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Ultrasound evaluation of peripheral arterial disease with clinical correlation

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Abstract

Aim: To evaluate the role of Doppler as an imaging modality in diagnosing Peripheral artery disease of lower/upper limbs and to study the severity of symptoms with findings on Doppler ultrasound.

Material and Methsod: This prospective observational study was conducted in the Department of Radio-diagnosis, Imaging & Interventional Radiology N.S.C.B Shubharti Medical College, CSS Hospital Meerut among patients with clinically suspected peripheral artery disease referred for Color Doppler ultrasound imaging. Doppler's Ultrasonography was done using Samsung Hs70A and HsS50 Ultrasonography machine. Data so collected was tabulated in an excel sheet, under the guidance of statistician and analysed using SPSS 22.00.

Results: Out of 50 subjects, 34 (68%) were males and 16 (32%) were females. According to grey scale findings, subcutaneous odema, plaques, partial thrombosis, complete thrombosis, athero-calcific changes and increased IMT was reported among 26%, 22%, 26%, 28%, 54% and 18% of the subjects respectively. According to doppler ultrasound findings, haemody namically significant stenosis, total occlusion, collateral formation and Arterio-venous malformation was found among, 40% 30%10%and 2% of the subjects respectively.Out of 16 patients with diabetic foot, 8 had total arterial occlusion (50%), 6 had haemody namically significant stenosis (37.5%) and only 1 (6.25%) person had a normal scan.

Conclusion: Our study showed high diagnostic yield of Doppler ultrasound in depicting abnormalities in patients with clinical features of peripheral arterial disease.

Keywords: doppler ultrasound, pad, stenosis, diabetes

Introduction

Peripheral artery disease (PAD) is a circulatory condition in which there is reduced blood flow to limbs due to narrowed vessels. It is a common vascular condition that affects both quality of life and life expectancy with an increased risk of cardiovascular events [1]. The PAD affecting the limbs may occur where there is a blood circulation disorder of the arteries that supply the limbs, which may be partial (due to a stenosis) or complete (due to an occlusion). It is a complex medical condition, which may be asymptomatic in its early stages, although that may affect all arterial vascular regions of the body. PAD is most commonly due to atherosclerosis (95%), where an atherosclerotic plaque causes arterial stenosis or occlusion [2]. The incidence of PAD varies in the general population from 3 to 10% in people younger than 70 years to 15–20% in people older than 70 years [3]. There are several signs of PAD in the affected extremities: absent or diminished dorsalis pedis pulse, coolness and/or paleness, rubor of the skin and trophic lesions. In the end, severe ischemia results in ulceration and gangrene.

Duplex ultrasound imaging combines B-mode imaging and Doppler coding of velocity shifts with pulse-wave/continuous-wave ultrasonography, and therefore, provides detailed examination of both the anatomic characteristics and the functional significance of an arterial stenosis. By superimposing the color Doppler coding on the B-mode images, the location and severity of stenosis can be identified. The combination of these modalities has significantly improved the sensitivity and specificity of ultrasound imaging in detecting hemody namically significant stenoses against the traditional gold standard for defining stenosis severity of digital subtraction angiography (with a diameter stenosis ≥ 50% considered the cutoff that defines a significant lesion) [4].

In the last decade or so, with the development of software and hardware technology diagnostic quality CT (computed tomography) and MRA (magnetic resonance angiography) has become feasible with reconstruction possible in any desired plane and facility for subtracted and Maximum in tensity projection and 3D imaging. These modalities offer a quick and noninvasive means of depicting the entire vascular tree in single image which is quite helpful in surgical planning and operative guidance, as well as in eliminating operator dependence and error associated with ultrasound. However the limited availability, the associated high cost, ionizing radiation risk with CT and limitations with MR scanning, and the need for post processing of images which makes the procedure time consuming and technically demanding, preclude their widespread use in our healthcare setup and as a screening modality compared to ultrasound color Doppler imaging [5].

With this background and keeping in mind about the paucity of data regarding the role of color Doppler imaging in diagnosis of peripheral artery disease in and around western

Uttar Pradesh, the present study has been undertaken to evaluate the role of Doppler as an imaging modality in diagnosing Peripheral artery disease of lower/upper limbs and to study the severity of symptoms with findings on Doppler ultrasound.

Materials and Methods

This prospective observational study was conducted in the Department of Radio-diagnosis, Imaging & Interventional Radiology N.S.C.B Shubharti Medical College, CSS Hospital Meerut among patients with clinically suspected peripheral artery disease referred for Color Doppler ultrasound imaging. Patients who did not give their consent, patients with limb amputation proximal to head of Metatarsal of one or both Lower limb and amputation proximal to wrist of one or both arms, patients with H/Oprior bypass surgery from the lower limb arteries and patients with acute limb ischemia on cuff inflation were excluded from the study. Taking sensitivity and specificity both as 90% and expected maximum prevalence as 50%, L= absolute precision as 10% and Z=2 (for 95% confidence interval), sample size was found to be =50

Procedure of Doppler's Ultrasonography for PAD

We used Samsung Hs70A and HsS50 Ultrasonography machine. The thorough clinical examination, pertaining to PAD was performed. After questioning the patients as to whether or not they had pain in their arms while doing movements or legs as they walked, how many meters after the beginning of the walk the pain started and whether or not they had leg pain during rest, both upper and lower extremities were evaluated in terms of the presence of ulceration that was not cured, and the existence of trophic changes in the legs and arms. Patients were provided with detailed information about the procedures and they signed written consent forms. The presence/absence of peripheral pulses and bruits were documented. The patient was asked to lie in the supine position on an examination table. Arterial duplex imaging was performed using high frequency (5-20MHz) linear transducer and after applying gel on patient skin over the area of interest. The display of both two-dimensional structure and motion in real-time Doppler ultrasonic signals were documented. Also spectral analysis with or without color Doppler imaging was performed.

Doppler for Upper Limb

The ultrasound evaluation was performed from the Sub clavian artery to the wrist to facilitate clinical management decisions. For this procedure, the patient's head was slightly elevated and the arm was slightly rotated externally. While examining the axillary artery, a pledge patient position was maintained. The arm was placed on a pillow for patient comfort. During the procedure, the radiologist followed the standard imaging protocol. Doppler was performed in grey scale first followed by color Doppler and spectral Doppler. The Spectral Doppler waveforms were obtained in a longitudinal plane at an angle of 60° and parallel to the direction of the blood flow/vessel walls. Doppler angles were maintained between 45° to 60° whenever possible. Angles greater than 60° were avoided. The Doppler images of Subclavian artery, Axillary artery, Brachial artery, Radial and ulnar arteries of upper extremity were evaluated by a single experienced sonographer independently. The display of both two-dimensional structure and motion in real-time Doppler ultrasonic signals were documented. Also spectral analysis with or without color Doppler imaging was performed. If abnormalities were detected further examination and additional ultrasono graphic images were taken.

Areas of stenosis

The peak systolic velocity ratio (PSV) was determined at Pre-stenosis, at stenotic site, and Post-stenotic turbulence, to evaluate if the lesion was hemo dynamically significant. The PSV ratio was obtained by taking the PSV at the area of stenosis and dividing by the PSV in the normal segment proximal to the stenosis.

Areas of an aneurysm

The vessel diameter was measured from outer wall to outer wall and spectral Doppler velocities were measured: proximal to, within and distal to the aneurysm. Due to proximity of Sub clavian artery with the clavicle bone aneurysm images were difficult to obtain. If mural thrombus was found, it was also documented.

Doppler for Lower Limb

The Peripheral arterial imaging for lower extremity was started at the level of the aortic bifurcation. It was best to use a low frequency transducer (2.0-3.5 MHz) for the proximal segment of the examination followed by high frequency probe for distal segments. The aortic bifurcation was best seen with the patient turned to the left side and with the transducer placed just in front of the right iliac crest in a longitudinal plane. The distal aorta was usually visualized with the origin of both common iliac arteries. The Doppler signals were obtained from all the three vessels at this location. The patient was turned to a lateral decubitus position (side being evaluated up) to evaluate the internal and external iliac arteries with the transducer being placed between the iliac crest and umbilicus. The common femoral artery was located at the level of the groin. The artery lies lateral to the common femoral vein. The ultra sono graphic imaging was performed in the longitudinal plane, and a Doppler signal was obtained from this artery. The vessel was followed distally on the leg up to the origin of the superficial femoral and pro funda femoris (deep femoral) arteries. The superficial femoral artery was followed distally as it courses down the medial aspect of the thigh. This artery was followed distally in the limb till it becomes the popliteal artery. The popliteal artery was followed through the popliteal fossa and it lies deep to the vein. The distal popliteal artery was followed in a longitudinal plane, the origin of the anterior tibial artery was usually visualized diving deep on the monitor. The remainder of the vessel was imaged distally by placing the transducer on the lateral calf and it was followed to the level of the ankle. The tibial-peroneal trunk extends into the calf from the popliteal artery. The posterior tibial and peroneal arteries were usually visualized by placing the transducer on the medial calf. The peroneal artery lies deep and runs parallel to the posterior tibial artery. These vessels were located above the malleolus and followed proximally.

Statistical Analysis

Data so collected was tabulated in an excel sheet, under the guidance of statistician and analysed using SPSS 22.00 (for windows; SPSS inc, Chicago, USA).

Results

The study comprised of 50 patients with clinical suspicion of peripheral artery disease and was referred for Color Doppler ultrasound imaging for evaluation of peripheral arterial disease of the lower / upper limb. Out of 50 subjects, 34 (68%) were males and 16 (32%) were females. In our study, 12%, 10%, 26%, 24% and 28% of the subjects belonged to 15-30, 31-40, 41-50, 51-60 and >60 years of age respectively. Lower and upper limb was affected in 86% (43) and 14% (7) of the subjects respectively, showing predominance of lower limb (Table 1).

Table 1: Gender, age and affected limbs among the study subjects

Gender	N	%
Male	34	68
Female	16	32
Total	50	100
Age Group (in years)		
<15	0	0
15-30	6	12
31-40	5	10
41-50	13	26
51-60	12	24
>60	14	28
Limb Examination		
Lower Limb	43	86
Upper Limb	7	14
Total	50	100

In our study diabetic foot disease, gangrene, intermittent claudication, limb swelling, limb pain and old history of peripheral vascular disease was reported among 32%, 18%, 20%, 28%, 8% and 6% of the subjects respectively(graph 1).

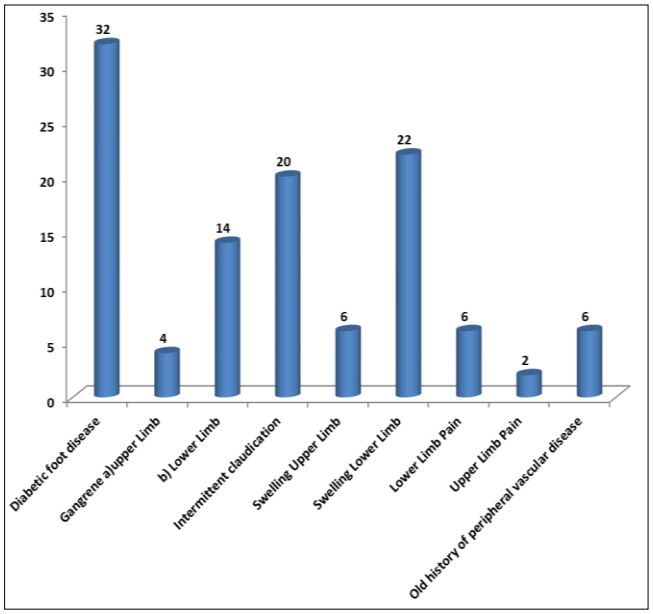

Fig 1: Distribution of clinical data

In our study, diabetes and hypertension was found among 46% and 26% of the subjects respectively. Deleterious habits like alcohol, smoking and both were reported among 32%, 42% and 8% of the subjects respectively. Tobacco smoking affects both arteriosclerosis obliterans and thromboangitisobliterans (TAO) but TAO is exclusively seen in young smokers (table 2).

Table 2: Distribsution of co-morbidities and deleterious habits among the patients

Past History	N	%
Diabetes	23	46
Hypertension	13	26
None	14	28
Deleterious Habits		
Alcohol	16	32
Smoking	21	42
Both	4	8
None	9	18

According to grey scale findings, subcutaneous odema, plaques, partial thrombosis, complete thrombosis, athero-calcific changes and increased IMT was reported among 26%, 22%, 26%, 28%, 54% and 18% of the subjects respectively. According to doppler ultrasound findings, haemodynamically significant stenosis, total occlusion, collateral formation and Arterio-venous malformation was found among, 40% 30%10%and 2% of the subjects respectively. Normal doppler ultrasound findings were reported in 28% of the subjects. Doppler ultrasound findings found abnormality among 72% of the subjects (table 3).

Table 3: Grey scale and Doppler ultrasound findings in the patients

Grey Scale Finding	N	%
Subcutaneous Odema	13	26
Plaques	11	22
Partial thrombosis	13	26
Complete thrombosis	14	28
Athero-calcific changes	27	54
Increased IMT	9	18
Doppler Findings		
Haemodynamically significant stenosis	20	40
Total occlusion	15	30
Normal	14	28
Collateral formation	5	10
Arterio-venous malformation	1	2

Graph 2 shows the spectral findings in the patients. Triphasic flow, altered flow, absence of diastolic flow, no flow and spectral broadening was revealed among 15 (30%), 21 (42%), 8 (16%), 15 (30%) and 6 (12) subject's respectively.

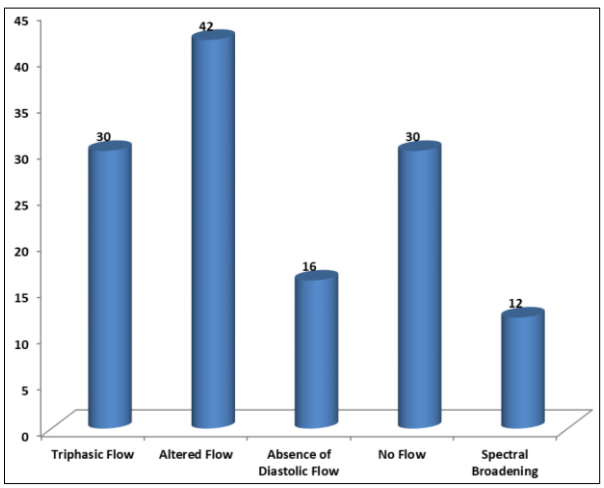

Fig 2: Spectral findings in the patients

Out of 16 patients with diabetic foot, 8 had total arterial occlusion (50%), 6 had haemodynamically significant stenosis (37.5%) and only 1 (6.25%) person had a normal scan.Out of 10 patients with intermittent claudication, 7 (70%) had haemodynamically significant stenosis, 2 (20%) had increased IMT while 1 case had normal scan.Out of the 12 patients with limb swelling, 5 (41.67%) hadincreased IMT, 3 (25%) had haemodynamically significant stenosis, 3 (25%) had a normal scan and 1 (8.33%) had arterio-venous malformation (table 4).

Table 4: Ultrasound findings correlation with clinical findings

USG Findings	N	Diabetic foot disease (N=16)		Intermittent claudication (N=10)		Limb swelling (N=12)		Peripheral vascular disease (N=3)	
		N	%	N	%	N	%	N	%
Haemody namically significant stenosis	20	6	37.5	7	70	3	25	1	33.33
Total occlusion	15	8	50	0	0	0	0	2	66.67
Increased IMT	9	1	6.25	2	20	5	41.67	0	0
Normal	9	1	6.25	1	10	3	25	0	0
Arteriovenous malformation	1	0	0	0	0	1	8.33	0	0

Diabetic foot disease was more common on the right (8) than the left (3) and gangrene was also more common on the Right (6) than the left (2). The side predilections of abnormalities in other patients are shown in Table 5.

Table 5: Relationship between the laterality of the lesion with the clinical presentation

Clinical History and Indications	N	Right	Left	Bilateral
Diabetic foot disease	16	8	3	5
Gangrene	9	6	2	1
Intermittent claudication	10	5	3	2
Limb swelling	14	7	5	2
Limb pain	4	2	1	1
History of Peripheral vascular disease	3	0	1	2
Total	50	21	14	15

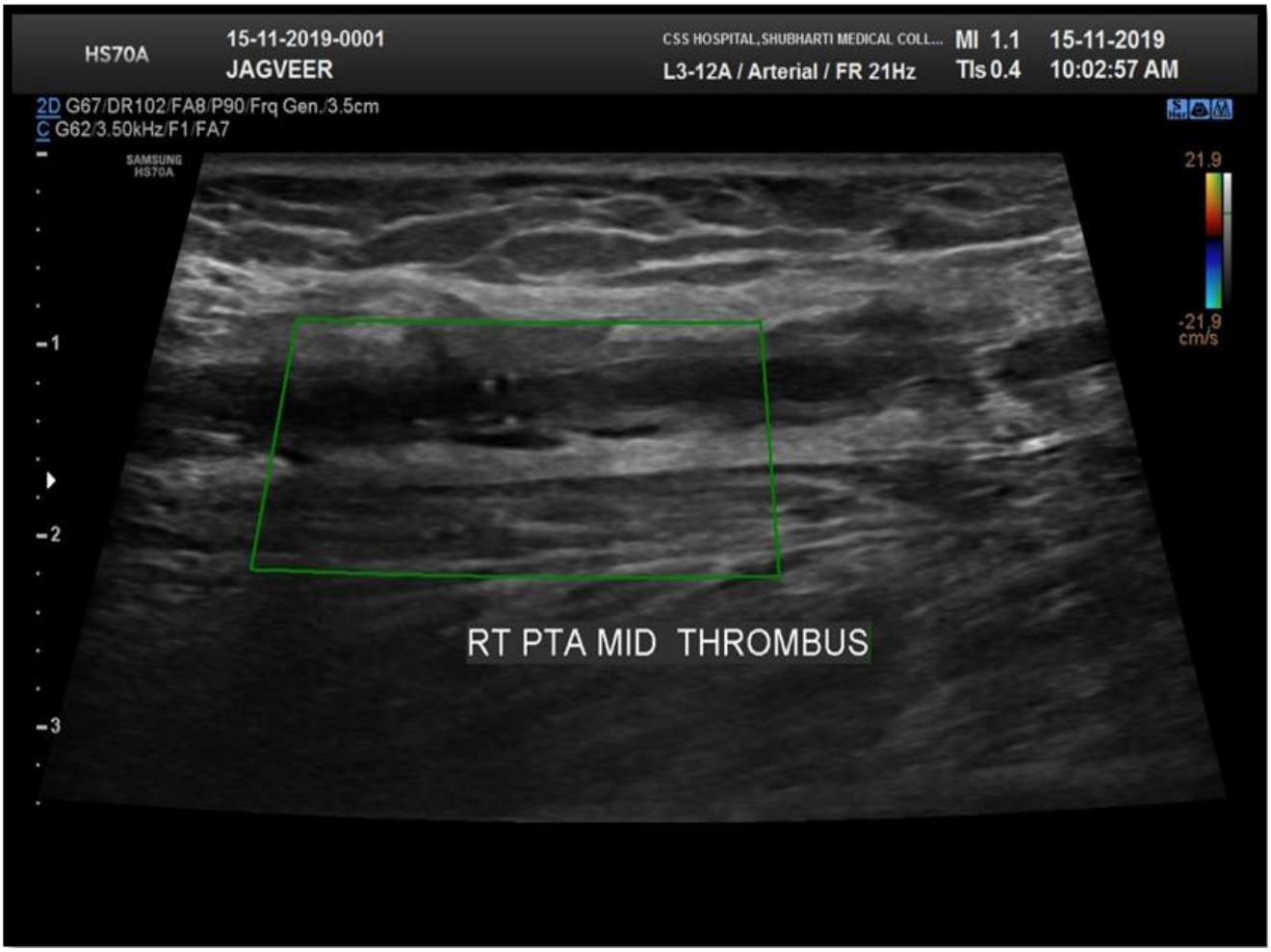

Fig 1: Shows thrombus in Right Posterior Tibial Artery.

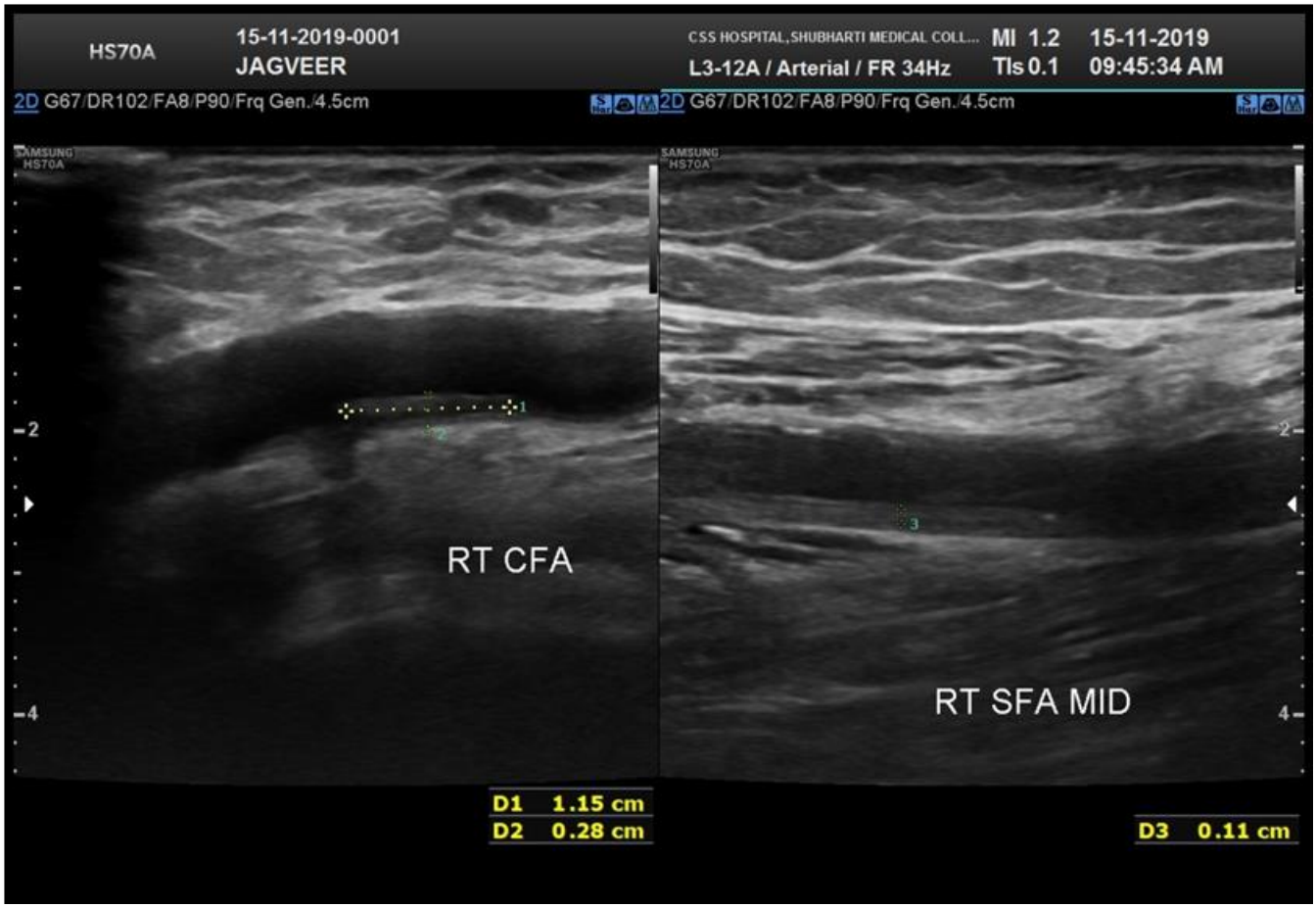

Fig 2: Shows soft plaque in right common femoral artery and thickening of intimal media in right superficial femoral artery.

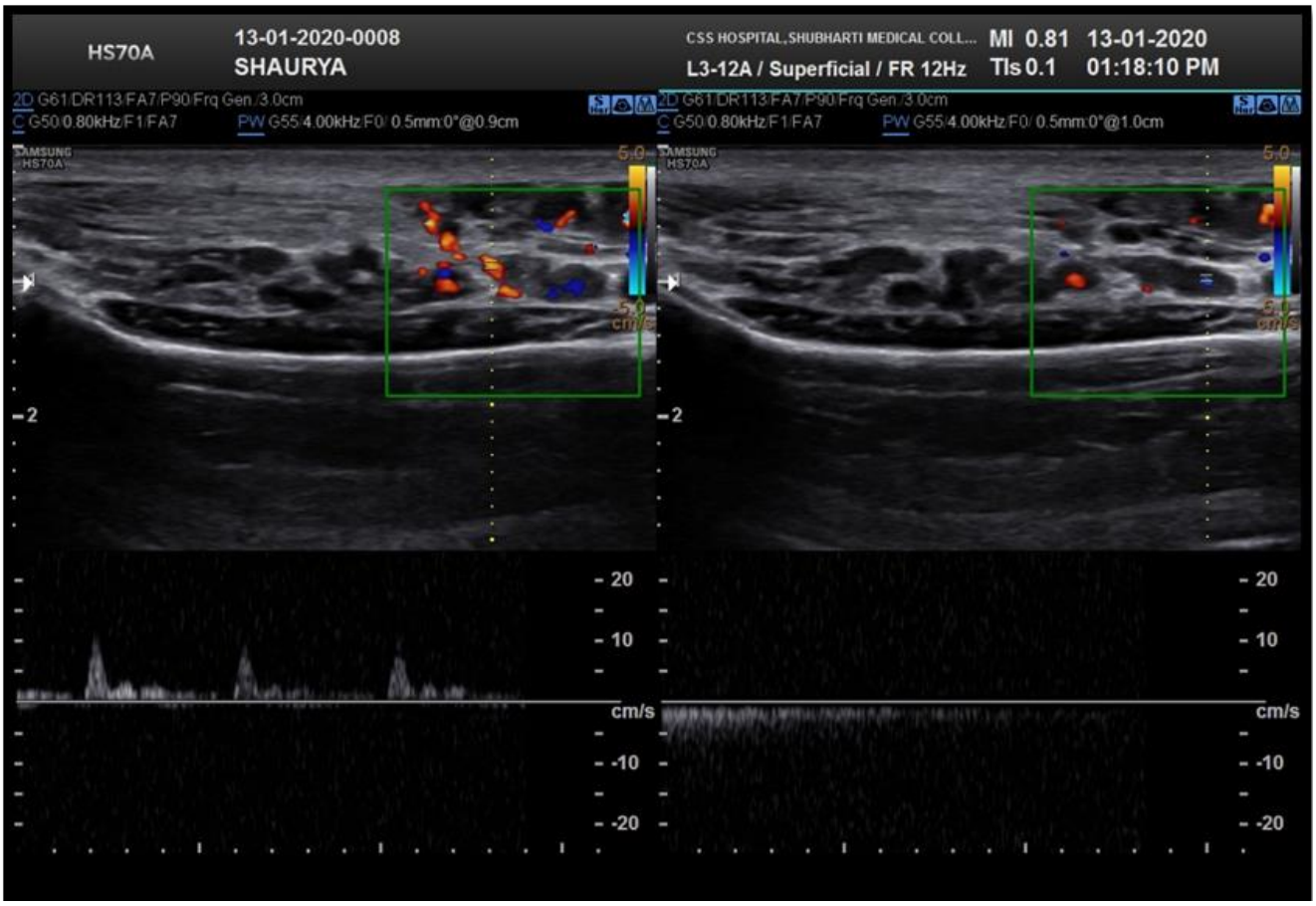

Fig 3: An echogenic lesion showing multiple anechoic vascular channels with arterial &venous flow in superficial plane on medial aspect of distal forearm - arteriovenous malformation

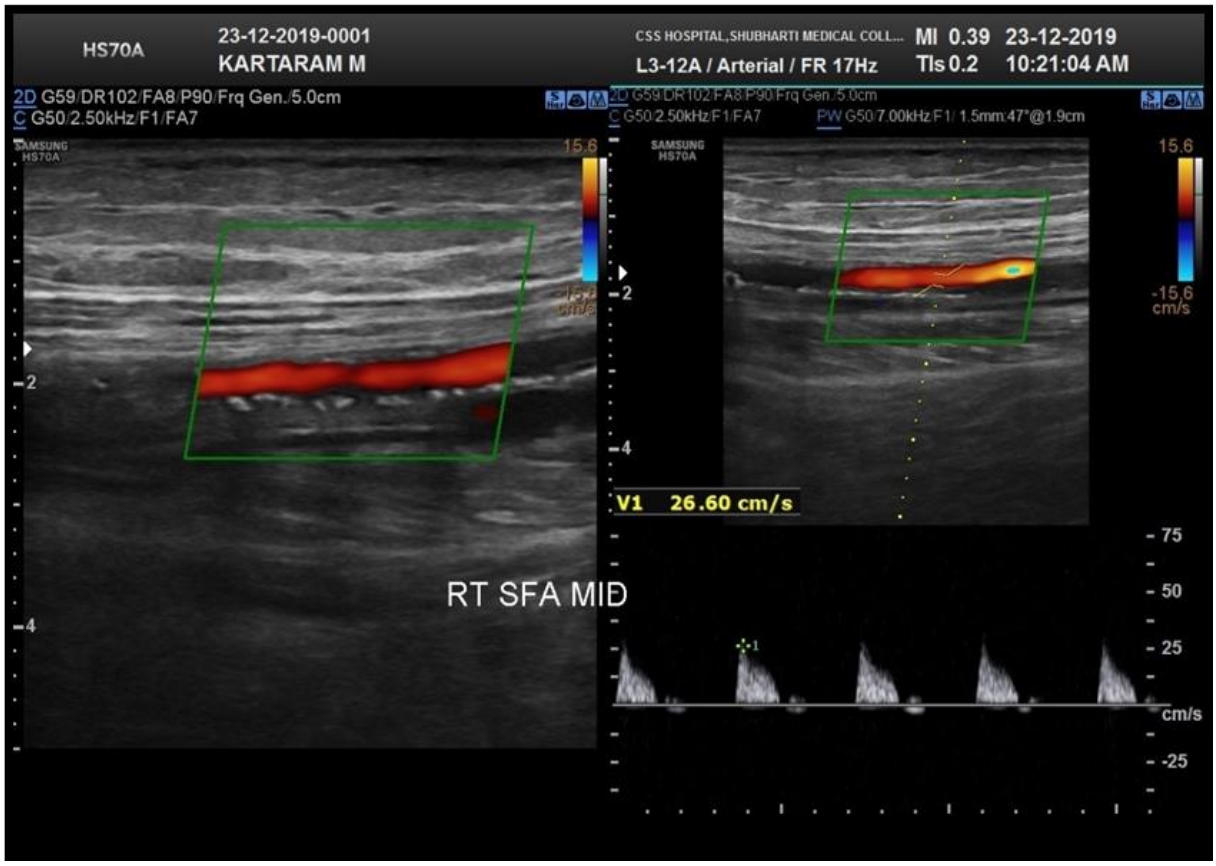

Fig 4: Shows tiny calcified plaques in arteries of lower limb causing monophasic flow.

Discussion

For long angiography has been considered the Gold standard in evaluation of PVD and is done before any surgery is planned. This investigation is done to demonstrate the extent of the lesion, condition of vessels above the lesion, development of collaterals and reformation of distal vessels. It provided excellent anatomical detail. However, it does not give adequate physiological information about the hemodynamics of lower limb. It is associated with risks due to its invasiveness, cost, contrast associated complications and it does not give information about plaque and this is the advantage in ultrasonography.

Our study showed that the frequency of PAD was more common in lower limb (86%) than upper limb. This could be due to that the lower extremity ischemia is also associated with pathophysiologic changes in calf skeletal muscle including smaller calf muscle area, increased calf muscle fat content, impaired leg strength, and impaired metabolic function.Among individuals aged 40 years and older, the prevalence of lower extremity arterial disease (LEAD) is 4.3%, ranging from 3.1% to 5.5%. However, the prevalence in individuals with diabetes ranges from 20% to 30% (6).

In our study diabetic foot disease, gangrene, intermittent claudication, limb swelling (upper and lower limb), limb pain(upper and lower limb) and old history of peripheral vascular disease was reported among 32%, 18%, 20%, 28%, 8% and 6% of the subjects respectively. Anas Ismail *et al* (7) in their study revealed similar results.

In our study, according to doppler ultrasound findings, haemodynamically significant stenosis total occlusion and Arterio-venous malformation, was found among, 40% 30% and 2% of the subjects respectively. Normal Doppler ultrasound findings were reported in 28% of the subjects. Doppler ultrasound findings found abnormality among 72% of the subjects. This is higher than 62% reported by Shaheen and Sohail (8), though their sample size was relatively larger (100 compared to 50 in this study) and lower than 87% reported by Ismail *et al* (7). This disparity in Doppler ultrasound findings may be from differences in the experiences of the radiologists may also increase the sensitivity of ultrasound results as well as differences in the characteristics of the study subjects. On the other hand, this disparity may imply a possible higher prevalence of peripheral vascular disease in our local environment compared to theirs.

Triphasic flow, altered flow, absence of diastolic flow, no flow and spectral broadening was revealed among 15 (30%), 21 (42%), 8 (16%), 15 (30%) and 6 (12) subject's respectively in the present study.These findings are comparable to findings of other studies Jager KA *et al* (9).

Biphasic altered flow was more as compared to monophasic altered flow among the study subjects. Most commonly involved arterial territories include anterior as well as posterior tibial artery (20%) femoral and popliteal artery. Other less commonly involved arterial territories include radial (4%), brachial (6%) and axillary as well as subclavian arteries in the present study.

Similarly results were reported by Guo *et al* (10) in 2013 on 162 diabetics with arterial lesions. This pattern slightly differs from the report of Ismail *et al* (7). Ismail *et al* in their study reported that femoro-popliteal 21 (26.9%), multiple below-knee arteries14 (17.9%), posterior tibial artery 8 (10.3%), each of the subclavian, anterior tibial and dorsalispedis arteries have a frequency of 4 (5.2%). Other less commonly involved arterial territories include ilio-

femoral (2.6%), radial and peroneal arteries.

In our study, Out of 16 patients with diabetic foot, 8 had total arterial occlusion (50%), 6 had haemodynamically significant stenosis (37.5%) and only 1 (6.25%) person had a normal scan. They also showed additional incidental findings of increased IMT (6.25%) in other arteries. In this regard, Umuerri and Obasohan (11) found a prevalence of LEAD (lower extremity peripheral artery disease) at 35.6% of the 380 diabetics using Dopplerankle-brachial index (ABI) <0.9 in Benin City, Nigeria. On the other hand, Framingham Heart Study (12) revealed that 20% of symptomatic patients with LEAD had diabetes. Nevertheless, this may still underestimate the prevalence, given that many more people with LEAD are more often asymptomatic.

In our study, deleterious habits like alcohol, smoking and both were reported among 32%, 42% and 8% of the subjects respectively. Tobacco smoking affects both arteriosclerosis obliterans and thromboangitis obliterans (TAO) but TAO is exclusively seen in young smokers. The relationship between smokers and PVD is known since 1911 when Erb[13] reported intermittent claudication was 3 times more common among the smokers. William F. Ganong[15] noted intake of alcohol promotes increase in blood lipid levels, which promotes atherosclerosis. In our study 50% of patients with hyperlipidemia, 50% of patients had hypertension, 26% were diabetes and 10% had IHD.

The present study had some limitations like small sample size. Patients are from a single centre, therefore results cant be generalized.

Conclusion

This preliminary study of 50 patients showed high frequency of tibial and femoro-popliteal involvement in PAD. In addition, Athero-calcific changes, plaques and increased IMT were the common incidental findings while diabetes, hypertension and old age were frequently associated clinical problems of these patients. Our study showed high diagnostic yield of Doppler ultrasound in depicting abnormalities in patients with clinical features of peripheral arterial disease.

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