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Comparison of multidetector CT angiography and color doppler findings in the diagnosis of peripheral arterial diseases in lower limbs

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Abstract

Background: Peripheral arterial disease (PAD) is the most common condition affecting arteries of lower extremities. PAD adversely affects functional status of limb and is associated with poor quality of life.

Methodology: This study was conducted in Gandhi Medical College Bhopal in patients with peripheral arterial diseases. Suspected patients underwent USG & MDCT angiography and observations were recorded in predesigned proforma.

Results: The mean age was 46.66 years [SD = 13.51]. Majority (83%) participants were male. Out of 720 segments of lower limb arteries color doppler reported, total of 92/720 (12.8%) segments had grade I & II stenosis while 215/720 (29.9%) segments had grade III & IV stenosis and MDCT also reported a total of 307/720 stenosed segments. On comparison $p<0.001$ was obtained. Kappa statistics was applied to assess the level of agreement between MDCT & color doppler. Substantial level of agreement (0.7130) was observed for identification of stenosis. Other parameters compared were wall morphology and detection of collateral vessels.

Conclusion: In assessing mild PAD patients needing medical therapy & contraindicated to undergo CT, ultrasound is the better imaging modality. In patients with moderate to severe PAD & requiring surgical

intervention, CTA is preferred for thorough evaluation of entire lower limb arteries.

Keywords: Critical Limb Ischemia, Arteries, Duplex Ultrasound

Introduction

Peripheral vascular disease (PVD) refers to the diseases of blood vessels outside the heart & brain.[1] It is often referred to as the narrowing of vessels that carry blood to the legs, arms, stomach, or kidneys. It's a common vascular disorder with high incidence rates in the industrialized world making it a major contributor to significant morbidity & mortality.[1,2]Peripheral arterial disease (PAD) is defined as a clinical disorder in which there is occlusion or stenosis of the aorta or arteries of the limbs.[3]It is an occlusive atherosclerotic condition in which plaque is build up in the distal arteries, constricting the circulation & blood flow.[4,5] The term PAD is also used more broadly to include a larger range of non-coronary arterial diseases or syndromes that are caused by the altered structure or function of arteries to the brain, visceral organs, & limbs.[4]

PAD is diffuse in nature & contributes significantly towards the morbidity & mortality in the industrialized world. [6,7] As such, the true prevalence of PAD in the general population is unknown. [4,8] The incidence of PAD varies in the general population from 3% to 10% in people younger than 70 years to 15% to 20% in people older than 70 years. However, about 40% of PAD patients are asymptomatic.[9] From 1999 to 2004, 5.9 percent of the Indian population of age 40 years or older had a low ABI, which amounts to 7.1 million people. [4, 9] Symptomatic PAD might be observed as an estimated annual incidence of 26/10,000 in male & 12/10,000 in female population. [1, 10]

Atherosclerosis is the most common cause for PAD.[11] Other causes include thromboembolism, micro embolism, acute thrombotic occlusion, trauma, entrapment syndromes, vasculitis including vasospastic disorders & Buerger's disease. [11,12] Risk factors for atherosclerosis include race, male gender, increasing age, smoking, hypertension, diabetes, hypercoagulable states, dyslipidaemia, hypercholesterolemia & impaired kidney function etc. [4,13]

It is the most common condition affecting arteries of the lower extremities. [7,12] The disorder affects the lower limbs eight times more than the upper limbs. The lower limb ischaemia presents as two clinically distinct entities: intermittent claudication & critical limb ischaemia.[14] The most common symptom is intermittent claudication defined as numbness, pain, or a sense of fatigue in the muscles, which is increased by exercise & relieved by rest. Critical lower limb ischemia is defined as rest pain (night pain), tissue loss (Ulceration or gangrene) lasting for more than 2 weeks, presence of ankle blood pressure of less than 50 mmHg.[14]

Usually, the presence of symptoms in PAD depends on the metabolic demands of the affected ischemic tissue during exercise, the degree of collateral circulation, as well as the size & location of the affected artery.[9] The disease may manifest as claudication, rest pain, local tissue loss (Ulceration), or gangrene.[15]

Clinical history & evaluation play a decisive role in discriminating symptoms of PAD from other conditions presenting with leg pain, elucidating cardiovascular risk factors & the effect of symptoms on the patient's quality of life. Palpation of peripheral pulses must be supplemented by determining the ankle-brachial pressure index using a hand-held Doppler. [9,16]

Several imaging techniques available include CT angiography, magnetic resonance (MR) angiography & duplex ultrasonography. These techniques are less invasive as compared to contrast angiography, although

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CT angiography carries risks related to ionizing radiation, & both contrast-enhanced MR angiography & CT angiography carry drawbacks associated with the use of contrast agents. [9,17] These are indicated to identify the severity &location of arterial stenosis when considering possible intervention. [11,18]

Conventional angiography is the gold standard for imaging of occlusive disease in the lower extremity. However, this method is invasive, expensive & has a definite, though low, morbidity.[9] But the major disadvantage is that it fails to estimate the hemodynamic significance. [4,12]

Color Doppler ultrasonography is a non-invasive method for the tentative finding of Peripheral arterial disease.[19] CD-US detects arterial flow spectrum with the identification of stenosed or blocked parts.[19-21] It is an inexpensive, easily accessible investigation, with no risk of radiation exposure also no contrast is required & no part preparation is needed.[19,22,23] But it is less accurate in the aortoiliac region & in obese patients because of increased bowel gas & limited sensitivity for multilevel stenosis. Ultrasonographic anatomy of the lower limb &knowledge of equivalent anatomical land-marks are important for colour Doppler ultrasound. Lower extremity arteries can be noticed through associated vein, encompassing from the iliac to the popliteal area.[19]

CT angiography is increasingly attractive because of the complete coverage of the arteries of lower extremity. Collaterals are also best seen with MDCT. [7,12] Imaging of inflow & run off arteries is possible with one acquisition by using a single contrast bolus in MDCT angiography. MDCT angiography aides in adequate decision making for treatment recommendations concerning both the anatomical level of stenosis & the revascularisation technique. During the last decade, it has been comparable with conventional angiography for the assessment of aorta, carotid, renal, iliac & pulmonary arteries. [7,9]

It is a reliable non-invasive tool in quantifying the number, length & grade of stenosis. [6,21] It mainly delineates the presence or absence of significant obstruction to the blood flow, the anatomical site & extent of obstruction, the status of collaterals & distal vasculature which is crucial for planning the treatment & to monitor the results of therapy & disease progression. [6,22]

The first medical approach in patients presenting with PAD consists of screening for other associated cardiovascular & cerebrovascular pathologies. Secondarily an optimal medical management of the cardiovascular risk factors is imperative with an attempt for healthy life-style modifications. Thirdly, walking exercises are necessary in order to improve walking capacity & thus quality of life, especially for patients with claudication. Finally, in cases of severe life-limiting claudication or with signs of critical limb ischemia, a revascularization procedure should be attempted. For this reason, the evaluation of peripheral vasculature is an integral part in the management of patients with peripheral vascular disease. Also, polytrauma patients with suspected vascular injury &those with bone & soft tissue tumors need to be evaluated further for better treatment. [23]

Acute compromise of arterial flow due to stenosis & occlusion can result in limb ischemia resulting in amputation, stroke &myocardial infarction. It is an independent risk factor for vascular disease in other regions. PAD adversely affects the functional status of the limb & is consequently associated with poor quality of life.[12] Therefore, early diagnosis & effective treatment is mostly rewarded with good outcome &

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averts dreadful complications. Thus, the study was conducted to assess color Doppler ultrasonography & MDCT findings in patients with peripheral arterial disease & also to compare color Doppler ultrasonography findings with MDCT angiography & correlation of severity of stenosis, plaque morphology &collaterals in patients with peripheral arterial disease.

Methods

The present study entitled "Comparison of multidetector CT angiography and color doppler findings in the diagnosis of peripheral arterial diseases in lower limbs" was carried out over a period of two years. The study was conducted at Gandhi Medical College, & associated Hospitals (Hamidia Hospital) Bhopal, which acts as a referral centre catering to the needs of people from different strata of society, predominantly to lower & lower middle class. Considerable numbers of patients seek care at the hospital despite of many hospitals in the city. Patients from almost all the areas of Bhopal & nearby districts (rural as well as urban) seek medical attention there. A total of 80 participants were enrolled in the study.

Inclusion Criteria

- Patients presenting with lower limb intermittent claudication/ rest pain.
- Patients with gangrene of limbs.
- Patients with absent peripheral pulses in limbs.
- Patients with positive findings on colour flow imaging (USG).

Exclusion criteria:

- Patients not consenting to the study
- Pregnancy (Risk vs benefit ratio to be assessed)
- Patients with adverse reactions to contrast.
- Patients with deranged renal function test (serum creatinine>1.4mg/dl).

All patients were subjected to the following

Permission to conduct the study was obtained from the ethical committee of Gandhi Medical College, Bhopal, Madhya Pradesh.

The study was conducted on patients which were referred to radiodiagnosis department, Gandhi Medical College, & associated Hospitals (Hamidia Hospital) Bhopal with suspected peripheral arterial diseases. After obtaining informed consent & explaining the purpose of study to the participants, data collection was done & information was recorded on a predesigned, pretested & semi-structured proforma. The questionnaire included information on brief history from the participant regarding symptomatology & duration of disease. The patients then underwent USG & CT Peripheral angiography. The observations were recorded on stenosis of vessels, plaque morphology (which included occlusion, thrombus formation & plaque calcification), peak systolic velocity (PSV), wall morphology (which included wall thickening, calcification & atheromatous changes), spectral waveform & collaterals.

Sample size and statistical analysis

The present study was done on 80 patients referred to our radiodiagnosis department for peripheral arterial diseases.

Data was entered into MS excel 2007, analysis was done with the help of Epi info Version 7.2.2.2. Frequency & percentages were calculated.

Quantitative variables were expressed as the mean & standard deviation. Categorical data was expressed as percentage. Microsoft office was used to prepare the graphs.

Chi- square/ Fischer's exact test was applied for comparison. $P<0.05$ was considered to be statistically significant. Kappa statistics was applied for measurement of degree of agreement.

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Results

The mean age was 46.66 years [SD = 13.51]. Majority (83%) of participants were male.

A.1. Color Doppler USG findings in Lower limb arteries

Table 1: Distribution of arteries of lower limb on the basis of grade of Stenosis on color doppler

		Stenosis Grade					Total
		Nil	I	II	III	IV	
Anterior Tibial Artery	N	40	5	7	4	24	80
	%	50.00%	6.30%	8.80%	5.00%	30.00%	100.00%
Common Femoral Artery	N	62	1	5	1	11	80
	%	77.50%	1.30%	6.30%	1.30%	13.80%	100.00%
Common Iliac Artery	N	57	1	3	4	15	80
	%	71.30%	1.30%	3.80%	5.00%	18.80%	100.00%
Dorsalis Pedis Artery	N	38	8	3	5	26	80
	%	47.50%	10.00%	3.80%	6.30%	32.50%	100.00%
External Iliac Artery	N	57	1	3	4	15	80
	%	71.30%	1.30%	3.80%	5.00%	18.80%	100.00%
Peroneal Artery	N	25	6	18	5	26	80
	%	31.30%	7.50%	22.50%	6.30%	32.50%	100.00%
Popliteal Artery	N	53	4	4	3	16	80
	%	66.30%	5.00%	5.00%	3.80%	20.00%	100.00%
Posterior Tibial	N	31	4	9	4	32	80
	%	38.80%	5.00%	11.30%	5.00%	40.00%	100.00%
Superficial Femoral	N	50	1	9	8	12	80
	%	62.50%	1.30%	11.30%	10.00%	15.00%	100.00%
Total	N	413	31	61	38	177	720
	%	57.40%	4.30%	8.50%	5.30%	24.60%	100.00%

Table depicts Distribution of arteries of lower limb on the basis of grade of Stenosis in color doppler. 92/720 (12.8%) segments had grade I & II Stenosis while 215/720 (29.9%) segments had grade III & IV Stenosis. A total of 307 segments (out of 720 segments) of 80 patients in lower limb were found to be stenosed, which included anterior tibial artery (40 segments), common femoral artery (18 segments), common iliac artery (23 segments), dorsalis pedis artery (42 segments), external iliac artery (23 segments), peroneal artery (55 segments), popliteal artery (27 segments), posterior tibial artery (49 segments) & superficial femoral artery (30 segments).

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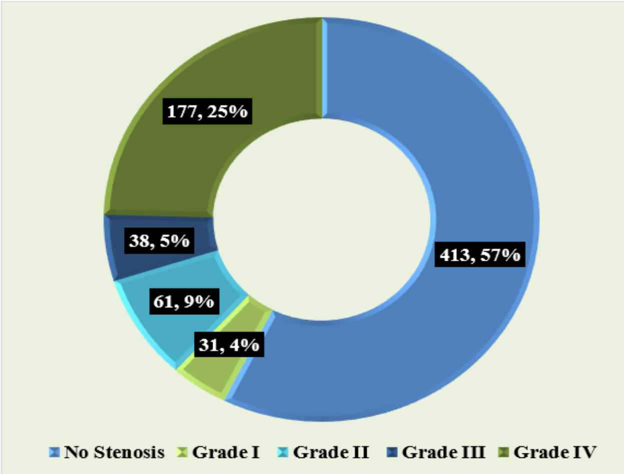

Figure 1: Lower limb arterial Grade of Stenosis in color doppler

Table 2: Distribution of arteries of lower limb on the basis of grade of plaque morphology on color doppler

		Plaque Morphology			Total
		No Plaque	Heterogenous Plaque	Homogenous Plaque	
Anterior Tibial Artery	n	48	6	26	80
	%	60.00%	7.50%	32.50%	100.00%
Common Femoral Artery	n	63	10	7	80
	%	78.80%	12.50%	8.80%	100.00%
Common Iliac Artery	n	58	16	6	80
	%	72.50%	20.00%	7.50%	100.00%
Dorsalis Pedis Artery	n	48	4	28	80
	%	60.00%	5.00%	35.00%	100.00%
External Iliac Artery	n	58	13	9	80
	%	72.50%	16.30%	11.30%	100.00%
Peroneal Artery	n	34	5	41	80
	%	42.50%	6.30%	51.20%	100.00%
Popliteal Artery	n	54	10	16	80
	%	67.50%	12.50%	20.00%	100.00%
Posterior Tibial Artery	n	36	5	39	80
	%	45.00%	6.30%	48.80%	100.00%
Superficial Femoral	n	51	13	16	80
	%	63.70%	16.30%	20.00%	100.00%
Total	n	450	82	188	720
	%	62.50%	11.40%	26.10%	100.00%

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The table depicts the distribution of arteries of lower limb on the basis of plaque morphology on color doppler. A total of 270 segments (out of 720 segments) reported plaque formation with heterogenous (11.4%) & homogenous (26.1%) plaques. In anterior tibial artery, 32.5% segments reported homogenous plaque & 7.5%segments reported heterogenous plaque. In common femoral artery,8.8% segment reported homogenous plaque & 12.5% segments reported heterogenous segment. In common iliac artery, 7.5% segment reported homogenous plaque & 20% segments reported heterogenous segment. In dorsalis pedis artery, 35.0% segment reported homogenous plaque & 5.0% segments reported heterogenous segment. In external iliac artery, 11.3% segment reported homogenous plaque & 16.3% segments reported heterogenous segment. In peroneal artery, 51.2% segment reported homogenous plaque & 6.3% segments reported heterogenous segment. In popliteal artery, 20.0% segment reported homogenous plaque & 12.5% segments reported heterogenous segment. In posterior tibial artery, 48.8% segment reported homogenous plaque & 6.3% segments reported heterogenous segment. In superficial femoral artery, 20.0% segment reported homogenous plaque & 16.3% segments reported heterogenous segment.

Table 3: Distribution of arteries of lower limb on the basis of grade of peak systolic velocity on color doppler

		PSV			Total
		Normal	Abnormal	Completely Obstructed	
Anterior Tibial Artery	N	45	12	23	80
	%	56.30%	15.00%	28.70%	100.00%
Common Femoral Artery	N	65	3	12	80
	%	81.30%	3.80%	15.00%	100.00%
Common Iliac Artery	N	54	10	16	80
	%	67.50%	12.50%	20.00%	100.00%
Dorsalis Pedis Artery	N	46	6	28	80
	%	57.50%	7.50%	35.00%	100.00%
External Iliac Artery	N	59	3	18	80
	%	73.80%	3.80%	22.50%	100.00%
Peroneal Artery	N	36	19	25	80
	%	45.00%	23.80%	31.30%	100.00%
Popliteal Artery	N	50	12	18	80
	%	62.50%	15.00%	22.50%	100.00%
Posterior Tibial Artery	N	39	11	30	80
	%	48.80%	13.80%	37.50%	100.00%
Superficial Femoral	N	55	11	14	80
	%	68.80%	13.80%	17.50%	100.00%
Total	N	449	87	184	720
	%	62.40%	12.10%	25.60%	100.00%

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Table C3 shows Distribution of arteries of lower limb on the basis of Peak systolic velocity on color doppler. 25.6% of segments observed complete obstruction which included anterior tibial artery (23 segments), common femoral artery (12 segments), common iliac artery (16 segments), dorsalis pedis artery (28 segments), external iliac artery (18 segments), peroneal artery (25 segments), popliteal artery (18 segments), posterior tibial artery (30 segments) & superficial femoral artery (14 segments). While abnormal peak systolic velocity was observed in 12.1% of segments which included anterior tibial artery (12 segments), common femoral artery (3 segments), common iliac artery (10 segments), dorsalis pedis artery (6 segments), external iliac artery (3 segments), peroneal artery (19 segments), popliteal artery (12 segments), posterior tibial artery (11 segments) & superficial femoral artery (11 segments).

Table 4: Distribution of arteries of lower limb on the basis of grade of wall morphology on color doppler

		Wall Morphology			Total
		Nil	Normal	Abnormal	
Anterior Tibial Artery	N	0	77	3	80
	%	0.00%	96.30%	3.80%	100.00%
Common Femoral Artery	N	0	70	10	80
	%	0.00%	87.50%	12.50%	100.00%
Common Iliac Artery	N	0	63	17	80
	%	0.00%	78.80%	21.30%	100.00%
Dorsalis Pedis Artery	N	1	75	4	80
	%	1.30%	93.80%	5.00%	100.00%
External Iliac Artery	N	0	67	13	80
	%	0.00%	83.80%	16.30%	100.00%
Peroneal Artery	N	0	77	3	80
	%	0.00%	96.30%	3.80%	100.00%
Popliteal Artery	N	0	66	14	80
	%	0.00%	82.50%	17.50%	100.00%
Posterior Tibial Artery	N	0	77	3	80
	%	0.00%	96.30%	3.80%	100.00%
Superficial Femoral	N	0	67	13	80
	%	0.00%	83.80%	16.30%	100.00%
Total	N	1	639	80	720
	%	0.10%	88.80%	11.10%	100.00%

Distribution of arteries of lower limb on the basis of wall morphology on color doppler have been displayed in above table. 11.1% of segments have shown abnormal wall morphology. 3.8% of anterior tibial artery, 12.5% of common femoral artery, 21.3% of common iliac artery, 5.0% of dorsalis pedis artery, 16.3% of external iliac

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artery, 3.8% of peroneal artery, 17.5% of popliteal artery, 3.8% of posterior tibial artery & 16.3% of superficial femoral artery have reported abnormal wall morphology.

*Note: in one patient dorsalis pedis artery could not be assessed as the patient was amputated.

A.2. MDCT findings in Lower limb arteries

Table 5: Distribution of arteries of lower limb on the basis of presence of filling defect on MDCT

		Filling Defect		Total
		Present	Absent	
Anterior Tibial Artery	N	25	55	80
	%	31.30%	68.80%	100.00%
Common Femoral Artery	N	17	63	80
	%	21.30%	78.80%	100.00%
Common Iliac Artery	N	23	57	80
	%	28.70%	71.30%	100.00%
Dorsalis Pedis Artery	N	26	54	80
	%	32.50%	67.50%	100.00%
External Iliac Artery	N	22	58	80
	%	27.50%	72.50%	100.00%
Peroneal Artery	N	34	46	80
	%	42.50%	57.50%	100.00%
Popliteal Artery	N	17	63	80
	%	21.30%	78.80%	100.00%
Posterior Tibial Artery	N	37	43	80
	%	46.30%	53.80%	100.00%
Superficial Femoral	N	26	54	80
	%	32.50%	67.50%	100.00%
Total	N	227	493	720
	%	31.50%	68.50%	100.00%

On MDCT of lower limb arteries, filling defect was observed in 31.3% of anterior tibial artery, 21.3% of common femoral artery, 28.7% of common iliac artery, 32.5% of dorsalis pedis artery, 27.5% of external iliac artery, 42.5% of peroneal artery, 21.3% of popliteal artery, 46.3% of posterior tibial artery & 32.5% of superficial femoral artery.

Table 6: Distribution of arteries of lower limb on the basis of grade of stenosis on MDCT

		Stenosis Grade					Total
		Nil	I	II	III	IV	
Anterior Tibial Artery	n	38	2	14	11	15	80

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	%	47.50%	2.50%	17.50%	13.80%	18.80%	100.00%
Common Femoral Artery	n	59	0	7	5	9	80
	%	73.80%	0.00%	8.80%	6.30%	11.30%	100.00%
Common Iliac Artery	n	57	0	2	7	14	80
	%	71.30%	0.00%	2.50%	8.80%	17.50%	100.00%
Dorsalis Pedis Artery	n	43	1	9	4	23	80
	%	53.80%	1.30%	11.30%	5.00%	28.70%	100.00%
External Iliac Artery	n	58	0	2	3	17	80
	%	72.50%	0.00%	2.50%	3.80%	21.30%	100.00%
Peroneal Artery	n	25	2	21	11	21	80
	%	31.30%	2.50%	26.30%	13.80%	26.30%	100.00%
Popliteal Artery	n	55	1	3	10	11	80
	%	68.80%	1.30%	3.80%	12.50%	13.80%	100.00%
Posterior Tibial Artery	n	30	1	16	9	24	80
	%	37.50%	1.30%	20.00%	11.30%	30.00%	100.00%
Superficial Femoral	n	48	1	6	10	15	80
	%	60.00%	1.30%	7.50%	12.50%	18.80%	100.00%
Total	n	413	8	80	70	149	720
	%	57.40%	1.10%	11.10%	9.70%	20.70%	100.00%

Above table depicts Distribution of arteries of lower limb on the basis of grade of Stenosis in MDCT. A total of 307 segments (out of 720 segments) of 80 patients in lower limb were found to be stenosed, which included anterior tibial artery (42 segments), common femoral artery (21 segments), common iliac artery (23 segments), dorsalis pedis artery (37 segments), external iliac artery (22 segments), peroneal artery (55 segments), popliteal artery (25 segments), posterior tibial artery (50 segments) & superficial femoral artery (32 segments).

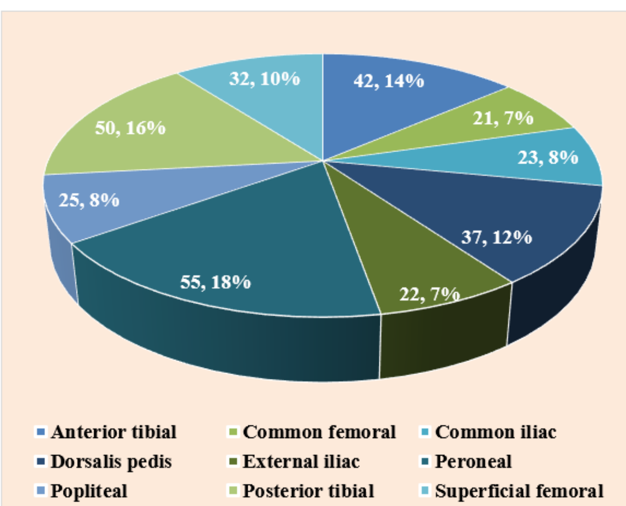

Figure 2: Lower limb arterial Grade of stenosis on MDCT

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Table 7: Distribution of arteries of lower limb on the basis of wall morphology on MDCT

		Wall Morphology			Total
		Nil	Normal	Abnormal	
Anterior Tibial Artery	n	0	73	7	80
	%	0.00%	91.30%	8.80%	100.00%
Common Femoral Artery	n	0	65	15	80
	%	0.00%	81.30%	18.80%	100.00%
Common Iliac Artery	n	0	62	18	80
	%	0.00%	77.50%	22.50%	100.00%
Dorsalis Pedis Artery	n	1	73	6	80
	%	1.30%	91.30%	7.50%	100.00%
External Iliac Artery	n	0	65	15	80
	%	0.00%	81.30%	18.80%	100.00%
Peroneal Artery	n	0	72	8	80
	%	0.00%	90.00%	10.00%	100.00%
Popliteal Artery	n	0	66	14	80
	%	0.00%	82.50%	17.50%	100.00%
Posterior Tibial Artery	n	0	74	6	80
	%	0.00%	92.50%	7.50%	100.00%
Superficial Femoral	n	0	60	20	80
	%	0.00%	75.00%	25.00%	100.00%
Total	n	1	610	109	720
	%	0.10%	84.70%	15.10%	100.00%

Distribution of arteries of lower limb on the basis of wall morphology on MDCT have been displayed in table C8. 15.1% of segments have shown abnormal wall morphology. 8.8% of anterior tibial artery, 18.8% of common femoral artery, 22.5% of common iliac artery, 7.5% of dorsalis pedis artery, 18.8% of external iliac artery, 10% of peroneal artery, 17.5% of popliteal artery, 7.5% of posterior tibial artery & 25% of superficial femoral artery have reported abnormal wall morphology on MDCT.

*Note: in one patient dorsalis pedis artery could not be assessed as the patient was amputated.

A 3. Comparison of Color Doppler findings with MDCT findings in Lower limb arteries

Table 8: Comparison on the basis of presence of stenosis

		MDCT Stenosis Grade, n(%)					Total
		Nil	I	II	III	IV	
Color Doppler Stenosis Grade, n(%)	Nil	389 (94.2)	3 (37.5)	18 (22.5)	2 (2.9)	1 (0.7)	413 (57.4)
	I	12 (2.9)	3 (37.5)	14 (17.5)	1 (1.4)	1 (0.7)	31 (4.3)
	II	5 (1.2)	2 (25.0)	40 (50.0)	9 (12.9)	5 (3.4)	61 (8.5)
	III	1 (0.2)	0 (0.0)	6 (7.5)	26 (37.1)	5 (3.4)	38 (5.3)
	IV	6 (1.5)	0 (0.0)	2 (2.5)	32 (45.7)	137 (91.9)	177 (24.6)
Total		413 (100.0)	8 (100.0)	80 (100.0)	70(100.0)	149 (100.0)	720(100.0)

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On comparison of stenosis grade between color doppler & MDCT finding, it was observed that both color doppler & MDCT have detected 413 segments without stenosis. p<0.001 indicates that there is significant difference in the detection of the extent of segment involvement in lower limb arteries.

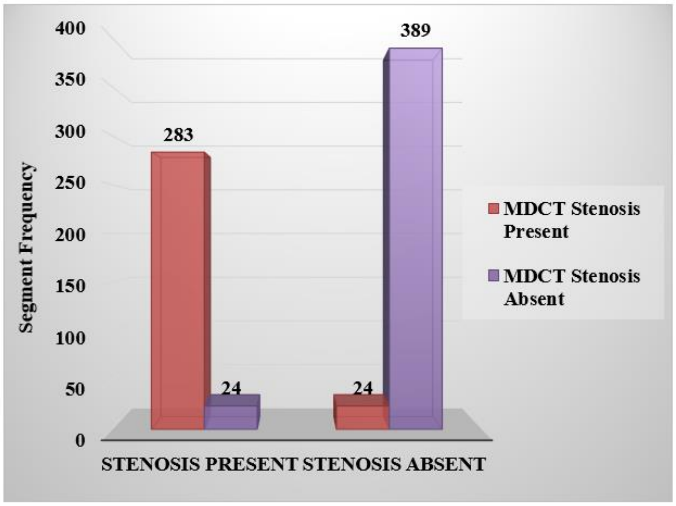

Figure 3: Comparison of color doppler finding with MDCT for lower limb arterial stenosis

Kappa statistics was applied to assess the level of agreement between MDCT &color doppler. Substantial level of agreement (0.7130) was observed for identification of stenosis.

Table 9: Comparison on the basis of wall morphology

		MDCT Wall Morphology n(%)		Total	Cohen's k, p value
		Normal	Abnormal		
Color Doppler Wall Morphology n(%)	Normal	599 (98.2)	40 (36.7)	639 (88.9)	0.6828, <0.001
	Abnormal	11 (1.8)	69 (63.3)	89 (12.4)	
Total		610 (100.0)	109 (100.0)	719 (100.0)	

On comparison for wall morphology, p value < 0.001 indicates that there is significant difference in detection of the extent of segment involvement in lower limb arteries. It was observed that color doppler has detected stenosis in 89 segments with abnormal wall morphology while MDCT has detected the same in 109 segments.

Kappa statistics was applied to assess the level of agreement between MDCT &color doppler. Substantial level of agreement (0.6828) was observed for identification of morphology.

Table 10: Comparison on the basis of presence of collaterals

		MDCT Collaterals, n(%)		Total	Cohen's k, p value
		Present	Absent		
Color Doppler Collaterals, n (%)	Present	32 (65.3)	9 (29.0)	41 (51.3)	0.3463, 0.002
	Absent	17 (34.7)	22 (71.0)	39 (48.8)	
Total		49 (100.0)	31 (100.0)	80 (100.0)	

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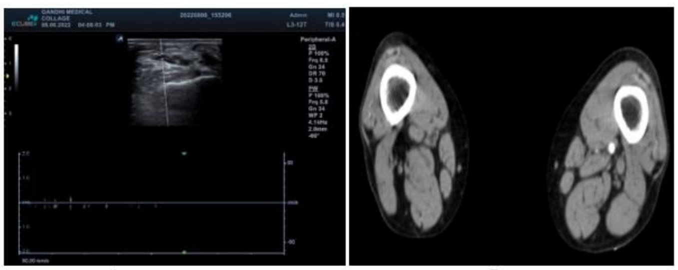
On comparison for presence of collaterals, p value 0.002 indicates that there is significant difference in detection of the extent of segment involvement in lower limb arteries. It was observed that color doppler has detected stenosis in 41 segments with collaterals while MDCT has detected the same in 49 segments.

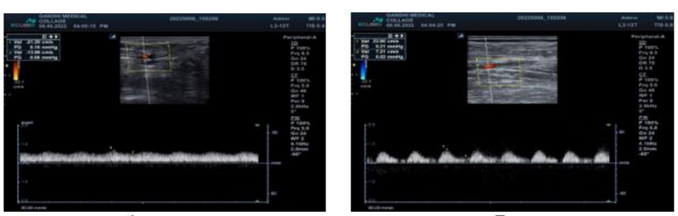
Kappa statistics was applied to assess the level of agreement between MDCT &color doppler. Fair level of agreement (0.3463) was observed for identification of collaterals.

Observations

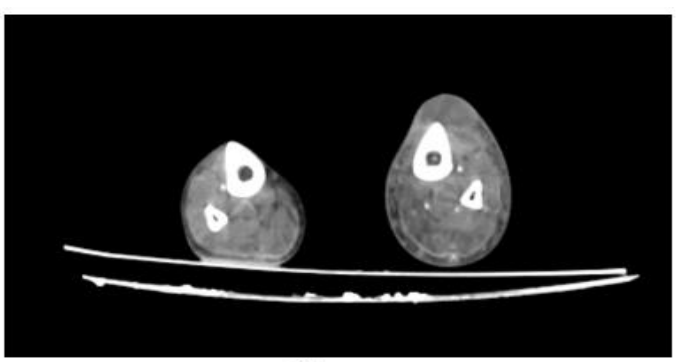


A B

Figure 4: 52-Year-old, diabetic, came with acute right leg pain at rest (A) Colour doppler study shows heterogenous heteroechoic thrombus occluding lumen of right SFA with no colour flow, no spectral waveform (B) CT angiogram axial section shows filling defect in right SFA due to thrombus causing its complete occlusion (grade 4 stenosis) , Left SFA shows normal contrast opacification.

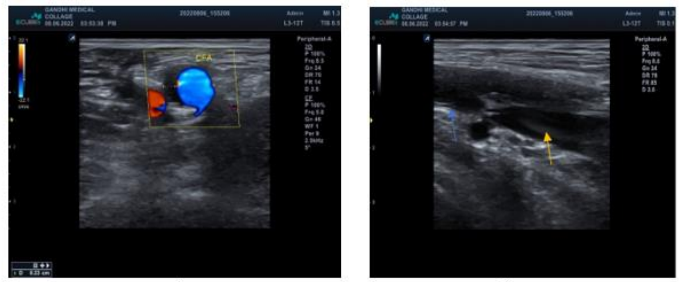


A B



C

Figure 5: 46 years old smoker & hypertensive patient, came with right leg claudication (A) Colour doppler study shows moderate stenosis of right PTA with spectral broadening & monophasic spectral pattern (B) Colour doppler study shows mild stenosis of right peroneal artery with slightly reduced colour flow & biphasic spectral pattern (C) CT angiogram axial section shows filling defect in right PTA & peroneal artery likely due to thrombus, bilateral ATA, left PTA & left peroneal artery shows normal contrast opacification.



A B

Figure 6: 61 years old diabetic patient, came with left leg pain & distal toe gangrene (A) Color doppler study shows eccentric atherosclerotic wall thickening of maximum thickness measuring approx. 2.3mm left CFA causing 20% occlusion of its lumen, patent lumen shows normal color flow (B) Grey scale ultrasound image shows CFA (blue arrow) & its branches SFA & DFA with hyperechoic thrombus (yellow arrow) in DFA causing partial occlusion of its lumen.

A B

Figure 7: 57 years old smoker, non-hypertensive patient, came with left thigh & leg pain & dry gangrene CT angiogram with VRT & MIP images showing filling

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defect in left DFA, distal SFA, popliteal artery, tibio-peroneal trunk & proximal ATA & attenuation of distal ATA, PTA & peroneal artery.

Discussion

The present study entitled "**Comparison of multidetector CT angiography & color doppler findings in the diagnosis of peripheral arterial diseases of lower limbs**" was carried out for a period of two years. A total of 80 participants were enrolled in the study. A total of 720 arterial segments were examined from lower limb.

Age distribution

Recent study found that the mean age of participants in in lower limb is 46.66 ± 13.51 years suggesting that PAD affected middle aged & elderly more. Similar results have been observed in various studies. **Kumar K et al (2020) [24]** encountered age range of 27-76 years with mean age of 50.6yrs. **Deepa S et al (2020) [11],** observed age group of 40-70 years.

Gender distribution

Male predominance was observed in our study (87.5%). Similar results were obtained by **Sarkar S et al (2021)[9], Zakir M et al (2021)[19], Deepa S et al (2020)[11], Kondeti K et al (2020)[12], Prasad MBV et al (2020)[25], Raj MBN et al (2020)[6], Choudhary VK et al (2019)[13], Kadhim MA et al[26] in 2018 , Hasa R et al**(2016)**[27], Shirol RJ et al (2015)[7], Elsaied FM et al (2015)[70]**&**Rajpal K et al (2016)[1]**where 60.4%, 69.6%, 72%, 67.5%, 91.4%, 75%, 75%, 66.6%, 85%, 80%, 90% & 72% male participants were reported respectively.

Plaque morphology

As per recent study, plaque morphology on color doppler in upper limb arteries reported that 37.5% out of 720 segments had plaque formation with 11.4% heterogenous & 36.1% homogenous plaques. **Prasad MBV et al (2020) [25]** were MDCT was able to identify calcified plaque in more arterial segments than color doppler. Especially in iliac group, MDCT could detect 47 segments in comparison to 28 segments detected on doppler & in tibio-peroneal segments, out of 210 segments, doppler detected 27 segments & MDCT detected 35 segments with calcified plaque.in our study, the overall sensitivity, specificity, positive & negative predictive values & accuracy of doppler in detecting calcified plaque is 74%, 100%, 100%, 94% & 94% respectively. Better sensitivity &specificity of MDCT were also observed in studies by **Sathyabhuwan et al[28]**& **Hideki ota et al[29]**

Peak systolic velocity (PSV)

As per our study, PSV on color doppler of lower limb PSV showed that 25.6% of segments had complete obstruction which included anterior tibial artery (23 segments), common femoral artery (12 segments), common iliac artery (16 segments), dorsalis pedis artery (28 segments), external iliac artery (18 segments), peroneal artery (25 segments), popliteal artery (18 segments), posterior tibial artery (30 segments) & superficial femoral artery (14 segments). While abnormal peak systolic velocity was observed in 12.1% of segments which included anterior tibial artery (12 segments), common femoral artery (3 segments), common iliac artery (10 segments), dorsalis pedis artery (6 segments), external iliac artery (3 segments), peroneal artery (19 segments), popliteal artery (12 segments), posterior tibial artery (11 segments) & superficial femoral artery (11 segments). **Sarkar S et al (2021) [9]** & **Raj MBN et al (2020) [6]** observed that there was a significant relation between PSV ratio values & grade of Stenosis.

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Grade of stenosis

Current study found that in lower limb, 92/720 (12.8%) segments had grade I & II Stenosis while 215/720 (29.9%) segments had grade III & IV Stenosis. Both color doppler &MDCT have detected 317 segments with stenosis. p<0.001 indicates that there is a significant difference in the identification of the extent of arterial segment involvement. For detection of grade of stenosis sensitivity, specificity, PPV & NPV of colour doppler in comparison to MDCT is 92.15%, 94.96%, 92.96% & 94.36% respectively. Kappa statistics was applied to assess the level of agreement between MDCT &color doppler. Almost perfect level of agreement (0.872) was observed for identification of stenosis. This suggests that MDCT is a better than color doppler in detection of Stenosis.

Similar results were observed by various studies. **Sarkar S et al (2021) [9]**foundsensitivity of CT in comparison to DSA was 66%, 86% & 96% in detection of stenosis for <20% , 20-49% & 50-74% respectively. Results of **Zakir M et al (2021) [19]** found the sensitivity value was 86.84% & specificity value was 87.50 when compared color doppler with MDCT. **Kumar K et al (2020) [24],** the number of segments with greater than 50% stenosis were 54 (11.34%) on DUS. When DUS &MDCTA were compared in identifying stenotic or occlusive lesions, MDCTA showed 9.8% lesions more than DUS. **Deepa S et al (2020) [11]** observed that the detection rate for Grade 1 &2 stenosis were higher in CDUS than CTA in all the three arterial regions.

Wall morphology

In our study, on comparison for wall morphology between colour doppler & MDCT findings for all arteries, it was observed that MDCT detected 121/819 (14.8%) of abnormal segments while colour doppler detected 90/819 (11.0%) of abnormal segments. Both colour Doppler &MDCT have detected 685 segments with normal wall morphology. p<0.001 indicates that there is significant difference in the identification of extent of the arterial segment involvement. For detection of normal wall morphology sensitivity, specificity, PPV& NPV of colour doppler in comparison to MDCT is 98.14%, 63.64%, 93.96% & 85.56% respectively. Kappa statistics was applied to assess the level of difference between MDCT & colour doppler. Substantial level of difference (0.691) was observed for wall morphology.

Joshi A[18], Nimbkar A, Merchant S, *et al*.[3]in 2004 also found CTA to be more accurate in the identification of calcified plaque. In our study, a total of 120 (7.1%) segments on CDS & 178 (10.5%) segments on CTA showed calcification similar to above studies.

Prasad MBV et al (2020)[25] found that colour doppler ultrasound was less accurate than MDCTA for detection of arterial occlusion & thrombus'. **Thomas Schertler et al(2005)[30],** studied the analysis of section width in the arterial occlusive disease of lower limb with sixteen detector CT & found that with thinnest possible section the sensitivity, specificity&accuracy was 95%, 95% & 96% respectively. [15]

In study by **Choudhary VK et al (2019)[13]**also found that MDCTA identified atheromatous wall changes & attenuated calibre of affected vessels better as compared to Doppler USG.On CTA, diffuse atheromatous wall changes were identified in 82.5% (33) cases & attenuated lumen of the affected arterial segment(s) were identified in 57.5% (23) cases. **Hasa R et al2016[27]**evaluated that the agreement was 84% in between the two methods, a finding which was also highly statistically significant (P<0.001). Furthermore, the extent of the wall thickening in the vessels detected by colour Doppler USG versus MDCT was also rather congruent (kappa=0.74, P<0.001). As per study by **Shirol RJ et al (2015)[7],** the observed

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agreement between the two modalities in assessing wall calcification is 87% with almost perfect agreement between them. While the observed agreement between two modalities of assessing wall thickening was 70.1%. All these studies were in accordance with our study findings.

Collaterals identification

Recent study found that the presence of collaterals on MDCT was seen in 51% cases where as colour doppler showed collaterals in only 44% cases which concluded MDCT was more efficient in detecting presence of collaterals when compared to colour doppler. p<0.001 indicates that there is significant difference in the detection of the extent of segment involvement in the lower limb arteries. For detection of collaterals sensitivity, specificity, PPV &NPV of colour doppler in comparison to MDCT is 66.67%, 79.59%, 77.27% & 69.64% respectively. Kappa statistics was applied to assess the level of agreement between colour doppler &MDCT. Almost perfect level of agreement (0.461) was observed for collateral.

The results were similar to findings of **Deepa S et al (2020) [11]** who also reported presence of collaterals on CTA was seen in 46% cases where as CDUS showed collaterals in only 26% cases. **Raj MBN et al (2020) [6]** found that in comparison to color doppler ultrasound though the number of collateral circulations MDCTA was significantly better than color doppler ultrasound in evaluation of the morphologic features of the runoff arteries in their full length which is an important imaging finding, hence MDCT is needed before vascular intervention.

Choudhary VK et al (2019) [13] also found that identification of collaterals were better identified on CTA as compared to DUS. While on CTA, collaterals were identified in 24 cases whereas on DUS they were identified only in 6 cases. The agreement regarding the extent of collaterals was moderate between the same two methods as in our study (kappa=0.62) which was also statistically significant (P<0.001), **Hasa R et al2016[27].** Similarly, the observed agreement between two modalities of assessing collaterals was 58.1% with moderate agreement, as per study by **Shirol RJ et al (2015) [7]. Rajpal K et al (2016) [1],** collaterals were best seen by MDCT in 25 (61%) patients out of 41 non-trauma patients, which depicted the efficiency of MDCT in evaluation of collateral circulation. Conclusions:

This was a comparative study done on 80 patients with signs & symptoms of lower limb peripheral arterial occlusive disease & their evaluation by colour doppler ultrasonography & MDCT angiography. Majority (83%) of participants were male. As per our findings, both colour doppler & MDCT can be complimentary in evaluation of lower limb arterial disease.

In our study the sensitivity of the doppler for detection of Stenosis was 92.15%, for wall morphology was 98.14% & for collaterals was 66.6%. Color Doppler showed good sensitivity, specificity, PPV, NPV & accuracy when compared to MDCT. It showed very good results in diagnosing complete occlusion, significant stenosis, collaterals detection & the patency of distal vessel. Thus, color doppler is a non-invasive initial imaging modality of choice in suspected patients with PAD.

MDCT has shown that it is accurate in identifying the degree, severity & level of peripheral vascular disease. It is an outstanding, fast, accurate & non-invasive imaging test for the evaluation of patients with PAD. It has high diagnostic performance & reproducibility in evaluating PAD. MDCT can depict whole of the arterial map of the limb affected thereby playing crucial role in decision making for management.

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Thus, in assessing mild PAD patients who needs medical therapy & in whom the CT is.

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