

PERIPHERAL ARTERIAL DISEASE STUDY OF LOWER EXTREMITY BY DOPPLER ULTRASONOGRAPHY.

*¹Dr. R.Raja, ²Dr.M.Adaikappan and ³Dr. S.Sethurajan

*¹Radiology Resident, Rajah Muthiah Medical College & Hospital ,Annamalai University, Annamalainagar

²Professor, Rajah Muthiah Medical College & Hospital ,Annamalai University, Annamalainagar 3

³Asst.Professor, Rajah Muthiah Medical College & Hospital ,Annamalai University, Annamalainagar

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ABSTRACT

Objectives:

The main objective of the study is to identify and evaluate the haemodynamically significant peripheral arterial disease by using duplex ultrasonography. **Methods:** 50 Limbs were studied with peripheral arterial disease by duplex colour doppler with symptoms and signs suggestive of lower limb arterial insufficiency and were evaluated for the presence of stenosis / occlusion and reformed collaterals. **Results:** Among 50 patients examined , 70% of them had hemodynamically significant stenosis and it was found that number of collaterals increased with the severity of arterial stenosis . Most of these patients with atherosomatous plaque were males and were found at femoro-popliteal segment. 38% of patients had complete occlusion. In this study 30% had PSV ratio of 2 - 4 and 8% had >4. **Conclusion:** Atherosomatous plaque changes with significant stenosis / occlusion was seen among peripheral vascular insufficiency patients . Colour Doppler is a cheap , safe, non- invasive, easily repeatable and primary modality of choice for screening peripheral arterial disease.

Keywords: Arterial Doppler , Collaterals, Lower Extremity, Occlusion / Stenosis,

1.INTRODUCTION

Peripheral artery disease (PAD) is a manifestation of systemic atherosclerosis where, typically , atherosclerotic plaque formation in arteries to the legs results in a decrease in limb blood flow . Atherosclerosis is the most common cause of arterial occlusive disease of the lower extremities. The arterial narrowing or obstruction that occurs as a result of the atherosclerotic process reduces blood flow to the lower limb during exercise or at rest . A spectrum of symptoms results, the severity of which depends on the extent of the involvement and the available collateral circulation. Thus, symptoms may range from intermittent claudication to pain at rest. Intermittent claudication denotes pain that develops in the affected limb with exercise and is relieved with rest. This pain usually occurs distal to the arterial narrowing or obstruction. Since the superficial femoral and popliteal arteries are the vessels most commonly affected by the atherosclerotic process , the pain of intermittent claudication is most often localized to the calf. Symptomatically , this manifests as pain in the lower limbs upon exertion and / or at rest depending on the severity of the occlusion.^{1,2}

Peripheral arterial occlusive disease (PAOD) is the most common disease of extremity arteries and is characterised by narrowing of the extremity arteries causing a reduction in blood flow and ischemic changes in the limbs affected. Approximately 90% of patients show involvement of lower extremity arteries. The most common cause in the lower limb arterial occlusive disease is atherosclerosis. Less common causes include thromboembolism, acute thrombotic occlusion, micro embolism trauma and vasculitis including vasospastic disorders and Beurer's disease.

Atherosclerosis, though typically asymptomatic for decades , eventually produces two main problems: First, the atherosomatous plaques, though long compensated for by artery enlargement , eventually lead to plaque ruptures and clots inside the artery lumen over the ruptures. The clots heal and usually shrink but leave behind stenosis (narrowing) of the artery (both locally and in smaller downstream branches) , or worse, complete closure , and therefore , an insufficient blood supply to the tissues and organ it feeds. Second , if the compensating artery enlargement process is excessive , then a net aneurysm results. Not only we can save the limb but improve the function of the limb by diagnosing and treating this condition.³

*Corresponding author Dr R.Raja,, Post Graduate, Department of Radiology, Rajah Muthiah Medical College, & Hospital, Annamalai University, Annamalainagar – 608 002, Tamilnadu, India

Risk factors that include age , diabetes mellitus , smoking , hypertension and hyperlipidemia. Signs and symptoms of PAOD depends on presence or absence of collaterals.⁴

Hemodynamic circuit consist of diseased major artery , a parallel system of collaterals and the peripheral run off bed. Collaterals vessels are much smaller more circuitous and more numerous then the major arteries . They replace and always have a higher resistance then the original unobstructed artery. Stimuli for development of collaterals are the presence of abnormal pressure gradient across the collaterals system and increased velocity of flow through intramuscular channels.

The duplex imaging criteria for the normal arterial evaluation of the lower extremity is a triphasic Doppler signal from the femoral artery to the tibial arteries at the ankle. The characteristic normal arterial waveform has a high velocity forward flow component during systole (ventricular contraction), followed by a brief reversal of flow in early diastole (because of peripheral resistance), and a final low velocity forward flow phase in late diastole (elastic recoil of the vessel wall) . Peak systolic velocity gradually decreases from the proximal to the distal arteries . The peak velocity in the abdominal aorta is approximately 100 cm / sec and the velocity gradually decreases to 70 cm/sec in the popliteal artery.

Interpretation of Arterial Duplex Imaging

Table - 1 : Mean Arterial Diameters and peak Systolic Velocities.

Artery	Diameter +/- SD (cm)	Velocity +/- SD (cm/sec)
External iliac	0.82 +/- 0.13	119.3 +/- 21.7
Common femoral	0.79 +/- 0.14	114.1 +/- 24.9
Superficial femoral (Proximal)	0.60 +/- 0.12	93.8 +/- 13.6
Superficial femoral (Distal)	0.54 +/- 0.11	90.6 +/- 14.1
Popliteal	0.52 +/- 0.11	68.8 +/- 13.5

The following criteria are used: normal is a triphasic waveform; a minimal wall lesion (1% to 19% narrowing) is defined as spectral broadening alone ; and a 20% to 49% stenosis is indicated by an increase in peak systolic velocity > 30 % but < 100 % from the preceding segment with preserved reverse flow even though spectral broadening may be present . A critical stenosis (50% to 99%) is indicated by an increase in peak systolic velocity > 100 % from one segment to the next , although some investigators have found a 150 % increase to be more reliable . Finally , no flow indicates total occlusion.⁵

Table - 2 : Velocity criteria for the assessment of lower limb

Percentage stenosis	Peak systolic velocity (ms ⁻¹)	Velocity Ratio
Normal	<1.5	<1.5 : 1
0- 49	1.5 - 2.0	
50 - 75	2.0 - 4.0	1.5-2 : 1
> 75	> 4.0	
Occlusion		2-4 : 1
		>4 : 1

Limitations of the lower extremity arterial duplex imaging examination are:

- Non-visualization of the iliac system because of bowel gas or obesity.
- Shadowing because of calcification.
- Difficulty imaging the popliteal trifurcation.
- Difficulty evaluating lesions distal to tight stenosis because of low velocities in these segments

2.METHODS:

The study consisted of 50 patients with symptoms and signs suggestive of lower limb arterial insufficiency. The arterial system from common iliac artery to the dorsalis pedis artery was examined to study the location, size, echogenicity , stenosis, peak systolic velocity changes and spectral wave form changes at the site of atherosclerotic plaque from one segment to another.

Use a low frequency (2-3.5 MHz) curved array transducer for the proximal segment of the examination and a high frequency (5-10 MHz) linear array transducer for the evaluation of the leg.

3.RESULTS

Table -3: Sex wise distribution of patients

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

In the study , majority of the patients were males , comprising about 76%.

Table - 4 : Age wise distribution of patients

Age (Years)	Male	Female	No. of Patients	Percentage
15-30	1	2	3	6%
31-40	2	0	2	4%
41-50	8	6	14	28%
51-60	17	3	20	40%
61-70	8	1	9	18%
71-80	1	0	1	2%
80-90	0	1	1	2%

Among the 50 patients studied , most of them were above 40 years of age (90%).

Table-5: Site of lesions by colour doppler in lower limb

Level	Right limb	Left limb
Common iliac artery	2	1
External iliac artery	1	1
Common femoral artery	7	6
Superficial femoral artery	16	10
Deep femoral artery	6	2
Popliteal Artery	10	8
Posterior tibial artery	3	3
Anterior tibial artery	5	3
Peroneal artery	2	1
Dorsalis pedis artery	2	4

In the study, it was observed that most of the lesions involved SFA and PA and more so on right side.

Table-6: Distribution of patients based on percentage of collaterals visualised.

Grades of arterial stenosis	No. Of patients	Collaterals visualised	Percentage for collaterals visualised
Mild to moderate (0-49%)	33	5	15.1%
Severe (50-99%)	11	7	63.3%
Total occlusion	6	5	83.3%

It was found that the number of collaterals increased with increased severity of arterial stenosis.

Table - 7: Distribution of patients based on PSV ratio.

PSV ratio	No. of patient	Percentage
<2:1	12	24%
2-4:1	15	30%
>4	4	8%
Total block	19	38%

Among the patients studied, 24 % of them had PSV ratio < 2 , 30% had in between 2 - 4, 8% had > 4 and 38% showed total block.

Fig.1- Normal triphasic flow in Superficial femoral artery.

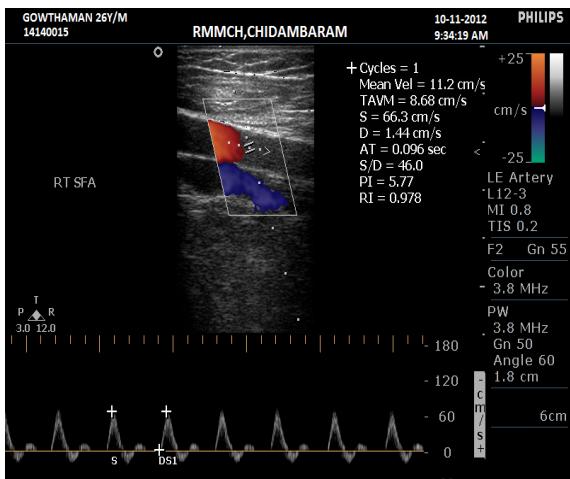


Fig.2- Normal triphasic flow in popliteal Artery.

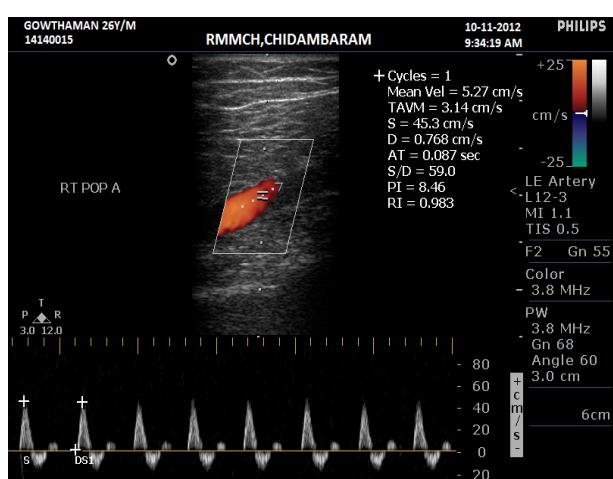


Fig.3- Occluded superficial femoral artery with collaterals.

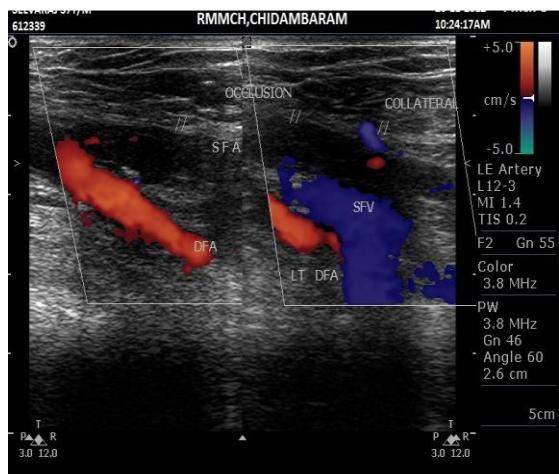
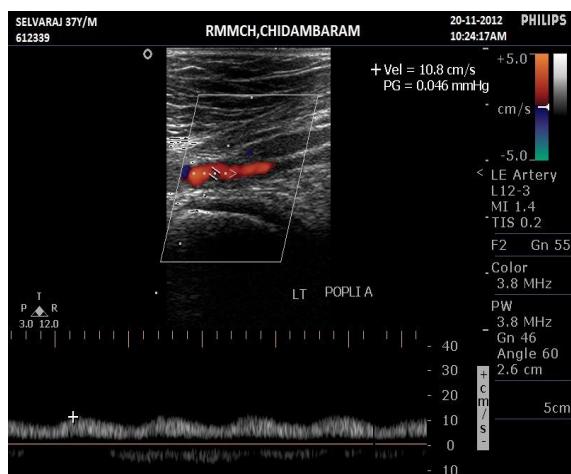


Fig.4- Low resistant flow in popliteal artery.



4.DISCUSSION

Peripheral arterial disease is the most common disease of the lower extremity. Symptomatic PAD is prevalent in the elderly population and puts patients at a significantly higher risk of myocardial infarction and stroke. Those with asymptomatic PAD are at higher risk for cardiovascular morbidity and mortality.

P.A.D. can affect your quality of life, make walking difficult, or worse, increase your risk of heart attack, stroke, leg amputation, and even death. Clinical presentation and treatment are significantly modified by presence and efficiency of collateral .⁶

Occlusion of upper part of the superficial femoral artery: collateral circulation was established through the deep femoral artery and through the perforating arteries .Occlusion of the terminal part of the superficial femoral artery: collateral circulation was formed by the articular branches of the same artery originating proximal to the occlusion and through branches of the deep femoral artery; occlusion of the superficial and deep femoral arteries at their origin: collateral circulation was established through the ischiatic artery (directly and, indirectly, through the perforating arteries).⁷

Collaterals are more frequently found in chronic and high grades of stenosis by duplex colour doppler. Following duplex colour doppler evaluation for collaterals it was found that out of 50 limbs showing the presence of Peripheral arterial occlusive disease 17 limbs showed that presence of collaterals and the frequency of collaterals increased in arterial occlusion (83.3%); followed by severe arterial stenosis (63.6%) and mild to moderate (15.1%).^{8,9}

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.

Recently, advances in duplex scan have raised the possibility that it could replace angiography as the primary imaging modality for assessment of limb ischemia. Ultrasonic imaging provides a non-invasive assessment of the arterial circulation in the lower limb and is accepted as a valuable diagnostic technique. Grey-scale images identify plaque and thrombus, duplex assessment provides a measurement of blood velocity through a vessel, and colour doppler imaging enables the rapid localization of arterial stenosis and occlusions. Its association with interventional endovascular processing explain its significant development these days. It thus allows the evaluation, the quantification and the follow-up of the arterial diseases by carrying out a precise vascular mapping that can guides the radiological or surgical processing if necessary. Colour Doppler imaging is safe , cost effective, repeatable, non-invasive procedure for investigating lower limb arteries.

With the recent introduction of CTA, MRA, the study has become further improvised but because of their high cost and unavailability, colour doppler Duplex sonography becomes the most easily available modality for evaluation of arteries. Over the past several years , interest in non invasive testing of PVD has increased rapidly. The use of the Duplex sonography has revolutionized the investigation of blood vessels. Colour Doppler is the most valuable of the noninvasive tests. Treatment options include medical therapy, bypass surgery and various percutaneous interventions such as angioplasty, atherectomy, stent placement, and thrombolysis.

5.CONCLUSION

- Duplex sonography can be used to classify peripheral arterial disease into hemodynamically non-significant and significant using Peak systolic velocity, Peak systolic velocity ratios and spectral waveforms which will help in management.
- Number and frequency of collaterals present in patient with peripheral arterial disease depends upon severity of stenosis . Duplex color Doppler sonography can accurately locate the site and extent of stenosis /occlusion.
- 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 and helps to decide the need for further evaluation by angiography.

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