Original Article

Color Doppler-based Evaluation of Lower Limb Arteries for Suspected Peripheral Arterial Disease in Patients of Diabetes Mellitus

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Abstract

Aims and Objectives: This study aims to study the patterns of vascular affection using Doppler sonography with spectral analysis and ankle brachial index in patients of diabetes mellitus as well as to detect site, severity of vessel narrowing, in those with peripheral arterial disease and assess the functional status of limb in diabetics who are at a risk of peripheral arterial disease. This study emphasizes the role of arterial Doppler in identifying the functional compromise in the diabetic patients, who are at risk of developing PAD and the prime role of the modality in preventing the long-term complications of PAD patients, who end-up having limb amputation surgeries, due to limb ischemia.

Materials and Methods: The study was carried out in the Department of Radiodiagnosis and Imaging, Government Medical College and New Civil Hospital, Surat, over a duration of 12 months on a total of 50 cases. The equipment used was Philips Affiniti 50 USG and Doppler machine by a linear 3–12 MHz L12-5 probe and a curvilinear 3–5 MHz C9-4V probe.

Results: In our study, we found that ulceration, burning sensation, intermittent claudication, and numbness were found to be among the most common clinical features in patients with PAD. The elderly age group (age group 41–50 and 50–60), males with hyperlipidemia, hypertension, and smoking are at increased risk. The infrapopliteal vessels were found to be most adversely affected, showing spectral broadening and speckled waveform pattern. Involvement of femoropopliteal segment was mainly in the form of atheromatous plaque and raised intimomedial thickness, whereas the involvement of anterior and posterior tibial arteries was in the form of mural calcification type of plaque formation. Most of the atheromatous plaques found were echogenic.

Key words: Peripheral arterial disease, Plaque, Stenosis

INTRODUCTION

The term "peripheral arterial disease" broadly encompasses the vascular diseases caused primarily by atherosclerosis and thromboembolic pathophysiological processes that alter the normal structure and function of the aorta, its visceral arterial branches, and the arteries of the lower extremity.[1] By early detection of the vascular changes in the hemodynamic parameters, end-stage complications related to peripheral arterial disease can be prevented and its morbidity reduced, thereby preventing functional compromise of the limb. Therefore, this study emphasizes on the early detection of these changes by means of arterial Doppler study and relevance of Doppler parameters in evaluating limb ischemia and claudication.

Risk Factors[2-4]
Modifiable
- Dyslipoproteinemia (unhealthy patterns of serum proteins carrying fats and cholesterol):+
- High serum concentration of low-density lipoprotein (LDL) and/or very low-density lipoprotein particles, that is, "lipoprotein subclass analysis"
- Low serum concentration of functioning high-density lipoprotein (HDL)
- An LDL:HDL ratio greater than 3:1

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- Tobacco smoking
- Having hypertension
- Elevated serum C-reactive protein concentrations.

Non-modifiable
- Advanced age
- Male sex
- Having close relatives who have had some complication of atherosclerosis.

Clinical Presentation[5,6]
- The most common symptom is muscle pain in the lower limbs on exercise (intermittent claudication)
- Ischemic rest pain
- Sores, wounds, or ulcers.

MATERIALS AND METHODS

The study was carried out after the approval of the Institutional Review Board, in the Department of Radiodiagnosis and Imaging, Government Medical College and New Civil Hospital, Surat, over a duration of 12 months. The equipment used was Philips Affiniti 50 USG and Doppler machine by a linear 3–12 MHz L12-5 probe and a curvilinear 3–5 MHz C9-4V probe.

Number of Patients
50.

Inclusion Criteria
Patients with diabetes mellitus referred from medicine OPD or surgery OPD for lower limb arterial Doppler with suspected peripheral arterial disease (any of the following symptoms/signs: Tingling/numbness, cold leg/feet, and abnormal lower extremity pulse examination).

Exclusion Criteria
Patients <18 years and >70 years of age; patients with lower limb swellings due to surgical causes (e.g., filariasis) or with leg ulcers which would impair Doppler quality; and patients with H/O trauma were excluded from the study.

Observations
A total of 50 patients were taken for the study.

From Table 1, ulceration, burning sensation, intermittent claudication, and numbness were found to be among the most common clinical features in patients with PAD, whereas rest pain and gangrene with burning sensation were found to be the least common.

Among the 50 patients studied, most of them were above 40 years of age (90%) as shown in the Table 2.

In the study, majority of the patients were male, comprising about 76% as shown in the Table 3.

From Table 4, it can be inferred that infrapopliteal vessels are more adversely affected than the proximal vessels as indicated by spectral broadening and speckled waveform patterns.

From the above-mentioned Table 4 and Graph 1, it can be inferred that SFA is most commonly involved by atheromatous plaque lesions. Example of SFA involvement is shown in Figure 1.

Table 5 shows, among the patients with atheromatous plaques, 41.3% were moderately echogenic, 37.9% were severely echogenic, and 20.6% showed low echogenicity.

From the above-mentioned graph and Table 6, it can be inferred that majority of the patients (70%) had a normal ankle brachial index (ABI) (>0.9) while only 3% of the cases had severely reduced ABI values (<0.7). About 20% of patients had ABI in the range of 0.8–0.89.

In the study, hemodynamically significant stenosis, that is, >50% stenosis is mostly found in femoropopliteal

Table 1: Signs and symptoms distribution of cases

Sign/Symptom	No. of cases
Ulcer	28
Gangrene	17
Intermittent claudication	20
Rest pain	5
Numbness	20
Burning sensation	32
Gangrene and numbness	10
Gangrene and burning	3

Table 2: Age-wise distribution of patients

Age (years)	Male	Female	No. of patients	Percentage
18–30	1	2	3	6
31–40	2	0	2	4
41–50	9	6	14	30
51–60	17	3	20	40
61–70	8	2	10	20
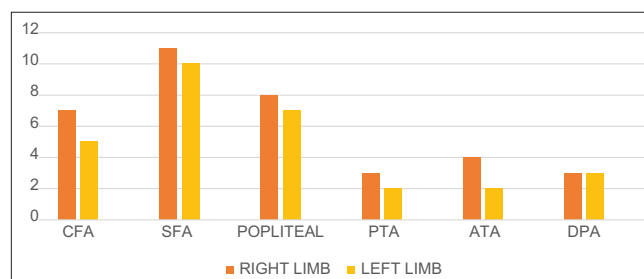
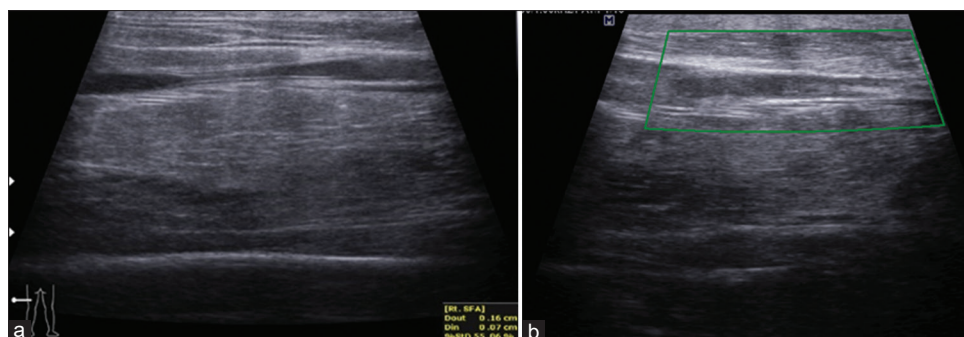**Graph 1: Atheromatous plaque distribution of cases**

Figure 1: (a and b) The two images show atheromatous plaque in SFA causing nearly 55% luminal occlusion with no color filling seen on color Doppler interrogation. Findings likely represent chronic thrombosis of SFA.

Table 3: Sex distribution of cases

Sex	No. of patients	Percentage
Male	38	76
Female	12	24
Total	50	100

Table 4: Waveform pattern analysis distribution of cases

Vessel	Good	Spectral broadening	Speckled	Nil
CFA	94	-	6	-
SFA	87	6	7	-
PA	84	8	8	-
ATA	59	19	20	2
PTA	56	14	26	4
DPA	59	19	19	3

Table 5: Plaque characterization

Plaque characteristic	No. of patients (*n*=29)	Percentage
Low echogenicity	6	20.6
Moderate echogenicity	12	41.3
Severe echogenicity	11	37.9

Table 6: Ankle brachial index distribution

Ankle brachial index values	Frequency	Percentage
>0.9	35	70
0.8–0.89	10	20
0.7–0.79	3	7
0.6–0.69	1	3

Table 7: Vessel distribution based on site of significant stenosis

Significant stenosis >50% artery	No. of patients (n = 35)	Percentage
CFA	9	17.1
SFA	26	57.1
Popliteal A	12	28.5
PTA	5	11.4
ATA	5	11.4
DPA	6	14.2

Table 8: Case distribution based on flow patterns

Vessel involved	Triphasic	Biphasic	Monophasic	Nil
CFA	43	6	0	1
SFA	26	16	6	2
PA	15	18	13	4
ATA	7	10	28	5
PTA	2	16	28	4
DP	0	7	35	8

segments followed by dorsalis pedis artery as shown in Table 7.

It can be inferred that intimomedial thickening and atheromatous plaque type of involvement are predominantly seen in the superficial femoral arteries and popliteal arteries, whereas anterior and posterior tibials show mural calcification type of plaque involvement. Hemodynamic patterns of the stenosis are shown in Figures 2 and 3.

From the above-mentioned Table 8, it can be inferred that dorsalis pedis followed by posterior tibialis artery was found to show maximum affection and showed significant hemodynamic changes, as indicated by mono/biphasic waveform patterns and absent color filling. Figure 4 shows the same.

DISCUSSION

Age Distribution
In our study, 90% of the cases were above the age of 40 years and 10% of the cases were between the age of 18 and 40 years. It is well accepted fact that the lower extremity arterial disease is the disease of middle and older age groups as cited by Cossman *et al.*[7] and Hughson *et al.*[8]

Plaque Characterization and Percentage of Stenosis
In patients who had complete occlusion, collaterals were noted in significant number of cases but exact site of origin, number of collaterals, and distal reformation site could not
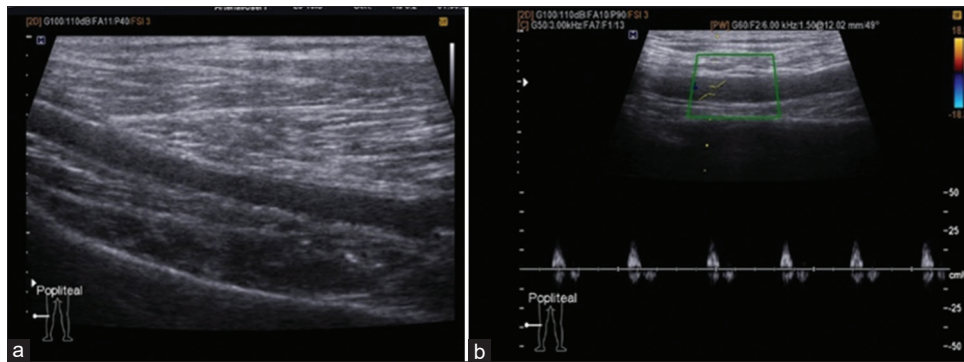
Figure 2: (a and b) Above-mentioned gray scale and pulse Doppler modes reveal atherosclerotic wall thickening and calcification in the popliteal artery with biphasic waveform patterns on pulse Doppler analysis
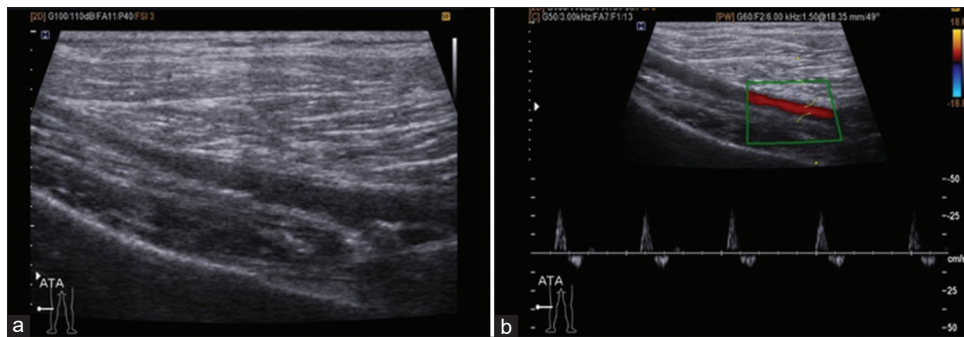

Figure 3: Above images show atherosclerotic wall thickening and calcification in ATA with biphasic waveform patterns. Distal flow from SFA being maintained through collaterals in this case
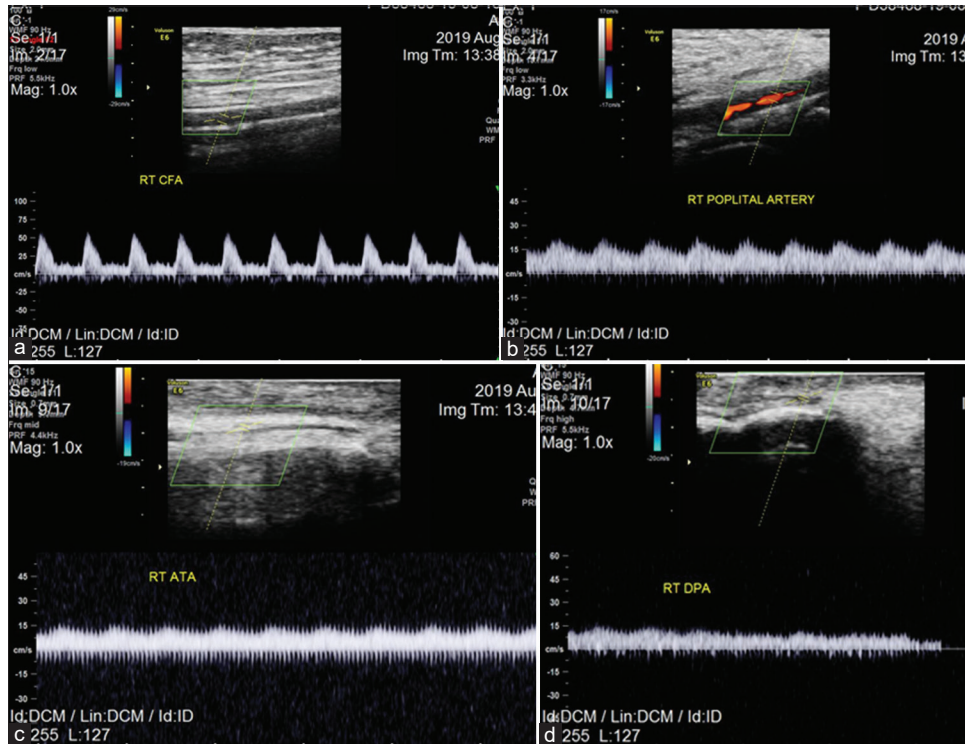

Figure 4: (a-d) Above images show chronic thrombosis in posterior tibial artery and severely reduced flow in rest of the arteries of the right lower limb with dampened monophasic waveform pattern with approx. 40% luminal narrowing in popliteal and 30% in anterior tibial and dorsalis pedis arteries. Findings represent changes of peripheral vascular disease
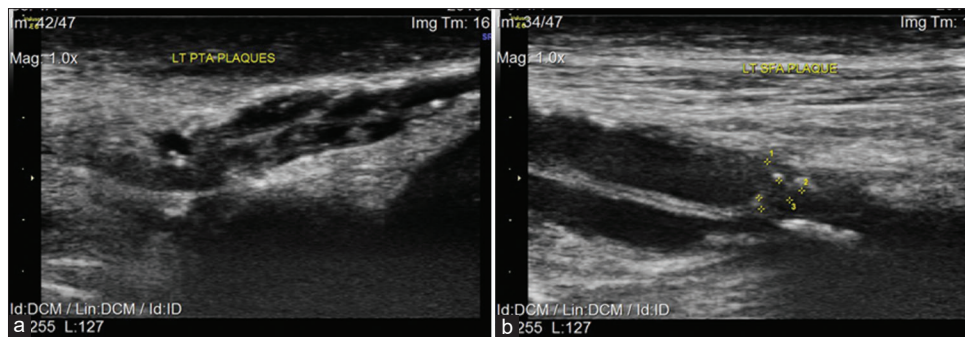
Figure 5: (a and b) Few atherosclerotic plaques as seen in above image in the left SFA and PTA causing nearly 30% luminal compromise
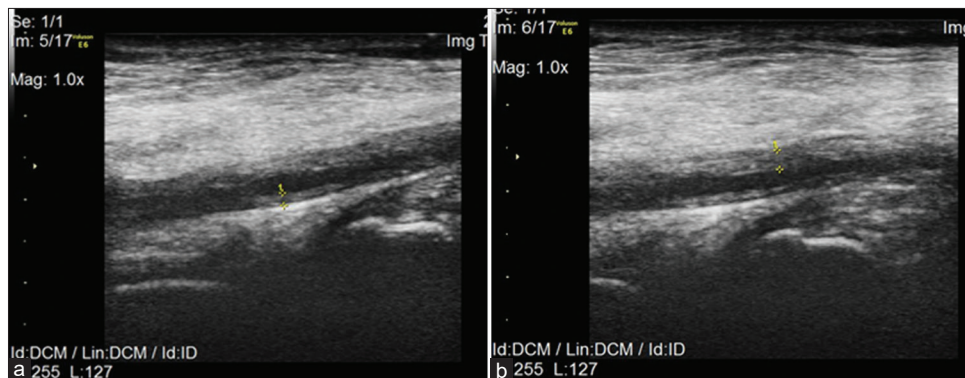

Figure 6: (a and b) Above two images show diffuse atherosclerotic wall thickening involving entire right lower limb arterial tree causing variable degree of luminal compromise

be demonstrated in all cases. Figures 5 and 6 exemplarily show plaques causing luminal stenosis.

Sacks *et al*. in their study observed the gradual decrease in peak systolic velocity from iliac to popliteal artery.[9] Resistance index (RI) is a quantitative analysis of the waveform and reflects resistance to blood flow. The lowest RI suggesting distal ischemia was most commonly seen in dorsalis pedis artery followed by posterior and anterior tibial artery. Das *et al*. demonstrated the low resistance pattern to be more common in dorsalis pedis artery (25.5%) followed by anterior tibial (23%) and posterior tibial (21.5%) artery.[10] Our present study findings were found to be consistent with it.

The earliest signs (gray scale) of atherosclerotic disease are thickening of intima and media followed by wall changes (luminal narrowing and soft or hard plaques) and turbulence and flow irregularities on color Doppler flow images. In our study, plaque variants intima thickening and atheroma were more common in popliteal (18.21% and 17.29%, respectively) and superficial femoral arteries (17.68% and 17.29%, respectively). Calcifications were more common in anterior and posterior tibial arteries (17.89% and 17.57%, respectively). Das *et al*. in their study stated that femoral artery was the most common site of plaque deposition.

Therefore, pattern of vessel narrowing varies in supra versus infrapopliteal vessels.

CONCLUSION

- Arterial Doppler study plays a central role in the management of the patients with peripheral arterial disease by early detection of the changes in the hemodynamic parameters long before limb ischemia sets in and identifying the functional compromise in the diabetic patients who are at risk of developing PAD, thereby decreasing disease morbidity. It can be implemented as an easily available screening tool in the management of these patients to identify the at-risk patients
- Doppler can also be useful in the post-interventional management of the patient as it can be repeated without exposure of the patient to any radiations
- In patients with diabetes mellitus, the elderly age group (age group 41–50 and 50–60) is at increased risk of peripheral arterial disease. Males are more commonly affected with hyperlipidemia, hypertension, and smoking being the most common associated comorbidities
- The infrapopliteal vessels were found to be most adversely affected, showing spectral broadening and

speckled waveform patterns. The most common site of pathology is femoropopliteal segment

- Involvement of femoropopliteal segment was mainly in the form of atheromatous plaque and raised intimomedial thickness, whereas the involvement of anterior and posterior tibial arteries was in the form of mural calcification type of plaque formation
- Most of the atheromatous plaques found were echogenic, showing moderate or severely increased echogenicity
- Duplex color Doppler sonography can accurately locate the site and extent of stenosis/occlusion
- Duplex sonography can be used to assess the peripheral arterial disease into hemodynamically non-significant and significant using PSV, PSV ratios, and spectral waveforms which will help in management
- Duplex Doppler imaging is safe, cost-effective, repeatable, non-invasive procedure for investigating lower limb arteries. Hence, it is the primary investigation of choice in all cases of lower extremity arterial disease
- Duplex sonography allows the evaluation and quantification of arterial disease
- Color Doppler study also helps in the follow-up of the arterial diseases.

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