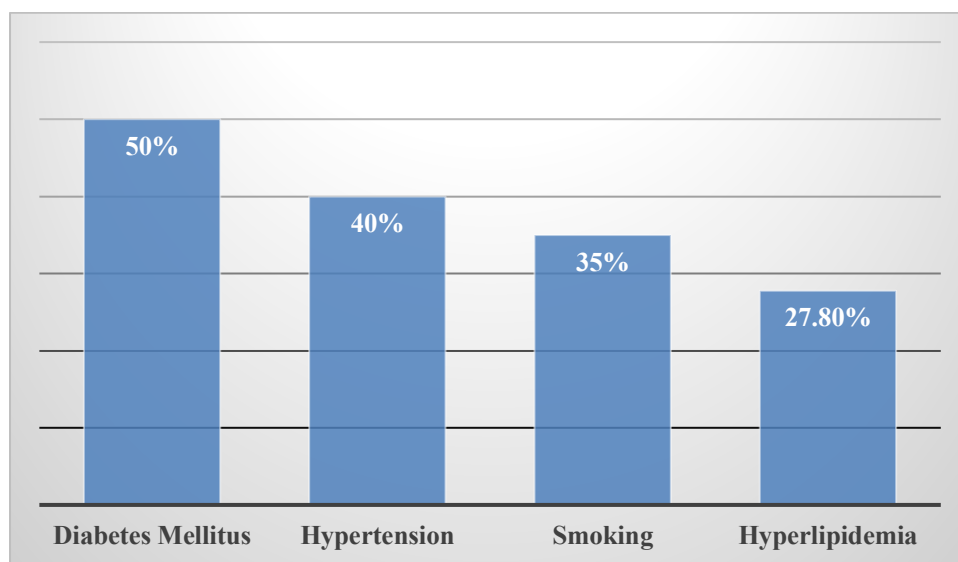


**Figure 1: Visual Representation of Demographic Profile (n = 180)**

Table 2 shows that diabetes mellitus (50%), hypertension (40%), smoking (35%), and hyperlipidemia (27.8%) were the highest risk factors. These results show the considerable importance of metabolic and behavioral risk factors in the development and pro-

gression of peripheral vascular disease; this trend is also illustrated in Figure 2 that graphically demonstrates the percentage of each risk factor in the cohort of the study.

Risk Factor	Frequency	Percentage
Diabetes Mellitus	90	50%
Hypertension	72	40%
Smoking	63	35%
Hyperlipidemia	50	27.8%

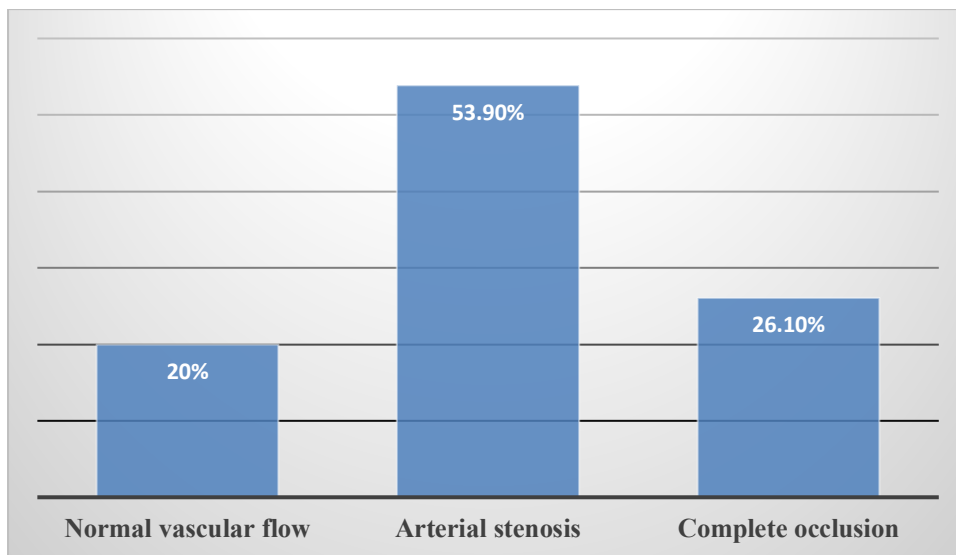


**Figure 2: Visual Representation of Distribution of Risk Factors (n = 180)**

Table 3 which summarizes the Doppler ultrasonography results shows that the most prevalent abnormality was arterial stenosis (53.9%), then complete occlusion (26.1%), and normal vascular flow was found in only 20% of the cases. This distribution indicates that a significant percentage of patients

had clinically significant vascular compromise that is measurable by Doppler imaging; this is further explained in Figure 3 that gives a visual comparison of the various Doppler results of the different patients in the study.

<b>Finding</b>	<b>Frequency</b>	<b>Percentage</b>
Normal vascular flow	36	20%
Arterial stenosis	97	53.9%
Complete occlusion	47	26.1%

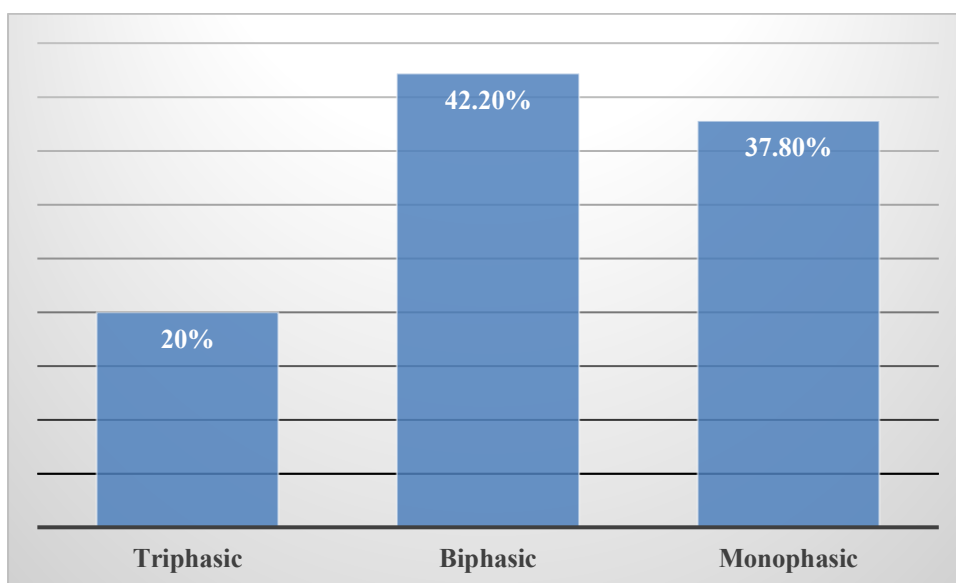


**Figure 3: Visual Representation of Doppler Ultrasonography Findings (n = 180)**

The analysis of waveforms presented in Table 4 shows that more common patterns were biphasic (42.2%) and monophasic (37.8%) than normal triphasic (20%). The excess of abnormal flow pattern denoting different levels of arterial inadequacy, the

monophasic waveforms depicting the higher levels of disease severity, are also presented in Figure 4 visualizing the distribution of flow patterns among the study population.

<b>Flow Pattern</b>	<b>Frequency</b>	<b>Percentage</b>
Triphasic	36	20%
Biphasic	76	42.2%
Monophasic	68	37.8%



**Figure 4: Visual Representation of Flow Pattern Analysis (n = 180)**

## Discussion

The current study indicates that Doppler ultrasonography has a high clinical value of measuring peripheral vascular disease. The sample size analysed was 180 with the largest percentage of 45% comprising of the 50-69 years age group, 30-49 years (30%) and 70 years or above (25%). This age distribution suggests that PVD becomes more common with age, which is probably caused by accumulating exposure to risk factors of atherosclerosis and progressive vascular degeneration over the lifespan (Rubenthaler et al., 2016) [16].

This study had a significant male bias as males represented 60% of cases as opposed to 40% of women. This difference can be explained by the fact that males are more exposed to the modifiable risk factors of smoking (35%) and work-related stress (Shirol et al., 2015) [17]. The same results have been obtained by R. W. Franz, who pointed out the impact of gender-specific risk factors on the progression of vascular diseases.

The risk factors analysis showed that the most common one was diabetes mellitus with 50% of the patients, hypertension with 40% of the patients, smoking with 35% of the patients and hyperlipidemia with 27.8% of the patients. These results highlight the close connection of metabolic and lifestyle-related diseases with PVD (Sumpio et al., 2013) [18]. Chronic hyperglycemia in diabetes causes endothelial dysfunction, oxidative stress and accelerated atherosclerosis, and hypertension causes the thickening of arterial walls and decreased vascular compliance, thus exacerbating the dynamics of blood flow.

According to the results of Doppler ultrasonography, the most frequent abnormality was arterial stenosis followed by complete occlusion at 53.9% and 26.1% respectively and normal vascular flow was found in only 20% of the patients. This distribution suggests that most of the patients were clinically significant with vascular compromise (Verim & Taşci, 2013) [19]. The capacity to measure the different levels of stenosis and occlusion gives the Doppler ultrasonography a chance to be a major diagnostic instrument in peripheral vascular disease.

More detailed examination of the waveform patterns revealed that biphasic flow was seen in 42.2% of the patients, monophasic flow in 37.8% and normal triphasic flow in only 20% of the cases. The abnormal waveforms prevalence is an expression of the different levels of abnormal arterial insufficiency with monophasic patterns presenting a more serious hemodynamic impairment (Yagis et al., 2010) [20]. These results are in line with the results of J. R. W. Brownrigg who emphasized the significance of waveform analysis in determining the se-

verity of disease and guiding clinical decisions.

Doppler ultrasonography has a number of benefits over invasive imaging modalities like angiography, such as being non-invasive, no ionizing radiation, cost-effective, and repeatable. These characteristics render it especially appropriate in the screening of individuals with high risks and in the development of an individual disease over time. All in all, the results of this study support the idea that Doppler ultrasonography is a valid and effective diagnostic tool that can give anatomical and functional information about vascular pathology, thus justifying their daily use in clinical practice.

## Conclusion

To sum up, this study has shown that Doppler ultrasonography is a very effective and dependable non-invasive mode of examination of peripheral vascular disease. The results show that the disease is prevalent within middle-aged and older adults with a significant male predisposition and is closely linked to the presence of significant risk factors that include diabetes mellitus, hypertension, smoking and hyperlipidemia. Doppler evaluation could detect different levels of vascular pathologies such as narrowing and total blockage of the arteries and typical alterations of the waveform pattern which indicate the extent of arterial insufficiency. These findings underscore the capability of Doppler ultrasonography to give detailed data on both vascular anatomy and hemodynamics. Due to the safety, low cost, and high availability, Doppler ultrasonography is a valuable first-line diagnostic method and is critical in the early diagnosis, clinical assessment, and treatment of peripheral vascular disease.

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