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ROLE OF DUPLEX ULTRASONOGRAPHY IN DIAGNOSIS OF PERIPHERAL VASCULAR DISEASE IN WESTERN INDIAN POPULATION: A CROSS-SECTIONAL STUDY OF 100 PATIENTS

Radio-Diagnosis

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ABSTRACT

Peripheral arterial disease (PAD) is a common vascular condition that affects the lower extremities, and its prevalence is increasing worldwide. We studied 100 patients over a period of 9 months to understand the role of duplex ultrasound in peripheral arterial disease and assess the spectrum of vascular disease in western Gujarat population. Duplex ultrasound is a non-invasive imaging modality that plays a crucial role in the diagnosis, evaluation, and management of PAD. This technique combines two types of ultrasound, B-mode and Doppler, to visualize the arterial anatomy and assess blood flow velocities. Duplex ultrasound provides accurate information about the presence and severity of stenosis or occlusion, as well as the hemodynamic significance of the disease. It can classify PAD based on various parameters, including the ankle-brachial index (ABI) and pulse wave velocity (PWV). Duplex ultrasound is also useful in monitoring disease progression and treatment response. The technique has several advantages over other imaging modalities, including its non-invasive nature, lower cost, portability, and ability to provide real-time imaging during interventions. However, interpreting duplex ultrasound results requires expertise in vascular anatomy and hemodynamics. Overall, duplex ultrasound is a versatile and valuable tool in the diagnosis and management of PAD.

KEYWORDS

Peripheral vascular disease, atherosclerosis, duplex ultrasound, limb ischemia, foot gangrene

INTRODUCTION

Peripheral arterial disease (PAD) is a common vascular condition that affects both quality of life and life expectancy with an increased risk of cardiovascular events such as myocardial infarction and stroke. PAD results from any disease causing stenosis or occlusion of the lower limb arteries, with atherosclerosis being the most common etiology.[1]Risk factors for atherosclerosis include race, male gender, increasing age, smoking, diabetes, hypertension, dyslipidemia, hypercoagulable states, chronic renal insufficiency etc. Prevalence of PAD in adult population is up to 4 to 12% and in elderly population (>70 years old) it may be 20%.[2,3] Although 65-75% of patients with PAD are asymptomatic, the classic presenting symptom is intermittent claudication which is usually described as muscle cramps, fatigue or pain in the lower limbs induced by exercise and rapidly relieved by rest. Non-invasive imaging modalities including duplex ultrasonography (DUS), magnetic resonance angiography (MRA) and multi-detector computed tomography angiography (MDCTA) are indicated to identify the location and severity of arterial stenosis when considering possible intervention.[4] Colour assisted duplex ultrasound scan is safe, non-invasive and nonexpensive and can provide anatomical as well as functional information.[3 4] Duplex ultrasonography (DUS) does not require contrast enhancement, preparation of the patient before the study or radiation exposure. Duplex ultrasound comprises of 3 levels of evaluation of vessels including gray scale, colour Doppler and spectral Doppler ultrasound. This help in assessment of pattern of blood flow, characterization of spectral waveform, vessel wall characteristics, luminal narrowing/ stenosis and presence of atherosclerotic changes in peripheral arterial disease. Utilized for screening and Follow-up, as well as for the definitive diagnosis of peripheral arterial disease. The only limitations are being operator dependent, patient non-compliance due to severe pain, severe ischemia resulting into large open wounds and gangrenes.

AIMS AND OBJECTIVES

Aim: To assess the role of duplex ultrasound in peripheral arterial disease and assess the spectrum of vascular disease in western Gujarat population.

With an objective to understand the pathophysiology of peripheral arterial disease, technique and different modes of ultrasound used for evaluation of peripheral arteries, assessment of severity of PAD and documenting abnormal imaging findings in PAD on duplex ultrasound.

METHODS AND MATERIALS

The present study of 'role of duplex ultrasound in peripheral arterial disease' was a cross-sectional study including 100 patients undergoing ultrasound examination for clinical presentation of peripheral arterial disease. The study was carried out for a period of 9 months.

Methods of collecting data: 1. Clinical: all patients were subjected to detailed clinical history and evaluation as mentioned in Performa. 2. Radiological investigation: Color assisted duplex ultrasound of extremities. Imaging technique: 5-15 MHz linear transducer was used to evaluate peripheral arteries in long and short axis in gray scale, colour and power Doppler as well as pulse wave modes along entire length. Pulse repetition frequency (PRF) was set optimally to detect best velocity and colour flow.

Affected arterial segments were identified on the basis of following parameters:

- Caliber of vessel- Normal caliber was interpreted by comparing the vessel caliber to adjacent vessel. Any abnormal dilatation or attenuation was noted. Arterial narrowing was graded using B mode images in Doppler USG.
- Atheromatous wall changes were identified in the form of any intimal thickening, mural calcification. - Lumen of affected arterial segments was assessed for presence of any plaque. Further plaque echogenicity was assessed qualitatively and categorized as low or moderate echogenicity.
- Colour Doppler and duplex imaging was performed to assess and document presence or absence of normal laminar flow within the affected vessel. Affected arterial segments were evaluated for their peak systolic velocities, spectral waveforms and documentation of peak systolic velocity ratios at the stenotic site.
- On spectral imaging, any deviation from normal triphasic waveform was noted in the arterial segments and in cases where the affected segment was not directly visualized, waveform changes distal to the point of stenosis were noted and stenosis grading was done accordingly.

Inclusion Criteria

Patients of any age group having unilateral or bilateral, acute or chronic extremity arterial disease, Symptomatic patients without signs & asymptomatic patients with signs of extremity arterial disease from March 2022 and November 2022.

Exclusion Criteria

Patients with extreme extremity ischemic pain, extensive ulceration and gangrene, history of extremity vascular surgery, traumatic extremity ulcers and immediate post-operative unstable patients with sterile dressing.

OBSERVATION AND RESULTS

Age group having highest incidence of peripheral arterial disease was 71- 80 years followed by 81 to 90 years. Ages below 50 years were noted to have the least incidence of peripheral arterial disease.

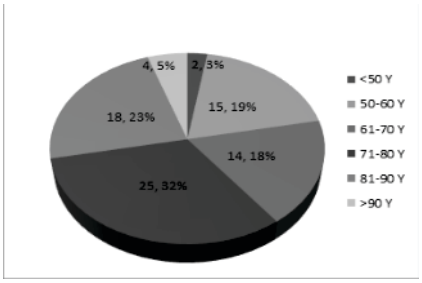

Chart 1: Distribution Of Patients According To Age

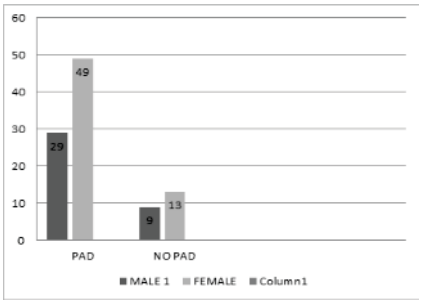

Chart2: Distribution Of Participants According To Gender

Females are noted to have a higher incidence of peripheral arterial disease as compared to males.

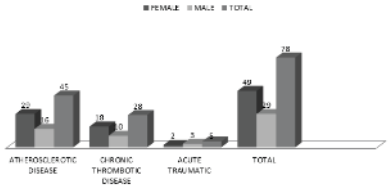

Chart 3: Gender Wise Distribution Of Patients According To Frequency Of Underlying Pathology

Atherosclerotic disease is the most frequent underlying cause of PAD in both males as well as females; acute traumatic embolism is the least frequent cause.

Table 01: Distribution Of Risk Factors Among Patients With Atherosclerosis

Risk Factors	No Of Male Patients With Pad Due To Atherosclerosis	No Of Female Patients With Pad Due To Atherosclerosis
HTN	10	13
DM	7	9
Deranged lipid profile	6	5
Smoking	12	-
NONE	03	2

Table 2: Gender And Underlying Pathology-wise Distribution Of Patients According To Multilevel Higher Grading Involvement

Sr. No.	Gender	Number Of PAD Patients ACC. To Multilevel Involvement Grade II & More At 2 & More Level			Total
		Atherosclerotic Disease	Chronic Thrombotic Disease	Acute Traumatic Embolism	
1.	FEMALE	10 (12.82%)	14 (17.95%)	--	24 (30.77%)
2.	MALE	10 (12.82%)	08 (10.26%)	--	18 (23.08%)
	TOTAL	20 (25.64%)	22 (28.21%)	--	42 (53.85%) (n=78)

Hypertension was found to be most commonly associated risk factor in both genders. However, no conclusions can be made on its statistical significance since atherosclerosis is a multifactorial disease and a cocktail of risk factors was found in our patients with various combinations of risk factors. Another major drawback was low prevalence of smoking in female population spuriously undermining its role as a cause of atherosclerosis.

Multilevel involvement of grade 2 and more at 2 and more sites is seen more frequently with chronic thrombotic disease in females while in males it is seen more frequently with atherosclerotic disease.

Table 3: Gender Wise Distribution Of Patients According To Underlying Pathology And Frequency Of Arterial Territorial Involvement

Sr. No.	ARTERY	Frequency Of Arterial Territorial Involvement					
		Atherosclerotic Disease		Chronic Thrombotic Disease		Acute Traumatic Embolism	
		F	M	F	M	F	M
1.	DAA	13	13	01	04	00	00
2.	CIA	15	06	02	01	00	00
3.	EIA	18	09	07	04	00	00
4.	CFA	15	07	08	04	00	00
5.	CFA Bi	17	05	08	04	00	00
6.	SFA	21	07	12	06	01	01
7.	DFA	13	06	08	05	00	00
8.	PA	15	08	10	05	01	01
9.	PEA	06	05	05	01	00	00
10.	ATA	10	08	07	06	00	00
11.	PTA	12	06	07	06	00	01
12.	DPA	13	07	08	03	00	00

In females, artery most frequently involved in atherosclerosis is noted to be superficial femoral artery (SFA) meanwhile in males, artery most frequently involved in atherosclerosis is noted to be distal abdominal aorta (DAA).

In females, artery most frequently involved in chronic thrombotic disease is noted to be superficial femoral artery (SFA) and in males, arteries most frequently involved in chronic thrombotic disease is noted to be superficial femoral artery (SFA), anterior tibial artery (ATA) and posterior tibial artery (PTA). No conclusions could be made on acute traumatic embolism due to less sample size.

Table 4: Distribution Of patients According To plaque Morphology

Sr. No.	Artery	Number Of Patientsacc. To Plaque Morphology			
		Hard Plaque	Soft Plaque	Marginal Plaque	Total (n=78)
1.	DAA	20 (25.64%)	11 (14.10%)	05 (06.41%)	36 (46.15%)
2.	CIA	16 (20.51%)	09 (11.53%)	17 (21.79%)	42 (53.85%)
3.	EIA	23 (29.49%)	18 (23.07%)	07 (08.97%)	48 (61.53%)
4.	CFA	18 (23.07%)	18 (23.07%)	06 (07.69%)	42 (53.85%)
5.	CFA Bi	23 (29.49%)	12 (15.38%)	12 (15.38%)	47 (60.26%)
6.	SFA	27 (34.61%)	22 (28.20%)	10 (12.82%)	59 (75.64%)
7.	DFA	19 (24.36%)	03 (03.85%)	19 (24.36%)	41 (52.56%)
8.	PA	23 (29.49%)	24 (30.77%)	02 (05.64%)	49 (62.82%)
9.	PEA	06 (07.69%)	18 (23.07%)	07 (08.97%)	31 (39.74%)
10.	ATA	14 (17.95%)	14 (17.95%)	02 (05.64%)	30 (38.46%)
11.	PTA	14 (17.95%)	16 (20.51%)	10 (12.82%)	40 (51.28%)
12.	DPA	17 (21.79%)	18 (23.07%)	10 (12.82%)	45 (57.69%)

The artery most severely affected by atherosclerosis is noted to be superficial femoral artery (SFA) followed by popliteal artery (PA). The artery least affected by atherosclerosis is noted to be peroneal artery (PEA).

Highest incidence of occlusion was noted in superficial femoral artery (SFA) followed by popliteal artery (PA) and least incidence of occlusion was noted in common iliac artery (CIA) followed by descending aortic artery (DAA).

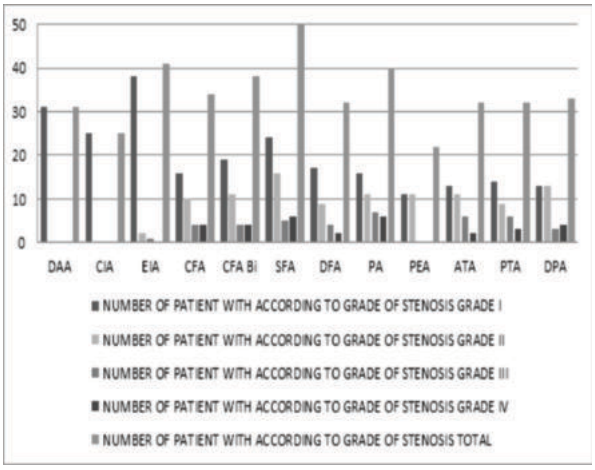

Chart 4: Distribution Of Patients According To The Grade Of Stenosis &frequency Of Arterial Territorial Involvement Among PAD Patients

The artery most affected by stenosis is noted to be superficial femoral artery (SFA) and least affected by stenosis is noted to be peroneal artery (PEA).

Table 5: Distribution Of Participants According ABI &AAPG

NUMBER OF PATIENTS ACCORDING TO ABI & AAPG			
ABI	AAPG (mmHg)	NUMBER OF PATIENTS	CLINICALLY CORRELATES WITH
>0.97	0 TO -20	50(%)	Walking distance >200 m
0.7-0.97	5 TO 20	39(%)	Walking distance <200 m
<0.7	>20	11(%)	Rest pain
TOTAL		100=n	

The highest number of participants had ABI more than 0.97. This indicates towards higher sensitivity of duplex study to detect PVD before clinical manifestations arise, which was found to be statistically significant. (P value: 0.00003)

Table 6: Spectral, PSV And PSVR Changes According To Grade Of Stenosis

	Grade Of Stenosis	Number Of Patient According To Chronic Thrombotic Disease			
		Decline in cross area	Increase in peak systolic velocity	Peak systolic velocity ratio	Intrastenotic spectrum changes
1.	No stenosis	--	--	~1	Triphasic
2.	Grade I	1 - 20 %	--	~1	Triphasic
3.	Grade II	21 - 50 %	≥40 %	≤2.4	Triphasic Raised PSV
4.	Grade III	51 - 99 %	≥120%	≥2.5	Monophasic Raised PSV Spectral broadening
5.	Grade IV	100 %	--	--	--

Higher grades (II and III) of stenosis are associated with hemodynamic alteration in form of raised PSV, PSVR and abnormal morphology of spectral waveforms.

Table 7: Average PSV In Patients Without PAD

ARTERY	AVERAGE PSV IN PATIENTS WITHOUT PAD (cm/s)
DAA	65
CIA	78
EIA	125
CFA	124
CFA Bi	117
SFA	99
DFA	98
PA	71
PERONEAL	65
ATA	59
PTA	58
DPA	33

Average PSV in patients without evident PAD at duplex ultrasound gives reliable normal values which can be generalized.

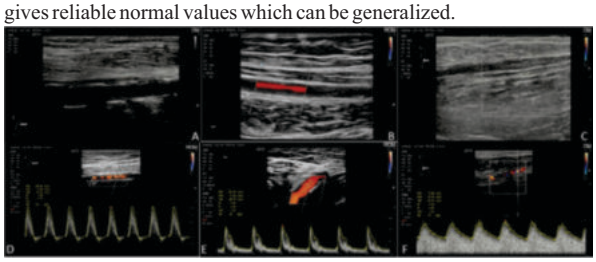

Figure 1 (A)- Atherosclerotic vessel wall calcification with posterior acoustic shadowing involving SFA. (B) Partial thrombosis, atheromatous vessel walls changes and increased IMT with resultant luminal narrowing involving distal SFA. (C) Complete thrombotic occlusion with atherosclerotic vessel wall thickening involving ATA. (D) Multisegmental partial thrombosis with resultant biphasic flow and increased PSV involving SFA (E) Large echogenic calcific atheromatous plaque causing partial stenosis with resultant intrastenotic monophasic spectral waveform, wide filling peak and raised PSV involving CFA. (F) Multisegmental partial stenosis with resultant monophasic spectral waveform and widening and filling of spectrum peak in anterior tibial artery.

DISCUSSION

Peripheral arterial disease is the most common condition affecting the arteries of the lower extremity, and duplex ultrasound is a valuable diagnostic technique to assess the severity of stenoses, thereby helping in early management. What we found in our study is that duplex ultrasound is an excellent tool for the evaluation of lower extremity arterial diseases and is sufficient for decision making in the treatment of these patients and can reduce the rate and risks involved in performing diagnostic angiography in resource-poor settings.

Here in a cross-sectional study with 100 participants having clinical (either symptoms or examination signs) suspicion of peripheral arterial disease were subjected to duplex ultrasound examination of which 78 were having notable evidence of PAD at ultrasound and in rest 22 patients, their clinical presentation (either symptoms or examination signs) were severe enough to suggest to indicate PVD but further contrast angiography might be needed to diagnose it.

Our study showed that peripheral arterial disease is more prevalent in females compared to males, as well as DM, HTN and hyperlipidemia as risk factors of peripheral artery disease and it matches with findings of study by S. P. Khan et al in gender prevalence as well as combination of HTN, high cholesterol and DM being responsible for the highest incidence of PAD in females and a combination of smoking, HTN, high cholesterol and DM having a high association with incidence of PAD in males. We also noted intra stenotic Doppler changes in form of increase in peak systolic velocity and spectral broadening which are corresponding to her findings [5] Ting Hway Wong et al (6) also observed HTN, DM, ESRD and IHD as prevalent risk factors and comorbidities in patients with PAD.

In our study, up to 90 % cross area reduction resulted in Intrastenotic increase in PSV; at 50-99 % cross area reduction, prominent spectral broadening and with ≥ 50 % cross area reduction Intrastenotic & downstream monophasic waveform were observed also as documented by Ji Young Hwang et al (7)

Our study demonstrated that most frequently involved arterial territory in PAD was SFA followed by PA and least involvement of peroneal artery which was similarly observed by Syeda Nilufar Islam et al (8)

Parameters	Our study	Syeda Nilufar Islam et al (43)
PSVR	≤2.4 at 21 to 50 % stenosis	1.5-2:1 at 25-50 % stenosis
	≥2.5 at 51 to 99 % stenosis	2-4:1 at 50-75 % stenosis >4:1 at >75 % stenosis
Atherosclerotic plaques	In 57.69 % patients	In 58.18 % patients

Arterial territorial involvement	SFA (59%) > PA (49%)	SFA (25%) > PA (20%)
PSV change in relation with vessel diameter reduction	≥40 % increase in PSV at 21-50% diameter reduction	48 % increase in PSV at 50 % diameter reduction

We found ABI cut off value for PAD 0.97 and most affected age group71 to 80 years, while ABI cut off value for PAD 0.89and most affected age group 65 to 74 years in study by Janaka Weragoda et al (9)

CONCLUSION

Duplex ultrasound scanning is a versatile and accurate first-line investigation method for the diagnosis, screening, and management of lower limb peripheral arterial disease. It has irreplaceable role because of its noninvasive and safer nature, lower cost, portability and additional advantage of providing important hemodynamic information to assess limb perfusion before and after interventions. However, the interpretation of arterial duplex testing requires knowledge of anatomy and hemodynamics. It is adequate, proven and excellent tool for management of peripheral vascular diseases reducing the risk and cost of diagnosis compared to CTA, MRA & DSA especially in lower income strata. Duplex ultrasound can accurately locate the site and assess severity of stenosis/occlusion and can classify peripheral arterial disease into hemodynamically nonsignificant and significant using various parameters. Diagnostic yield is highest in depicting abnormalities in patients with clinical features of peripheral arterial disease. Post intervention follow up study can be a future prospective in concerned study topic.

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