

Role of Doppler Ultrasound in Peripheral Vascular Disease: A Retrospective Study

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Received: 20-02-2023 / Revised: 18-03-2023 / Accepted: 26-05-2023

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Conflict of interest: Nil

Abstract:

Background: Peripheral Vascular Disease (PVD) refers to a widespread vascular ailment that affects the blood vessels of the extremities, which results in poor blood flow, pain, limb edema, ischemia, ulcers, and in extreme cases, amputation of limbs. Timely diagnosis is key to effective treatment, and one of the diagnostic techniques used in the evaluation of such abnormalities is Doppler ultrasonography.

Aim: To retrospectively assess the role of Doppler ultrasound in the diagnosis of peripheral vascular disease and also to study the demographic profile, clinical presentation, Doppler findings, vascular abnormalities, and treatment guidelines in peripheral vascular disease patients.

Methodology: The study is a retrospective and observational study carried out at the Department of Radiodiagnosis, Lord Buddha Koshi Medical College and Hospital, Saharsa, Bihar, India, for a year. A total of 180 patient charts of patients suspected clinically to have peripheral vascular diseases are studied. Information on demographics, clinical presentations, risk factors, doppler ultrasonographic findings, vascular diagnosis, and treatment recommendation is collected and analyzed by means of descriptive statistics, Chi-square test, independent Student's t-test, and logistic regression using SPSS version 27.0.

Results: Patients are mostly aged 51 to 60 years (27.8%) with men representing 61.1% of the patients. Diabetes mellitus (46.1%) and hypertension (42.8%) are the most prevalent risk factors associated. Patients present with intermittent claudication (37.8%) as the chief complaint. Arterial disease (58.9%) is more prevalent than venous disease (41.1%), and the most common type is atherosclerotic arterial stenosis (34.4%). The Doppler ultrasonography shows atherosclerotic plaque (58.3%), spectral waveform abnormalities (55.6%), and significant stenosis of arteries (48.9%). The most common form of treatment is conservative treatment (42.2%) and follow up Doppler studies (37.8%).

Conclusion: The Doppler ultrasound procedure is efficient, safe, and non-invasive imaging technique that can be used in peripheral vascular disease. The technique offers an accurate anatomical and physiological evaluation, helps in making the diagnosis early, assesses the extent of the disease, and helps in proper treatment planning. The regular application of the Doppler ultrasound enhances clinical decision-making in peripheral vascular disease.

Keywords: Peripheral vascular disease, Doppler ultrasonography, Color Doppler, Peripheral arterial disease, Venous disorders, Atherosclerotic stenosis, Deep vein thrombosis, Vascular imaging.

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Introduction

Peripheral vascular disease (PVD) refers to a range of conditions that affect the body's arteries and veins excluding the coronary and cerebrovascular systems, specifically the blood vessels supplying the upper and lower limbs [1]. It is a medical condition where there is reduced blood supply because of arterial narrowing, arterial blockage, aneurysms, venous blood clot, venous malfunction, and other vascular defects, leading to poor perfusion of the affected tissues. Peripheral vascular disease causes a lot of illnesses and is known to cause chronic pain,

limb swelling, non-healing wounds, limb ischemia, and even amputation, if severe enough [2]. The rise of many health conditions such as diabetes, high blood pressure, abnormal lipid levels, obesity, smoking, and physical inactivity has made peripheral vascular disease a major health concern.

Peripheral vascular disease can be generally subdivided into two categories: peripheral artery disease and peripheral venous disease [3]. The peripheral artery disease is usually the result of

developing atherosclerosis resulting in narrowing or blockage of arteries, while venous diseases include deep vein thrombosis, chronic venous insufficiency, superficial venous thrombosis, and varicose veins [4]. Patients exhibit such symptoms as intermittent claudication, limb pain, edema, discolored skin, coldness of limbs, non-healing ulcers, and even gangrene, depending on the degree of involvement of the vessels. Due to their similarity with symptoms of many other diseases, diagnostic imaging is crucial in diagnosing peripheral vascular disease [5].

Prevalence of peripheral vascular disease on a worldwide basis has seen considerable rise over the past few decades, especially in individuals older than 50 years as well as diabetics, hypertensive patients, renal impairment cases, hyperlipidemic and smokers [6]. In India, increasing cases of cardiovascular and metabolic diseases have resulted in higher prevalence of peripheral vascular disease, necessitating the use of reliable diagnostic methods [7].

Doppler ultrasound is now considered the method of choice in diagnosing peripheral vascular disease since it is noninvasive, involves no exposure to ionizing radiation, is available at almost all centers, is economical, and can provide dynamic imaging of vascular anatomy and hemodynamics [8]. It is capable of diagnosing arterial stenosis, occlusion, atherosclerotic plaque formation, aneurysm formation, venous thrombosis, venous reflux, formation of collaterals, and abnormal flow patterns due to its ability to combine grayscale imaging with color and spectral Doppler [9]. Furthermore, it gives information about hemodynamics by means of waveform analysis and flow velocity [10].

Modern developments in the field of Doppler ultrasound technique have increased its ability to diagnose accurately by means of improved color flow imaging, high frequency transducers, and more accurate spectral wave forms [11]. In addition to diagnostic purposes, Doppler ultrasound has many other applications like post-surgical observation, follow-up observation after vascular procedures, monitoring of chronic venous insufficiency, and evaluation of the results of treatment. Its ability to perform repeated examinations without radiation exposure makes it particularly suitable for long-term patient monitoring [12].

Although this modality is widely used in clinics, there have been few institutional studies investigating the spectrum of peripheral vascular disease and Doppler ultrasonographic findings in many countries [13]. These studies yield useful information about patterns, vascular problems, and treatment modalities in that particular population.

The current retrospective study was conducted to find out the importance of Doppler ultrasound in the

assessment of peripheral vascular disease amongst patients visiting the Department of Radiodiagnosis, Lord Buddha Koshi Medical College and Hospital, Saharsa, Bihar, India, for one year [14]. The objective of the study was to conduct an analysis of the demographic characteristics, clinical presentation, Doppler ultrasound findings, types of arterial and venous disorders, and management advice of patients suffering from peripheral vascular disease [15].

Methodology

Study Design: The current research is a retrospective observational study that is conducted to assess the significance of Doppler ultrasonography in the diagnosis and management of peripheral vascular disease. This study will involve the collection and analysis of clinical and Doppler ultrasonography data that have been documented prior to the conduct of the study in order to establish the demographic information, symptoms, vascular abnormalities, and extent of disease among the peripheral vascular disease patients. The use of the retrospective approach for this study has been chosen due to its ability to conduct an overview of patient's record during a specific time period.

Study Area: The research is being carried out in the Department of Radiodiagnosis of Lord Buddha Koshi Medical College and Hospital, Saharsa, Bihar, India for one year

Study Participants

Inclusion Criteria

- Patients older than 18 years of age, which are suspected of having peripheral vascular disease.
- Patients undergoing Color Doppler ultrasonography for assessment of any arterial or venous disorder of the upper or lower extremities.
- Patients suffering from complaints like intermittent claudication, limb pain, swelling, edema, ulcers that are not healing, cold extremities, varicose veins, discoloration of skin, or deep vein thrombosis.

Exclusion Criteria

- Patients less than 18 years of age.
- Patients with inadequate medical history or lacking Doppler ultrasonography findings.
- Patients who have suffered from vascular trauma necessitating urgent surgery before carrying out Doppler examination.

Sample Size: The total number of patients' records fulfilling the selection criteria is 180. The sample was chosen to guarantee that there is an adequate number of patients with different disorders of arteries and veins of the peripheral vascular system in order to assess adequately the role of Doppler

ultrasonography in diagnosis of peripheral vascular disease.

Procedure: Patient data are sourced from the Medical Records Department at the hospital and studied systematically. The information about demographic profile, clinical features, associated risk factors, Doppler ultrasonography results, and ultimate diagnosis of the vascular system disorders is documented using a proforma. The examination of arteries and veins is conducted using grayscale, color Doppler, power Doppler, and spectral Doppler methods. Artery and vein diseases are studied as to their patency, atheroma, lumen narrowing, occlusion, blood flow pattern, spectral waveforms, venous reflux, thrombus in lumen, collaterals, and degree of arterial stenosis. Arterial lesions are classified as mild (<50%), moderate (50–69%), severe ($\geq 70\%$), or occlusion based on criteria of Doppler velocity, whereas the venous disorders are classified as deep vein thrombosis, chronic venous insufficiency, superficial venous thrombosis, varicose veins, or venous normal flow.

Statistical Analysis: The collected data are analyzed using SPSS software version 27.0 (IBM, USA). The descriptive statistics are reported as mean $\pm$ SD for continuous data and as frequency (%) for categorical data. The associations among study variables are tested by using Chi-square test and independent Student's t-test; on the other hand, multivariate logistic regression is used to determine the predictors of severe peripheral vascular disease. $P < 0.05$ will be considered statistically significant.

Result

Table 1 displays the demographic profile of 180 participants of the study. The highest number of the study participants came from the 51–60 years group (50, 27.8%), followed by the 61–70 years (40, 22.2%) and the 41–50 years (38, 21.1%) groups. Males formed the highest percentage of the study participants (110, 61.1%), whereas females were the least percentage of the study participants (70, 38.9%). From the associated risk factors, the most prevalent one was diabetes mellitus (46.1%), followed

Table 1: Demographic Characteristics of Study Participants

Parameter	Category	Frequency (n)	Percentage (%)
Age (years)	18–30	14	7.8
	31–40	24	13.3
	41–50	38	21.1
	51–60	50	27.8
	61–70	40	22.2
	>70	14	7.8
Gender	Male	110	61.1
	Female	70	38.9
Associated Risk Factors	Diabetes mellitus	83	46.1
	Hypertension	77	42.8
	Smoking	65	36.1
	Dyslipidemia	58	32.2
	Coronary artery disease	29	16.1

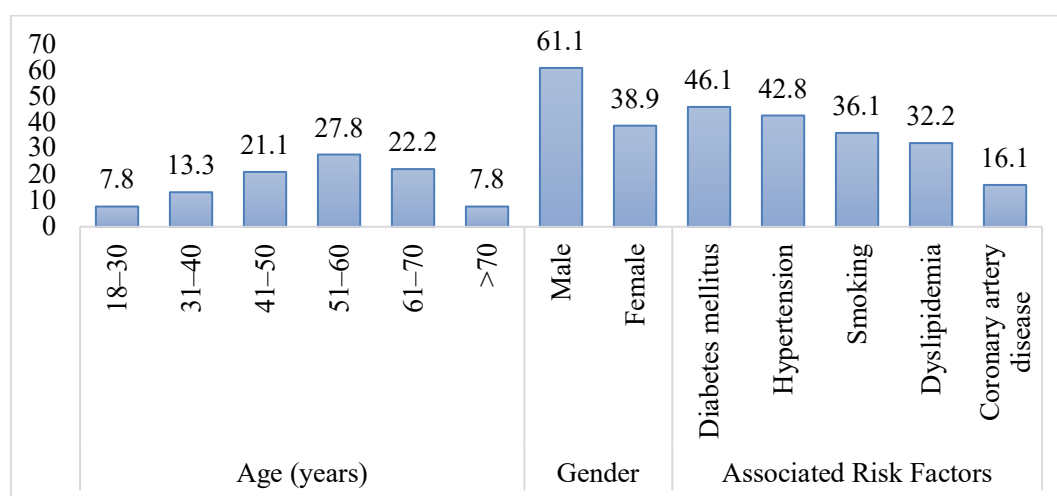


Figure 1: Visual Representation of Demographic Characteristics of Study Participants

As a result of these findings, it is evident that the condition known as peripheral vascular disease was most common among middle and old age people and especially among those between the ages 51 and 70 years and more frequently among males. High incidences of diabetes mellitus and hypertension make it evident about their crucial significance in the pathogenesis of peripheral vascular disease.

The presentation of peripheral vascular disease among the 180 patients is detailed in Table 2 below.

The most common mode of presentation was intermittent claudication (68; 37.8%), then pain (54; 30.0%) and swelling of limbs (48; 26.7%). Others were non healing ulcers (18.3%), pain at rest (16.7%), change of skin color (15.0%), varicose veins (13.3%), cold limbs (11.7%) and gangrene (6.7%). The average duration of presentation was 5.8.

Table 2: Clinical Presentation of Patients with Peripheral Vascular Disease

Clinical Presentation	Frequency (n)	Percentage (%)
Intermittent claudication	68	37.8
Limb pain	54	30.0
Limb swelling	48	26.7
Non-healing ulcer	33	18.3
Rest pain	30	16.7
Skin discoloration	27	15.0
Varicose veins	24	13.3
Cold extremity	21	11.7
Gangrene	12	6.7
Duration of symptoms (months)	Mean $\pm$ SD	5.8

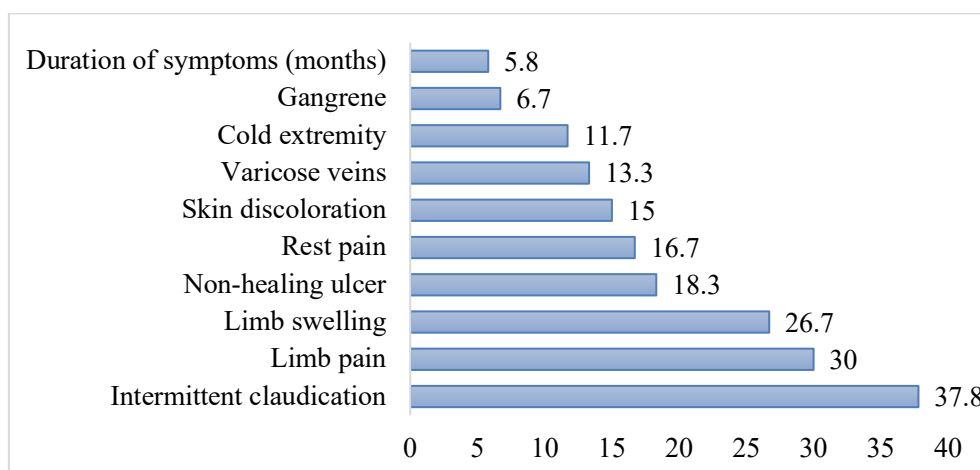


Figure 2: Visual Representation of Clinical Presentation of Patients with Peripheral Vascular Disease

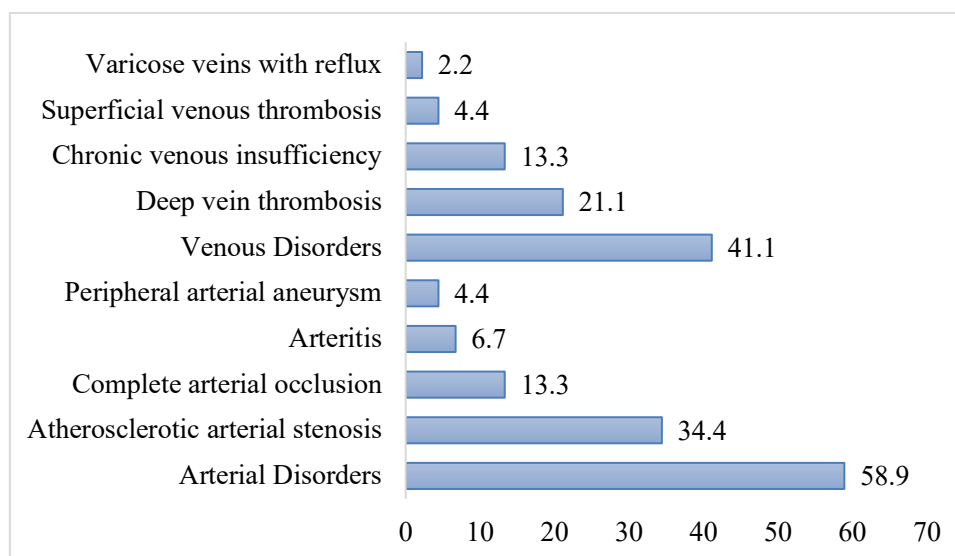
These results revealed that the most frequently occurring symptoms of peripheral vascular disease included intermittent claudication, pain, edema, and ulcers that failed to heal, implying serious involvement of the arteries and veins. The fact that some patients were experiencing rest pain, discolored skin, cold limbs, and gangrene points to the fact that there is advanced ischemia present. The average period during which the symptoms persisted before diagnosis reached 5.8 ± 2.6 months.

Table 3 describes the prevalence of peripheral vascular diseases discovered by Doppler

ultrasonography for the 180 subjects under study. Arterial disease (106; 58.9%) was prevalent compared to venous disease (74; 41.1%). For arterial disease, the leading diagnoses were atherosclerotic arterial stenosis (62; 34.4%), total occlusion of artery (13.3%), arteritis (6.7%), and peripheral aneurysm (4.4%). Chronic deep vein thrombosis was the most prevalent form of venous disease (21.1%), followed by chronic venous insufficiency (13.3%), superficial vein thrombosis (4.4%), and varicose veins with

Table 3: Distribution of Peripheral Vascular Diseases Detected by Doppler Ultrasonography

Diagnosis	Frequency (n)	Percentage (%)
Arterial Disorders	106	58.9
Atherosclerotic arterial stenosis	62	34.4
Complete arterial occlusion	24	13.3
Arteritis	12	6.7
Peripheral arterial aneurysm	8	4.4
Venous Disorders	74	41.1
Deep vein thrombosis	38	21.1
Chronic venous insufficiency	24	13.3
Superficial venous thrombosis	8	4.4
Varicose veins with reflux	4	2.2

**Figure 3: Visual Representation of Distribution of Peripheral Vascular Diseases Detected by Doppler Ultrasonography**

The data suggests that there were more arterial disorders compared to venous disorders, where the most prevalent vascular disease was found to be atherosclerotic arterial stenosis. Complete arterial occlusion is an indicator of advanced arterial disease, whereas deep vein thrombosis is the most prevalent form of venous disorder. This clearly demonstrates that the use of Doppler ultrasonography is quite efficient in the differentiation of arterial and venous diseases.

Table 4 indicates the key ultrasonographic Doppler observations of the 180 participants. The most

prevalent observations were those of atherosclerotic plaque formation (105, 58.3%), spectral wave abnormalities (100, 55.6%), and significant stenosis (88, 48.9%). Of the two types of waveform formations, monophasic waveforms were seen in 70 individuals (38.9%), and biphasic waveforms were seen in 42 individuals (23.3%). On the other hand, venous reflux and intraluminal thrombus were among the prominent venous findings (22.2% and 21.1%, respectively), and complete vascular occlusion

Table 4: Doppler Ultrasonographic Findings

Doppler Finding	Frequency (n)	Percentage (%)
Atherosclerotic plaque	105	58.3
Spectral waveform abnormality	100	55.6
Significant arterial stenosis	88	48.9
Complete vascular occlusion	24	13.3
Venous reflux	40	22.2
Intraluminal thrombus	38	21.1
Monophasic waveform	70	38.9
Biphasic waveform	42	23.3
Collateral circulation	22	12.2

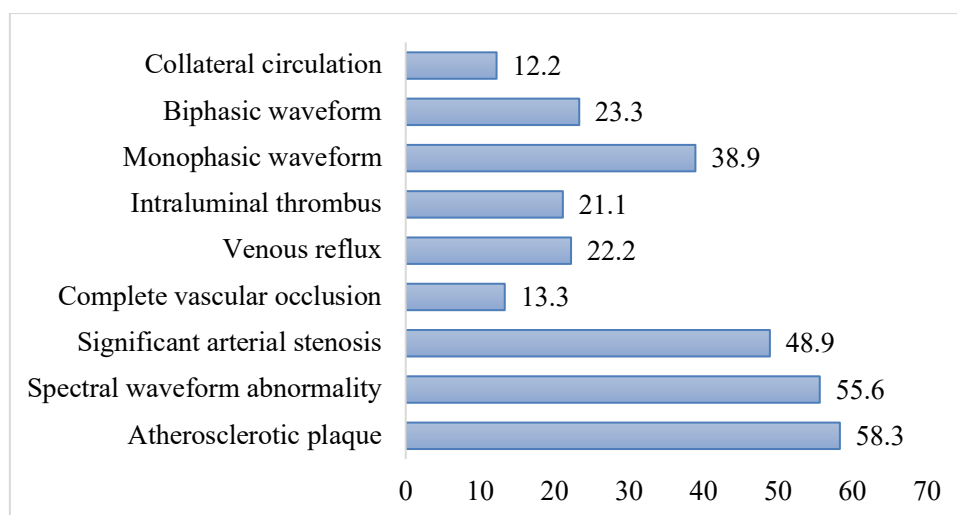


Figure 4: Visual Representation of Doppler Ultrasonographic Findings

These results clearly demonstrate that atherosclerotic plaque, spectral waveform abnormality, and stenosis of the arteries are the most common Doppler ultrasonographic abnormalities, owing to the significant prevalence of chronic arterial diseases in this group of patients. It is also evident from the presence of monophasic waveforms, venous reflux, intraluminal thrombosis, and complete occlusion of the vessels that Doppler ultrasonography not only detects both arterial and venous abnormalities but also helps to measure their severity.

Table 5 presents the management recommendations based on Doppler ultrasonography findings among the 180 patients. Medical management was the most common treatment (76, 42.2%), followed by follow-up Doppler evaluation (68, 37.8%). Vascular surgical consultation (40, 22.2%), anticoagulation therapy (38, 21.1%), endovascular intervention (34, 18.9%), and compression therapy (24, 13.3%) were recommended according to the severity and type of vascular disease, highlighting the important role of Doppler ultrasonography in guiding appropriate patient management.

Table 5: Management Recommendations Based on Doppler Ultrasonography Findings

Management	Frequency (n)	Percentage (%)
Medical management	76	42.2
Follow-up Doppler evaluation	68	37.8
Vascular surgical consultation	40	22.2
Anticoagulation therapy	38	21.1
Endovascular intervention	34	18.9
Compression therapy	24	13.3

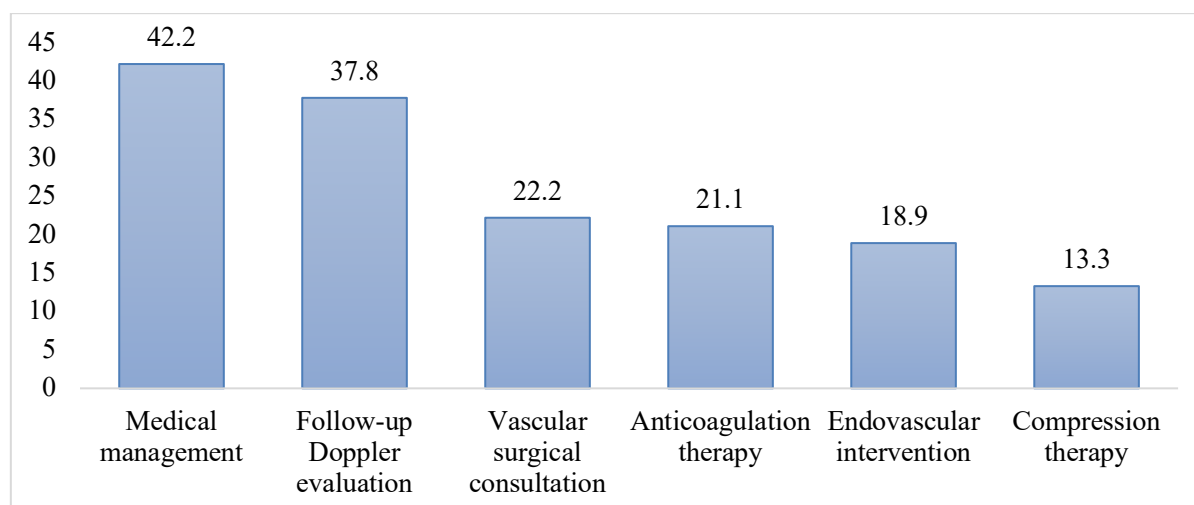


Figure 5: Visual Representation of Management Recommendations Based on Doppler Ultrasonography Findings

These results have shown that a majority of the patients have been managed using conservative treatment methods; however, Doppler ultrasound was very useful in evaluating the progress of the disease and its treatment. Those patients who had advanced arterial disease were referred to the vascular surgeons for further surgical treatment, but the patients with deep vein thrombosis and chronic venous insufficiency were put under anticoagulation and compression therapy, respectively. Therefore, the results have revealed that Doppler ultrasound is a very essential diagnostic tool.

Discussion

This particular retrospective study assessed the importance of Doppler ultrasonography for diagnosing and evaluating the condition of peripheral vascular disease in 180 patients (Shivu, 2018) [16]. It was found that the disease primarily occurred in middle-aged and older patients, especially men, suffering from diabetes mellitus, hypertension, and smoking, which were found to be the major associated risk factors (Chen et al., 2019) [17].

Intermittent claudication was the most frequent presenting complaint, followed by pain in the limbs, swelling of the limbs, and non-healing ulcers. The use of Doppler ultrasonography showed that arterial disease was more common than venous disease, where the former had atherosclerotic stenosis as the most frequent type, while the latter had deep vein thrombosis as the most frequent disease (Mao et al., 2018) [18]. The presence of a large number of atherosclerotic plaques, spectral wave form alterations, and arterial stenosis was used to demonstrate the usefulness of Doppler ultrasonography.

In addition to this, the importance of Doppler ultrasound in managing patients was found out from this study (Fang et al., 2018) [19]. Most of the patients were managed through conservative medical treatment followed by Doppler examination while some patients who had advanced disease needed surgical consultation and intervention. As a result, it was concluded that Doppler ultrasound is a valuable, non-invasive, and cost-effective technique for diagnosing, assessing, and treating peripheral vascular disease (Pedicelli et al., 2019) [20].

Conclusion

The current retrospective study revealed that Doppler ultrasonography is an efficient, safe, and non-invasive imaging method for peripheral vascular disease assessment. It was shown that peripheral vascular disease was mainly associated with middle-aged and elderly men. Moreover, diabetic mellitus, hypertension, and smoking were found to be the most prevalent risk factors among those studied. Intermittent claudication was the most

frequent clinical manifestation. Arterial pathology was diagnosed more often than venous disease. It was arterial pathology, including atherosclerotic arterial stenosis, that prevailed in this category. Doppler ultrasonography detected a variety of vascular diseases, including atherosclerotic plaque, arterial stenosis, vascular occlusion, venous reflux, and intraluminal thrombus, thus making a proper diagnosis, assessment of the condition severity, and adequate planning of its treatment possible. Patients were usually managed conservatively. In more severe cases, it became necessary to consult a surgeon or conduct endovascular procedures. Overall, the results of the present study emphasize the importance of Doppler ultrasonography as the first line diagnostic procedure in peripheral vascular disease evaluation and treatment.

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