ORIGINAL RESEARCH ARTICLE

CT Angiography in Evaluation of Peripheral Vascular Disease and Comparison with Color Doppler Ultrasound

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ABSTRACT

Introduction: Peripheral arterial disease is the narrowing or occlusion of arteries of the limb, resulting in complications ranging from minor disabilities to loss of the limb. Colour Doppler ultrasonography has been used as the initial imaging modality followed by Computed tomographic angiography in symptomatic patients. Present study evaluated the comparison between these two modalities in patients with peripheral vascular disease.

Material and methods: A total of 100 patients above 18 years of age with peripheral vascular disease were included in our study. After taking an informed consent a brief history was taken regarding symptomatology, risk factors and duration of disease. Patients were studied by using both Colour Doppler ultrasonography and Computed tomographic angiography to interpret lower limb arterial system and the comparison was made between the two modalities.

Results: Our study shows consistent association of risk factors such as increasing age, smoking, hypertension and diabetic mellitus with the disease. Early stenotic lesions were better picked by ultrasound. In infrapopliteal segments CT angiography was able to detect 20% positive cases with grade 3 & 4 stenosis in comparison to the Ultrasound which was able to detect 12%. Vessel calcifications and collaterals were better detected by computed tomographic angiography.

Conclusion: In assessing patients with mild disease who need medical therapy, ultrasound is the better modality. In patients with moderate to severe disease in whom surgical intervention is required, computed tomographic angiography is preferred for thorough evaluation of entire lower limb arterial tree.

Keywords: Peripheral Arterial Disease, Colour Doppler Ultrasound, Computed Tomographic Angiography, Stenosis.

INTRODUCTION

Peripheral arterial occlusive disease (PAD) is the narrowing or occlusion of an artery or arteries of the limb. Most commonly caused by atherosclerosis, less common causes include thromboembolism, trauma, entrapment syndromes and vasculitis including vasospastic disorders and buerger's disease.[1] Disorder of the arterial system produces complications ranging from minor disabilities to loss of the limb. Therefore, early diagnosis and effective treatment is usually rewarded with good outcome and averts dreadful complications.

Conventional digital subtraction angiography is considered as the gold-standard technique. There are several alternative imaging modalities to DSA, including Duplex ultrasonography (DUS), computed tomography angiography (CTA) and magnetic resonance angiography (MRA).[2]

DUS has been used as the initial imaging modality in mild symptomatic PAD. It is operator dependant, time consuming and is less accurate in assessing distal vasculature and collaterals.[3] With advancement in CT angiography, especially in the MDCT, larger body volumes can be scanned within short time period at high resolution to provide good delineation of arterial flow. This has enabled MDCT to become a promising new, fast, accurate, safe and non invasive modality in lower extremity arterial imaging for diagnosing, for grading, for potential usefulness and type of treatment.[4]

Present study has been conducted with the objective of evaluating and comparing the efficacy of MDCT angiography and color Doppler ultrasonography in diagnosing and assessing severity of peripheral vascular disease.

MATERIAL AND METHODS

The main source of data was patients presenting to Victoria Hospital and Bowring & Lady Curzon Hospital attached to Bangalore Medical College and Research Institute, Bangalore during the time period of November 2016 to may 2018 with suspected peripheral vascular disease on clinical examination including claudication, rest pain and tissue loss. After taking

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an informed written consent, a brief history was taken from each patient regarding symptomatology, risk factors and duration of disease. A focused clinical examination with the aid of the referring physician was undertaken as regards to severity and extent of involvement of the disease. A total of 100 patients were included in our study. Patients with history of trauma, altered renal function tests and history of contrast allergy were excluded in our study.

CDUS: Patients were scanned under Philips Affinity G machine in the supine position. Curvilinear 3.5 MHz probe was used to examine the aorta, common, and external iliac arteries. Linear 7.5 MHz probe was used to examine superficial femoral, deep femoral, popliteal, tibioperoneal trunk, posterior tibial, anterior tibial and peroneal arteries.

CT Peripheral Angiography: Patients underwent MDCTA on a "Ingenuity" 128 slice Philps CT scanner. Plain CT Acquisition is done from the level of infrarenal aorta till the toes. Arterial phase was taken when the ROI reaches threshold of 100HU in descending infrarenal aorta following contrast injection. Venous phase was taken at an interval of 60-65 sec from the time of contrast injection. 3D reconstruction with thin planar (1mm) MPR was performed in coronal and sagittal planes. The images were viewed on a workstation capable of viewing source axial images and 3D imaging software tools.

Data analysis

The lower limb arterial system was divided into 3 anatomical regions [Aorto-iliac region, Femoro-popliteal region & Tibioperoneal regions] and 11 anatomical segments [Infra-renal aorta, common iliac arteries, external iliac arteries, common femoral arteries, Superficial femoral artery, Deep femoral artery, popliteal artery, tibioperoneal trunk, anterior tibial artery, posterior tibial artery, peroneal artery]. Each and every anatomical segment of the arterial tree was assigned a grade for the disease extent using a five point ordinal scale: Grade 0- Normal, Grade 1- < 25% diameter reduction, Grade 2- 25-50% diameter reduction, Grade 3- 50-75% diameter reduction, Grade 4- 75-100% diameter reduction. These grades were given for all arterial segments in both the techniques. MDCT angiography and Doppler findings were compared for each arterial segment. For all practical purpose to analyse the data we had divided the grades of stenosis into hemodynamically significant [Grade 3 & 4] and hemodynamically nonsignificant [Grade 0, 1 & 2].

STATISTICAL ANALYSIS

Descriptive and inferential statistical analysis has been carried out in the present study. Results on continuous measurements are presented on Mean ± SD (Min-Max) and results on categorical measurements are presented in Number (%). Significance is assessed at 5% level of significance. Chi-square/ Fisher Exact test has been used to find the significance of study parameters on categorical scale between two or more groups and non-parametric setting used for Qualitative data analysis. Fisher Exact test used when cell samples are very small. The Statistical software namely SPSS 18.0, and R environment ver.3.2.2 were used for the analysis of the data and Microsoft word and Excel have been used to generate graphs, tables etc.

RESULTS

A total of 100 patients were included in our study. Most patients belonged to the age group of 40-70 years with half of the patients were smokers, diabetics and hypertensives. Out of 58 patients with significant stenosis, 65.5% cases were smokers and 24.1% were non smokers, 55.2% cases were hypertensives and 24.1% were non hypertensives, 79.3% cases were diabetics and 20.7% were non diabetics, showing significant statistical correlation of smoking, hypertension & diabetes with significant stenosis.

Out of 300 vessel segments in aortoiliac region 238(79.3%), 28(9.3), 10(3.3%), 12(4%), 12(4%) segments on CTA and 218(72.7%), 44(14.7%), 14(4.7%), 12(4%), 12(4%) segments on CDUS showed grade 0,1,2,3,4 stenosis respectively (table-1).

Out of 400 vessel segments in tibioperoneal region 288 (72%), 14 (3.5%), 22 (5.5%), 44 (11%), 36 (9%) segments

Stenosis Severity Grade					
Modality	0	1	2	3	4
	Infrarenal aorta segments				
CTA	82	16	0	0	2
CDUS	76	20	2	0	2
	Common iliac artery segments				
CTA	82	4	2	8	4
CDUS	76	8	4	8	4
	External iliac segments				
CTA	74	8	8	4	6
CDUS	66	16	8	4	6
	Common femoral segments				
CTA	66	6	20	2	6
CDUS	62	10	20	4	4
	Superficial femoral segments				
CTA	54	8	2	8	28
CDUS	48	10	8	6	28
	Deep femoral segments				
CTA	96	4	0	0	0
CDUS	82	16	2	0	0
	Popliteal segments				
CTA	80	4	6	6	4
CDUS	72	12	8	4	4
	Tibioperoneal trunk segments				
CTA	74	4	6	10	6
CDUS	70	12	10	4	4
	Posterior tibial segments				
CTA	66	4	4	12	14
CDUS (96%)	64	10	12	8	6
	Anterior tibial segments				
CTA	68	4	6	14	8
CDUS (96%)	68	8	10	12	2
	Peroneal segments				
CTA	74	2	6	8	10
CDUS (96%)	72	8	8	8	4

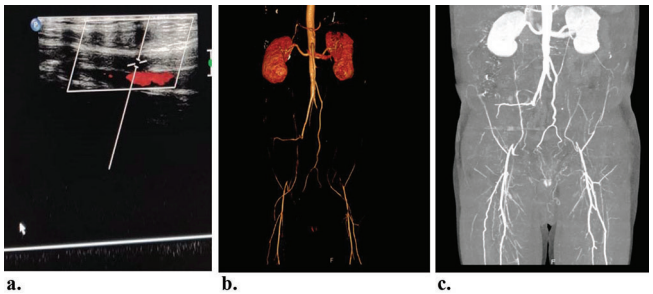
Table-1: Correlation of Characteristics- Stenosis in CTA and CDUS of aortoiliac femoropopliteal and tibioperoneal segments in patients studied

Stenosis Severity Grade					
Modality	0	1	2	3	4
	Tibioperoneal trunk segments				
CTA	74	4	6	10	6
CDUS	70	12	10	4	4
	Posterior tibial segments				
CTA	66	4	4	12	14
CDUS (96%)	64	10	12	8	6
	Anterior tibial segments				
CTA	68	4	6	14	8
CDUS (96%)	68	8	10	12	2
	Peroneal segments				
CTA	74	2	6	8	10
CDUS (96%)	72	8	8	8	4

Table-2: Correlation of Characteristics-Stenosis in CTA and CDUS of in patients studied

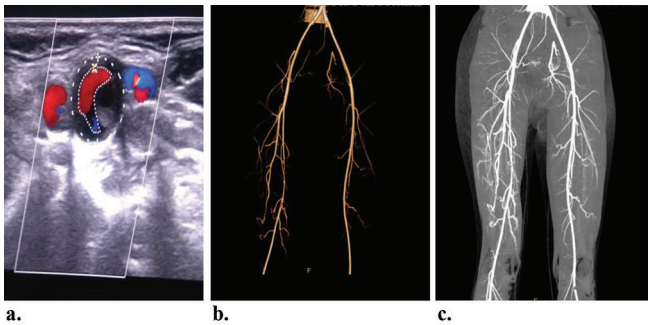
Stenosis Severity Grade						Total number of segments	P value
Modality	**0**	**1**	**2**	**3**	**4**		
	Aortoiliac segments						
CTA	238 (79.3%)	28 (9.3%)	10 (3.3%)	12 (4.0%)	12 (4.0%)	300	0.277
CDUS	218 (72.7%)	44 (14.7%)	14 (4.7%)	12 (4.0%)	12 (4.0%)	300	
	Femoropopliteal segments						
CTA	296 (74%)	22 (5.5%)	28 (7%)	16 (4%)	38 (9.5%)	400	0.022*
CDUS	264 (66.0%)	48 (12.0%)	38 (9.5%)	14 (3.5%)	36 (9%)	400	
	Tibial artery segments						
CTA (100%)	288 (72.0%)	14 (3.5%)	22 (5.5%)	44 (11%)	36 (9%)	400	<0.001**
CDUS (96%)	266 (66.7%)	38 (9.5%)	40 (10%)	34 (8.5%)	14 (3.5%)	400	

Table-3: Correlation of Characteristics-Stenosis in CTA and CDUS of following segments in patients studied



a. b. c.

Case-1: CDUS (a) with spectral Doppler shows grade IV stenosis of left external iliac artery showing absent color uptake and absent waveform on spectral Doppler. CTA of Aortoiliac Segments – VR (b) and MIP (c) reconstructed coronal images showing Grade IV stenosis of left common iliac and bilateral external iliac arteries.



a. b. c.

Case-2: CDUS (a) showing grade III stenosis of right superficial femoral artery. CTA of femoropopliteal segments –VR (b) and MIP (c) reconstructed coronal images showing Grade III stenosis of right superficial femoral artery.

on CTA and out of 388 segments on CDUS 266 (66%), 38 (9.5%),40 (10%), 34 (8.5%),14 (3.5%) segments on CDUS showed grade 0,1,2,3,4 stenosis respectively. 4% segments could not be assessed on CDUS

Out of 400 vessel segments in femoropoliteal region 296 (74%), 22 (5.5%), 28(7%), 16(4%),38(9.5%) segments on CTA and 264 (66%), 48 (12%), 38 (9.5%), 14 (3.5%), 36 (9%) segments on CDUS showed grade 0,1,2,3,4 stenosis respectively

Out of 1100 segments, 822 segments showed grade 0, 64 segments showed grade 1, 60 segments showed grade 2, 72 segments showed grade 3 & 86 segments showed grade 4 stenosis on CTA and 748 segments showed grade 0, 130 segments showed grade 1, 60 segments showed grade 2, 60 segments showed grade 3 & 62 segments showed grade 4 stenosis on CDUS (table-2,3).

Presence of collaterals on CTA was seen in 46% cases where as CDUS showed collaterals in only 26% cases. Out of 1100 vessel segments, 26% showed wall calcifications on CTA where as 12% showed wall calcification on CDUS.

DISCUSSION

Common risk factors for the PAD include increasing age,

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smoking, hypertension and diabetic mellitus. Out of the 100 patients we studied 72% were males and 28% were females indicating males are more affected by PVD compared to females which is in accordance with studies by Hughson et al.[5] and Gareth Morris and his co-workers.

Our study concludes that distribution of disease increases in elderly population which is in accordance to study by Selvin E, Erlinger TP et al[6] and Cossman et al[7] where they found PAD prevalence increases dramatically with age with middle aged and the elderly patients are commonly affected.

We found 50% of smokers in our study population, out of which 65.5% showed hemodynamically significant stenosis in comparison with non smoking population in whom 24.2% showed significant stenosis with P value <0.001, showing significant correlation with smoking and stenosis. This is in accordance to study by Cole CW, et al[8] where they found relative risk was 7 for ex-smokers and 16 for current smokers ($p < 0.001$).

In our study 60% of patients were hypertensive, out of which 55.2% showed hemodynamically significant stenosis in comparison with non hypertensive population in whom 44.8% showed significant stenosis with P value ~0.098, showing correlation with hypertension and stenosis which is in accordance to study by Selvin E, Erlinger TP et al.

We found 60% of diabetic patients in our study population, out of which 79.3% showed hemodynamically significant stenosis in comparison with non diabetic population in whom 20.7% showed significant stenosis with P value <0.001, showing significant correlation with diabetes mellitus and stenosis, which is in accordance to study by L. Norgren et al,[9] where they found insulin resistance and diabetes was important risk factor which raised risk approximately 40-50%.

In our study the detection rate for the Grade 1 and 2 stenosis was higher for CDUS than CTA in all the three arterial regions. Detection rate for the Grade 3 stenosis was similar for both CDUS and CTA in the arterial segments of the aorto-iliac group. However CTA was better than CDUS for grade 3 stenosis in the arterial segments of femoro-popliteal and tibio-peroneal regions. Both CDUS and CTA were able to detect all the Grade 4 stenosis segments in the aorto-iliac (P value -0.277) and femoro-popliteal region (P value -0.022).However greater number of the arterial segments with Grade 4 stenosis was detected by the CTA in the tibioperoneal region than CDUS with statistically significant P value <0.001.

Thus our study showed though early stenotic lesions (Grade 1 and grade 2) were better picked by the CDUS in all the regions, Grade-3 and 4 lesions were better demonstrated by the CTA in femoro popliteal & tibio peroneal regions more significantly in the infrapopliteal region which correlated with study by Sathyabhuwan Singh et al.[10] study who concluded that doppler sonography is better than CT angiography in the diagnosis of early onset (Grade I & II) cases while CT angiography is more accurate in assessing grade-3 and grade-4 stenosis

In our study we found more number of diseased segments were detected by CDUS than CTA which correlates to the study by Kayhan A et al[11] who found more diseased segments in CDUS than MDCT.

Collins R et al in 2007[12] and Met R et al. in 2009[13] also found CTA to be more accurate modality in assessing the presence and extent of peripheral arterial disease.

In this study, more number of vessel calcifications are detected by CTA than CDUS. Out of 1100 vessel segments assessed 26% showed vessel calcification on CTA in comparison with 12% detected on CDUS which is in accordance by Joshi A, Nimbkar A, Merchant S, et al in where they found CTA to be more accurate in detection of calcified plaque.

Among 100 cases, presence of collaterals were detected in 44 patients by CTA and in 26 patients in CDUS which concluded CTA was more efficient in detecting presence of collaterals when compared to CDUS which is in accordance by Rahul J. Shirol et al[14] who concluded that CTA detected more collaterals than CDUS with statistically significant p value.

We found that MDCT is more accurate in accessing multilevel stenosis, bilateral limb involvement & length of stenosis.

Limitations

Limitation of our study is colour flow imaging and MDCTA findings were not compared with DSA, which is considered to be the gold standard technique in detecting lower extremity PAD. Therefore, results may underestimate the percentages of arteries with lesions that are actually detectable in patients with PAD.

CONCLUSION

We conclude that in suspected PAD patients, ultrasound is best screening tool. In assessing mild PAD patients who needs medical therapy and in whom the CT is contraindicated, ultrasound is the better imaging modality. In patients with moderate to severe PAD and in whom surgical intervention is required, CTA is preferred for thorough evaluation of entire lower limb arterial tree.

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