ORIGINAL ARTICLE

ROLE OF MDCT IN EVALUATION OF PERIPHERAL VASCULAR DISEASE OF THE LOWER LIMB ARTERIES AND COMPARISON WITH COLOUR DOPPLER

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ABSTRACT: AIMS AND OBJECTIVE: To evaluate the efficacy of MDCT angiography and colour doppler ultrasonography to diagnose peripheral vascular disease in the lower limb. **MATERIALS AND METHODS:** A comparative study included 30 patients with PAD who underwent colour doppler ultrosonography and MDCT angiography at the department of Radio-Diagnosis at K. S. Hegde Medical Academy following which their data was compared and analyzed with respect to wall calcification, wall thickening, stenosis and colllaterals. **RESULTS:** In our study involving 30 patients in finding the agreement between the Doppler and MDCT of the lower limb arteries, the detection of calcification, stenosis, collaterals were significantly better in MDCT with a p value of <0.001. The detection of wall thickening was better in Colour Doppler. **CONCLUSION:** Imaging plays an important role in the management of the patients with peripheral arterial disease. Due to the limitations of the doppler ultrasound, CT Angiography is used prior to any vascular intervention is required in PAD. Doppler is also an effective tool which can detect the lesions to a comparable extent when no intervention is planned.
KEYWORDS: MDCT, PVD, Colour Doppler.

INTRODUCTION: Peripheral arterial disease (PAD) is the most common condition affecting the arteries of the lower extremity. Compromise of arterial flow due to the stenosis and occlusions can result in limb ischaemia, which may manifest as claudication, rest pain, local tissue loss (ulceration) and potentially amputation. Patients with PAD may or may not be symptomatic. These patients have increased risk of mortality, myocardial infarction and stroke. It is an independent risk factor for vascular disease in other regions, resulting in increased rate of cardiovascular events and mortality rate. It adversely affects the functional status of the limb and is associated with poor quality of life.

The most common cause of lower limb arterial occlusive disease is atherosclerosis. Less common causes include thromboembolism, acute thrombotic occlusion, micro embolism, trauma, vasculitis including vasospastic disorders and Buerger's disease. Atherosclerosis, though typically asymptomatic for decades, eventually produces two main problems. First, the atheromatous plaques, which gradually rupture and heal with residual stenosis or complete closure of the lumen. Second, if the compensating arterial enlargement process is excessive, then an aneurysm results. Not only can we save the limb but also improve the function of the limb by diagnosing and treating this condition.

Arteriography is considered the standard investigation for peripheral arterial disease. It gives an accurate anatomical description of obstructive arterial lesions. However, it does not estimate the haemodynamic significance of such lesions. Recently, advances in the duplex scan and CT have raised the possibility that it could replace arteriography as the primary imaging modality for the assessment of limb ischemia.

Ultrasound imaging 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

ORIGINAL ARTICLE

interventional endovascular procedures explains the significant development of colour Doppler these days. Thus it allows the evaluation, quantification and the follow up of the arterial disease by carrying out a precise vascular mapping that can guide the radiological or surgical procedure if necessary. Colour doppler imaging is safe, popular, cost effective, repeatable, non-invasive procedure for investigating lower limb arteries. Ultrasound currently remains an important modality in the evaluation of peripheral arterial disease and even if MR angiography eventually becomes the pre-eminent technique in the evaluation of this disease, ultrasound will likely continue to have a role in many settings (E.g., post-angioplasty assessment, pseudoaneurysm).

Lower extremity CT angiography is a fairly new technique when compared to duplex ultrasonography. Peripheral CT became a reality only after the introduction of multi detector-row- CT (MDCT) in 1998, which for the first time allowed scanning of the entire lower extremity inflow and runoff vessels in a single CT acquisition and with a single contrast medium injection at the adequate spatial resolution.[1]

NEED FOR THE STUDY: Peripheral vascular disease (PVD), commonly referred to as peripheral arterial disease (PAD) or peripheral artery occlusive disease (PAOD), refers to the obstruction of arteries of the limbs. Because lower extremity atherosclerosis is a marker for systemic atherosclerotic disease, these patients have significant systemic morbidities.

Acute occlusion of peripheral arteries commonly involves the infra inguinal segment. Underlying atherosclerotic disease may result in intraluminal strictures that impair blood flow and cause acute thrombosis. Emboli typically lodge at bifurcations but can also involve the arterial segments resulting in distal turbulent flow and deranged tissue perfusion. The clinical indications of occlusion of lower extremity arteries are the following - Claudication pain, paraesthesia, poikilothermia, pallor, pulselessness and gangrene. Clinically, the anatomic level at which pulse loss occurs helps identify the location of the occlusion.

Duplex ultrasonography with colour flow is often used to gauge the extent and severity of peripheral artery disease. It combines a local anatomical image, obtained in B-mode, with information about the direction pattern and magnitude of arterial and venous flow. The severity of the stenosis can then be derived from peak systolic and end diastolic velocity measurements.

OBJECTIVES:
- The purpose of this study is to evaluate and compare the efficacy of multi detector (16-row) computed tomography (MDCT) over Color Doppler ultrasonography in imaging the lower limb arterial tree in peripheral arterial occlusive disease (PAOD) and to derive the benefits and drawbacks of each modality.
- To assess advantages and disadvantages of volume rendered images and raw images.

MATERIALS AND METHODS: It was a comparative study done on 30 patients with signs and symptoms of peripheral arterial occlusive disease referred for evaluation for imaging by colour doppler ultrasonography and MDCT angiography to the department of Radiodiagnosis at a tertiary care hospital. The study was done over a period of 2 years from May 2011 to May 2013.

Inclusion Criteria: Referred cases of peripheral vascular disease.

ORIGINAL ARTICLE

Exclusion Criteria:
- Acute renal failure.
- Chronic renal failure.
- Children.
- Contrast allergy.

Colour Doppler ultrasonography was performed using GEVolusion 730e equipment and the arterial system of the lower limb was scanned with a linear phased array (6-12MHZ) transducer.

For performing the Doppler scanning of the lower limb arterial system, the patient was made to expose both the lower limbs in the supine position on the scanning couch. The distal common femoral artery was imaged and the Doppler waveform assessment was done visually for any loss of triphasic flow or rounding of the waveform due to significant iliac disease. In the presence of this finding, the iliac arteries were assessed for the evidence of atherosclerotic disease using the curvilinear probe and the abdominal vascular setting. The scan was continued distally from the common femoral artery assessing the superficial femoral artery and popliteal artery in the longitudinal plane, using the linear probe and the lower limb arterial scan pre-set. The extent and severity of the arterial disease was assessed using triplex mode by measuring the peak systolic velocity from the Doppler waveform just proximal to and through the stenosis. The severity of the disease was then classified using the following standard criteria mentioned in the table below.

A complete occlusion was confirmed by reducing the colour scale and/or using the power Doppler. Arteries were evaluated for calibre, lumen, flow velocity and spectral wave pattern. The data collected from the patients was classified according to the level of atherosclerotic disease. The patients who had at least one stenosis in the lower limbs with 50-70% block were classified as having moderate disease and placed into the moderate disease group, in patients whom at least one stenosis measured between 70-99% were classified as having significant disease and placed into the significant group and in patients with an occlusion were placed in the occlusive group.

The MDCT angiography was per formed following assessment by an arterial colour doppler. The scan direction was craniocaudal from the level of infrarenal aorta to the pedal arch. All scans are done using Wipro Ge Medical Systems (Bright speed elite) 16 slice MDCT with 120KVp and 300mAs with 1.25mm section thickness and reformation. Contrast study was done using 140-150ml of 350mg/ml non-ionic iodinated contrast, injected using pressure injector at the rate of 3-4ml/s. Volume rendering and maximum intensity projection images were obtained from raw images from all the cases. Images were analyzed for calcification, wall thickening, extent pattern of luminal narrowing and the collateral flow.

RESULTS: In our study of CT correlation with arterial colour doppler USG, we studied 30 patients, out of these 30 patients 24(80%) were male patients and 6(20%) were female patients.

Out of 30 patients, most of the patients belonged to the age group 61-70 years i. e. 10(33.3%) patients, followed by 51-60 years with 9 patients (30%) and 5 patients (16.6%) each in the age groups more than 70 years and 4(13.3%) less than 40 years.

40-50 years age group had the least number of patients with 2 patients (6.6%) suggesting that peripheral vascular disease is seen rarely in the younger age group.

The clinical data was analyzed the following results were obtained.

ORIGINAL ARTICLE

CLAUDICATION: All patients in the study had some form of claudication. Majority of the patients had grade III claudication based on modified Boyd classification with 15 (50%) patients, followed by grade II with 10 patients and grade IV with 5 patients.

GANGRENE: In our study of patients with peripheral arterial disease, we found that 4 patients had gangrene and all patients with gangrene had a history of smoking.

ALCOHOLINTAKE and SMOKING HISTORY: In our study of patients with peripheral arterial disease we found that 18 out of 30 patients had history of smoking and all patients had a history of smoking with more than 20 pack years.

CO MORBIDITIES: In this study, diabetes mellitus was the most common co-morbidity associated with PVD with 17 patients followed by hypertension with 7 patients, hyperlipidaemia with 3 patients and 1 patient had Takayasu arteritis.

ADVANCING AGE AND DEGREE OF STENOSIS: In our study, we evaluated that as the age advances, degree of stenosis increases.

Age Group	No. of Patients Having Stenosis	Percentage
Less than 40	1	4.8%
40-50	2	9.52%
51-60	4	19.08%
61-70	9	42.8%
More than 70	5	23.8%
Total	**21**	**100**
Table 1: Age wise distribution of arterial stenosis		

MDCT versus colour Doppler USG.
Extent of calcification in the vessels detected by MDCT versus colour Doppler USG.

		Wall Calcification in CT		Total	Kappa	P value
		-	+			
Wall Calcification in CD	-	14	0	14	0.87	0.000
	+	3	43	46		
Total		**17**	**43**	**60**		
Table 2: Extent of calcification in the vessels detected by MDCT versus Colour Doppler USG						

In our study, the observed agreement between the two modalities in assessing wall calcification is 87%. This means it has almost perfect agreement between them and it is statistically significant. Reliability is stastically assessed by estimating the degree of agreement.

ORIGINAL ARTICLE

MDCT versus VR.

Extent of calcification in the vessels detected by MDCT versus volume rendering images.

		Wall Calcification in CT		Total	Kappa	P value
		-	+			
Wall Calcification in VR	-	13	0	13	0.823	0.000
	+	4	43	47		
Total		17	43	60		
Table 3: Extent of calcification in the vessels detected by MDCT versus Volume Rendering images						

The observed agreement between two modalities in assessing wall calcification is 82.3%. This means it has almost perfect agreement between them and it is statistically significant.

COLOUR DOPPLERUSG versus MDCT extent of wall thickening in the vessels detected by colour Doppler USG versus MDCT.

		Wall Thickening in CD		Total	Kappa	P value
		-	+			
Wall thickening in CT	-	12	7	19	0.701	0.000
	+	0	41	41		
Total		12	48	60		
Table 4: Extent of wall thickening in the vessels detected by Colour Doppler USG versus MDCT						

In our study, the observed agreement between two modalities of assessing wall thickening is 70.1%.This means it has substantialagreement between them and it is statistically significant. 80% of the cases of wall thickening were seen on colour doppler whereas CT showed wall thickening only in 68.33%.

MDCT versus colour Doppler USG.

Extent of stenosis in the vessels detected by MDCT versus colour Doppler USG.

		Stenosis in CT		Total	Kappa	P value
		-	+			
Stenosis in CD	-	18	6	24	0.783	0.000
	+	0	36	36		
Total		18	42	60		
Table 5: Extent of stenosis in the vessels detected by MDCT versus colour doppler USG						

ORIGINAL ARTICLE

In our study, the observed agreement between two modalities of assessing stenosis is 78.3%. This means it has substantial agreement between them and it is statistically significant.

MDCT versus VR.

Extent of stenosis in the vessels detected by MDCT versus volume rendering images.

		Stenosisin CT		Total	Kappa	P value
		-	+			
Stenosis in VR	-	18	9	27	0.687	0.000
	+	0	33	33		
Total		18	42	60		
Table 6: Extent of stenosis in the vessels detected by MDCT versus volume Rendering images						

In our study, the observed agreement between two modalities of assessing stenosis is 68.7%.This means it has substantial agreement between them and it is statistically significant.

MDCT versus colour Doppler USG.

Extent of collaterals detected by MDCT versus colour Doppler USG.

		Collateralin CT		Total	Kappa	P value
		-	+			
Collateral in CD	-	27	13	40	0.581	0.000
	+	0	20	20		
Total		27	33	60		
Table 7:Extent of collaterals detected by MDCT versus Colour Doppler USG						

In our study, the observed agreement between two modalities of assessing collaterals is 58.1%.This means it has moderate agreement between them and it is statistically significant.

MDCT versus VR.

Extent of collaterals detected by MDCT versus volume rendering images.

		Collateral in CT		Total	Kappa	P value
		-	+			
Collateral in VR	-	27	3	30	0.90	0.000
	+	0	30	30		
Total		27	33	60		
Table 8: Extent of collaterals detected by MDCT versus Volume Rendering images						

ORIGINAL ARTICLE

In our study, the observed agreement between two modalities of assessing collaterals is 90%.This means it hasalmost perfect agreement between them and it is statistically significant.

MDCT versus VR.
Extent of involvement of the iliac artery as detected by MDCT versus volume rendering images.

		Iliac artery in CT		Total	Kappa	P value
		-	+			
Iliac artery in VR	-	55	0	55	1.00	0.000
	+	0	5	5		
Total		55	5	60		
Table 9: Extent of involvement of the iliac artery as detected by MDCT versus Volume Rendering images						

In our study, the observed agreement between two modalities of assessing iliac arteries is 100%.This means it has perfect agreement between them and it is statistically significant.

MDCT versus VR.
Extent of involvement of the aorta as detected by MDCT versus volume rendering images.

		Aortain CT		Total	Kappa	P value
		-	+			
Aorta in VR	-	27	1	28	0.783	0.000
	+	0	2	2		
Total		27	3	30		
Table 10: Extent of involvement of the aorta as detected by MDCT versus volume rendering images						

Our study shows that the observed agreement between two modalities of assessing wall calcification is 78.3%. This means it has substantial agreement between them and it is statistically significant.

DISCUSSION: Peripheral vascular disease is increasing in frequency with an increase in life expectancy and increase in its co-morbid conditions like advancing age, diabetes mellitus and hypertension. This disease is associated with a lot of morbidity due to its global involvement. Following cancer and heart disease, complications of atherosclerosis causing PVD is the third leading cause of death in the world. Precise diagnosis will therefore help to obtain a better understanding of the natural history of this condition and also determine a therapeutic regimen and prognosis. Several modalities of investigations are available to determine status and extent of peripheral vascular disease. Noninvasive modalities in evaluation of PVD are more popular because they are safe, requiring no intervention.

ORIGINAL ARTICLE

With advances in the field of vascular surgery, better affordability of the patients and they choosing a disease free interval; vascular imaging has a great role to play in this field, to help in accurately explaining the extent of the disease before any intervention is planned.

Although DSA is considered as a gold standard in the evaluation of peripheral vessels, especially in peripheral vascular disease, the role of DSA has now been challenged by recent advances in technology like colour Doppler, CTA and CEMRA.

Doppler ultrasound, Duplex Sonography, combining high resolution imaging and doppler spectrum analysis has proved to be popular, non-invasive, accurate and cost effective means of assessing peripheral vascular disease.

With the emergence of MDCT in clearly delineating the extent of arterial tree involvement in a non-invasive way and giving a result comparable to the invasive cumbersome angiography, MDCT is the present modality of choice in imaging the vascular tree before any intervention. MDCT is safe, has faster acquisition and is observer independent hence reliable.

In our study of comparison of MDCT with colour doppler ultrasound 30 patients were evaluated for the extent of disease in the lower limb arterial system and the data was compared with the existing studies available and the following observations were made to find an agreement between colour doppler ultrasound with MDCTA.

DEMOGRAPHIC DATA: Sex Distribution: We studied 30 patients of peripheral vascular disease, out of these 30 patients, 24 (80%) were male patients and 6 (20%) were female patients. Similar results were in the studies by Hughson et al. in which males were more affected by PVD which is comparable with studies by Gareth Morris and his co-workers in 2011 there were 310 males and 190 females giving a male to female ratio of 1.6:1. There is a mismatch in our study due to the less sample size.

Age Distribution: In a study by Cossmanet al[2] it was concluded that PVD is adisease which affects middle aged and the elderly which is comparable with our study, in which out of 30 patients studied the age group involved mostly 61-80 years 67% with 14 patients and 7 patients were in middle age.

Smoking and Claudication: Smoking tobacco is a major risk factor in the development of PAD. A population-based study in South India[3]found that smokers had 2.7 times higher risk for PAD. The Edinburgh Artery Study reported a dose-dependent relationship between smoking and PAD. The studies also concluded that a significant correlation was present between the frequency of severe intermittent claudication and smoking. These findings were in agreement with our study in which among the smoking group the incidence and grade of claudication was more than that of non-smokers.100% of smokers had severe claudication, grade 3 or grade 4 as per the Boyd's classification which is statistically extremely significant indicating that in smoking worsens the progression of PVD at a faster rate.

DIAGNOSIS: In our study of peripheral vascular disease atherosclerosis was the most common cause of PVD followed by TAO this is comparable with studies by Rosamond, Flegal andFurie.[4]

Advancing Age and Degree of Stenosis: In our study we concluded that as the age advances the degree of stenosis increases which is comparable with the study done by Premalathaet al.[3]

ORIGINAL ARTICLE

Co-Morbidities: The co-morbidities in patients with PVD included hypertension, coronary artery disease and Type 2 DM. We found that in our study the incidence of diabetes mellitus was more in PVD (56%) than hypertension which is similar to a study done by premalathaet al.[3]

Studies comparing the MDCTA, COLOUR DOPPLER ultrasound and other imaging modalities:
Various studies have shown that MDCT angiography is has an acceptable detection rate in comparison to DSA.

Ouwendijk et al[5] compared the costs and effects of three non-invasive imaging tests as the initial imaging test in the diagnostic workup of patients with peripheral arterial disease. Of 984 patients assessed for eligibility, 514 patients with peripheral arterial disease were randomized to MR angiography or duplex sonography in three hospitals and to MRA or CT angiography in one hospital. The outcome measures included the clinical utility, functional patient outcomes, quality of life, and actual diagnostic and therapeutic costs related to the initial imaging test during 6 months of follow-up.

Their study concluded that both CTA and MRA are clinically more useful than duplex sonography and that CTA leads to cost savings compared with both MRA and duplex sonography in the initial imaging evaluation of the peripheral arterial disease. In our study there is complete agreement to the above study, however doppler ultrasound is the best diagnostic for initial screening. It is cost effective and only the patients with significant disease can undergo CT for complete evaluation of the disease to evaluate the severity of the disease which decides the clinical management. Doppler can be safely suggested for all the patients in whom the contrast study is contraindicated (Renal failure) and when medical therapy is needed.

Kayhanet al[6] compared the efficacy of multi detector computed tomography angiography and duplex ultrasonography to diagnose mild peripheral arterial occlusive disease. In their study forty-three patients with 774 segments in patients with intermittent claudication and leg pain, diagnosed as mild PAOD, had undergone DUS followed by MDCTA of lower limb. MDCTA detected obstructed or stenotic lesions in 16.8% of arteries; they concluded that MDCTA could be used as ascreening tool in patients with mild lower extremity PAOD as it is a more accurate modality when compared to DUS.

In our study we also found that in comparison to colour doppler ultrasound in detecting hemodynamically significant stenosis, in the lower limb arterial systems MDCTA was significantly better statistically than colour doppler ultrasound.

In the study by Romanoet.al[7] the overall rate of helical CT was better in detecting lesions of the infrapopliteal arteries. In their study they concluded that sixteen detector row CT angiography is an accurate and reliable noninvasive alternative to conventional DSA in the assessment of aortoiliac and lower extremity arteries inpatients with peripheral arterial disease.

In our study when colour doppler ultrasound was compared to MDCT in detecting the infra popliteal the segment blocks, MDCT was better in detecting the infrapopliteal the segment blocks and the length. The p value was <0.001 which is statistically highly significant.

In another study by Romanoet.al [7] in the evaluation of peripheral vascular disease in detecting the femoro-popliteal occlusion. CT was able to detect the disease to astatistically significant level. In our study when colour doppler ultrasound was compared to MDCT in detecting the femoro-popliteal region in the distal femoral artery, MDCT was better in detecting the segment block, and the length of with a p value of<0.01 which is statistically significant.

According to Ouwendijk R, Kock, van Dijklc,[8] they showed that vessel wall calcifications on

ORIGINAL ARTICLE

CTA are associated with the need for additional vascular imaging and lower confidence in imaging findings. This result implies that it would be useful to identify patients in advance for whom the initial CTA is not conclusive due to vessel wall calcifications. Despite several limitations they performed an initial evaluation of clinical predictors of vessel wall calcifications on CTA. The results of their study demonstrated that vessel wall calcifications decrease the clinical utility of CTA in patients with peripheral arterial. In our study we found that though the VR technique under estimate the stenosis in the presence of vessel wall calcification, however the raw images with wider window settings (window level/width, 150/600 HU) can identify the stenosis in the presence of the vessel wall calcification. This study correlates with the study by Fishman et al.[9]

CONCLUSION: Role of multi detector computerized axial tomography in evaluation of peripheral vascular disease of the lower limb arteries and comparison with colour doppler has been performed and following conclusion is arrived at.

The study was a comparative study done on 30 patients with signs and symptoms of peripheral arterial occlusive disease referred for evaluation by imaging by colour doppler ultrasonography and MDCT angiography.

MDCT is better than Doppler in detecting the length of stenosis and calcification in the arterial system.

MDCT is better than Doppler in detecting the presence of occlusion especially in the infra-popliteal segment. In our study the sensitivity of the doppler was 78% sensitivity.

The main advantage of the CT is that, it shows the extent of the disease from the abdominal aorta till the arteries of feet. Which will help in planning the treatment modality.

Doppler is also an effective tool which is non-invasive, safe, relatively reliable, economical investigation and does not require special preparation prior to the examination. Doppler can detect the lesions to a comparable extent when no intervention is planned and only medical therapy is considered. In addition the arterial wall pathology better shown than CT and it is also excellent tool for follow up.

From this study, we conclude that the mild PVD patients who needs medical therapy and in whom the CT contrastis contraindicated, ultrasound is the best modality. And in patients with moderate to severe PVD who need intervention, CT is advised.

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ORIGINAL ARTICLE

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