Original Research Article

Diagnostic accuracy of Duplex Ultrasonography versus Multidetector CT Angiography in the Evaluation of Peripheral Arterial Disease of the Lower extremity

Suman T P[1], Sachin T[2] , Sudha Kiran Das[3*], Sachin P Shetty[4], Vikram Patil[5]

[1]Senior Resident, Department of Radiodiagnosis, Sri Sathya Sai Institute of Higher Medical Sciences, EPIP zone, Whitefield, Bengaluru, Karnataka, India

[2]Senior Resident, Department of Radiodiagnosis, Hassan Institute of Medical Sciences Sri Chamarajendra Hospital Campus, Krishnaraja Pura, Hassan, Karnataka 573201, India

[3]Professor, Department of Radiodiagnosis, JSS Medical College, JSS Academy of Higher Education and Research, Mysuru, Karnataka, India-570004

[4]Senior Resident, Department of Radiodiagnosis, JSS Medical College and Hospital, JSSAHER, Mysuru, Karnataka, India

[5]Associate Professor, Department of Radiodiagnosis, JSS Medical College, JSS Academy of Higher Education and Research, Mysuru, Karnataka, India

Received: 17-07-2020 / Revised: 30-09-2020 / Accepted: 28-10-2020

Abstract

Background: Peripheral arterial disease (PAD)is a common condition that affects the arteries of the lower extremity. Atherosclerosis is the leading cause of occlusive arterial disease of the lower extremities. Detailed evaluation of peripheral vasculature is an integral part in the management of patients with peripheral vascular diseases. In the present study, we compare the efficacy of Duplex Ultrasonography (DUS) and Multidetector Computed Tomography Angiography (MDCTA) in the evaluation of peripheral arterial disease ofthe lower limb. **Materials and Methods**: This prospective correlative longitudinal study included 50 patients with clinical suspicion of peripheral arterial disease of the lower limb. Duplex ultrasonography (DUS) was performed as an initial imaging modality followed by MDCT angiography. Arteries were scanned from the level of common femoral artery till the level of dorsalis pedis artery. Imaging findings of DUS and MDCTA were compared with respect to degree of stenosis, length of stenotic segments, vessel wall calcification and to assess collateral circulation.Categorical data was depicted in the form of frequencies and proportions. Chi-square test was used to analyse comparisons between the groups. Continuous data were represented as mean and standard deviation. **Results**:50 patients with a mean age of 55.76 ± 12.3 years (range between 36-74 years) were evaluated over a period of two years. Diagnostic accuracy of MDCT angiography superseded Duplex Ultrasonography not only in the detection of hemodynamically significant stenosis, but also in the delineation of extent of disease with a p-value < 0.001. Overall diagnostic accuracy of MDCTA in the evaluation of stenosis or thrombosis of popliteal, anterior tibial, posterior tibial, and dorsalis pedis arteries was more than duplex ultrasound with a p-value of less than 0.001. Extent of vessel wall calcification and collateralisation was better delineated on MDCT angiography.The image reconstruction with CT angiography provided better arterial tree delineation and an added advantage over DUS. **Conclusion:**Duplex ultrasonography can be used as an initial imaging modality followed by MDCT angiography in the evaluation of peripheral arterial disease. MDCT angiography is more sensitive and specific for diagnosis and pre-interventional work-up of PAD, especially in the infra-popliteal segments.

Keywords: Atherosclerosis, Claudication, Stenosis, Thrombosis.

Introduction

**Correspondence*

Dr. Sudha Kiran Das

Professor, Department of Radiodiagnosis, JSS Medical College, JSS Academy of Higher Education and Research, Mysuru, Karnataka, India

E-mail: sudhakirandas@jssuni.edu.in

Peripheral arterial disease (PAD) is one of the common manifestations of systemic atherosclerosis affecting the elderly population [1]. The lower extremity arteries are most commonly involved in atherosclerotic stenosis or occlusion resulting in limb ischemia [2]. Apart from atherosclerosis, other less common causes include thromboembolism, inflammation of vessel walls, micro embolism, and trauma [3]. Patients with peripheral vascular disease can be asymptomatic or have symptoms such as intermittent claudication, rest pain, local ulcerations, and gangrene. Less than 20% of the patients can present with typical symptoms of intermittent claudication, whereas another third have atypical exertional leg symptoms [4]. Digital subtraction angiography is the standard angiographic technique used in the preoperative evaluation of peripheral vascular disease. However, it is invasive and involves the risk of radiation [5]. Various non-invasive imaging modalities such as Duplex Ultrasonography (DUS), multidetector computed tomography angiography (MDCTA), and magnetic resonance angiography (MRA) are now used for the assessment of peripheral vascular disease. Duplex ultrasonography is non-invasive, readily available, cost-effective, and has no risk of ionizing radiation. It helps to determine the functional status of the vessels by measuring the flow velocity and also enables rapid localization of arterial stenosis and occlusions [6].MDCT angiography is a minimally invasive imaging technique that is increasingly being used in the evaluation of PVD. The advantage of multidetector row technology provides a shorter time of acquisition, increased volume coverage, lower dose of contrast medium, and higher spatial resolution [7]. The major disadvantage of CT Angiography is the radiation dose and the hemodynamic assessment, which is obtained by Doppler imaging. In spite of these limitations, CT Angiography is being increasingly used as a screening modality for the initial assessment of the presence of vascular disease, its extent, and severity. Vascular surgeons prefer CT images as they are presented in a format similar to conventional angiograms with which they are more familiar and comfortable to plan the most appropriate therapeutic method, reducing unnecessary intervention or possible intra-operative difficulty. The aim of our study was to determine the efficacy of Duplex ultrasonography and MDCT angiography in the evaluation of peripheral arterial disease of the lower extremity.

Materials and Methods

This prospective correlative longitudinal study included consecutive 50 patients with clinical suspicion of peripheral arterial disease. The patients were referred to the Department of Radiology for evaluation by Duplex ultrasonography and MDCT angiography. The study was conducted for a period of 2 years from August 2014 to August 2016 at JSS Medical College, JSSAHER.

Inclusion Criteria: Patients presenting with intermittent claudication, gangrene changes, and absent peripheral pulses.

Exclusion Criteria: Polytrauma patients with suspected acute arterial injury, pregnancy, acute or chronic renal failure, and patients with contrast allergy.

Imaging Protocol: Duplex ultrasonography of lower limb arteries from the level of common femoral artery till the dorsalis pedis artery was performed using Philips HD11 XE equipment using a linear phased array (5-12MHz) transducer. The following lower limb arterial segments were evaluated: Common Femoral Artery (CFA), Superficial Femoral Artery (SFA), Deep Femoral Artery (DFA), Popliteal Artery (PA), Anterior Tibial Artery (ATA), Posterior Tibial Artery (PTA), and Dorsalis Pedis Artery (DPA). The following parameters were recorded: Peak systolic velocity, PSV ratio, and luminal diameter reduction (stenosis).

MDCT angiography was then performed by using Philips Ingenuity 128 slices MDCT scanner. The following parameters were used: Tube voltage of 100–120 kV; tube current–exposure time product of 225 mAs; collimation of 0.625; table feed of 27 mm per gantry rotation and section thickness of 1 mm. A high-iodine concentration low osmolar non-ionic contrast agent (Iohexol 350 mg iodine per millilitre) was used. CT angiography was performed after intravenous injection of the contrast medium at a flow rate of 3.5 mL/sec to provide bolus duration of 31 seconds with 25mL of saline chase at a flow rate of 4.0 mL/sec for 6 seconds using a dual-head pressure injector(Medrad) and axial sections were obtained. All CTA images were then transferred to a workstation for 3D reconstructions, maximum intensity (MIP), and volume renderings (VRT) images. The following parameters were recorded: Luminal diameter reduction (stenosis), length of stenotic segments, collateral flow, and wall calcifications. Stenosis on duplex ultrasonography and MDCT angiography was graded as follows:

- Grade 0: normal or no stenosis
- Grade I: Mild arterial stenosis (1-49 % stenosis)
- Grade II: Moderate arterial stenosis (50-74% stenosis)
- Grade III: Severe arterial stenosis (75-99% stenosis)

- Grade IV: 100 % or complete occlusion.

Statistical analysis: Data from Microsoft excel sheet was analysed using IBM-SPSS statistics 22.0 version software. Categorical data was represented in the form of Frequencies and proportions. Chi-square test was used as a test of significance. Continuous data were represented as mean and standard deviation.

Results

A total of 50 patients with mean age of 55.76 ± 12.3 years (range between 36-74 years). Forty five patients (90%) were male and 5 patients (10%) were females.

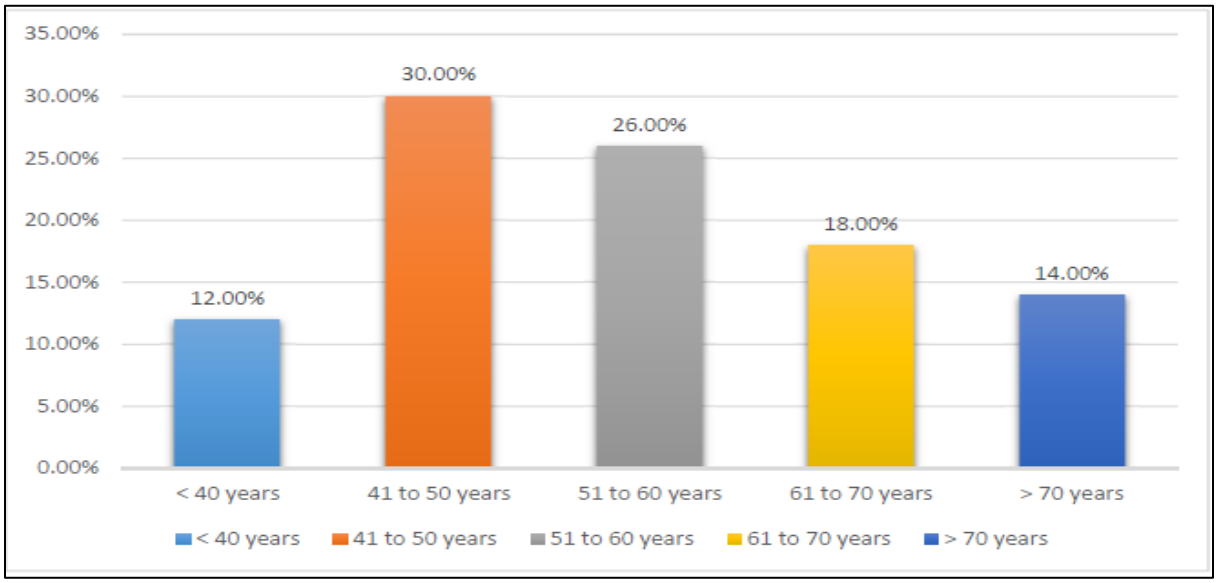

Fig 1: Age distribution of the subjects.

The majority of subjects in the study had atherosclerosis (84%), while 16% had thromboangiitis obliterans (TAO). Based on the clinical presentation, 20% had gangrene and 42% had presented with grade 2 claudication, 46% had grade 3 claudication, and 12% with grade 4 claudication.Diabetes Mellitus was seen in 28% of the subjects, 62% had a smoking history, 4% of the patients had a history of tobacco consumption.In comparison to Duplex ultrasound, MDCTA was statistically significant in detection of the length of stenotic segments with a p value < 0.001 as shown in Table 1.

Table 1:Length of stenotic segment as detected by MDCTA VS DUPLEX USG.

Length of stenosis	**MDCTA VS DUS**		
	Diagnostic accuracy (%)	Agreement	P value
Common femoral artery	98	0.90	<0.001
Superficial femoral artery	98	0.90	<0.001
Deep femoral artery	97	0.82	<0.001
Popliteal artery	98	0.90	<0.001
Anterior tibial artery	96	0.68	<0.001
Posterior tibial artery	96	0.68	<0.001
Peroneal artery	94	0.58	<0.001
Dorsalis pedis artery	96	0.68	<0.001

Duplex USG had an overall diagnostic accuracy of >80 % in detecting collateral flow except in popliteal (79%) and peroneal (76%) arteries. MDCT better delineated the arterial tree with higher detection rate of thrombosis and collateral flow in both supra-popliteal and infra-popliteal segments. Flow assessment in the calcified arterial segments was better with DUS compared to MDCTA, especially in the infra-popliteal small caliber arteries. Vessel wall calcification was better detected by MDCTA than DUS as shown in Table 2.

Table 2: Diagnostic accuracy of DUS VS MDCTA.

Characteristics	DUS	MDCTA
Thrombosis	94%	96%
Vessel wall calcification	91%	98%
Collateral flow	85%	98%

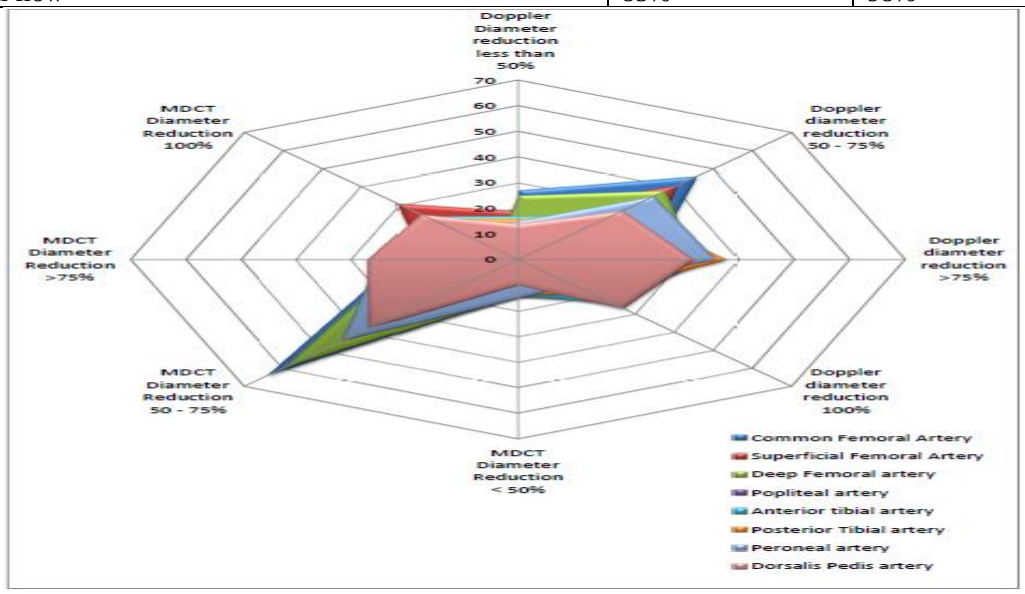

Fig 2:Comparison of diameter reduction in MDCT &Colour Doppler USG.

There was a statistically significant difference in detecting the number of hemodynamically significant stenosis by MDCTA than in Duplex USG as depicted in Figure 2. Duplex Ultrasonography was accurate in the diagnosis of mild (Grade I & II) cases, while MDCT angiography was more accurate in severe cases (Grade III & IV).

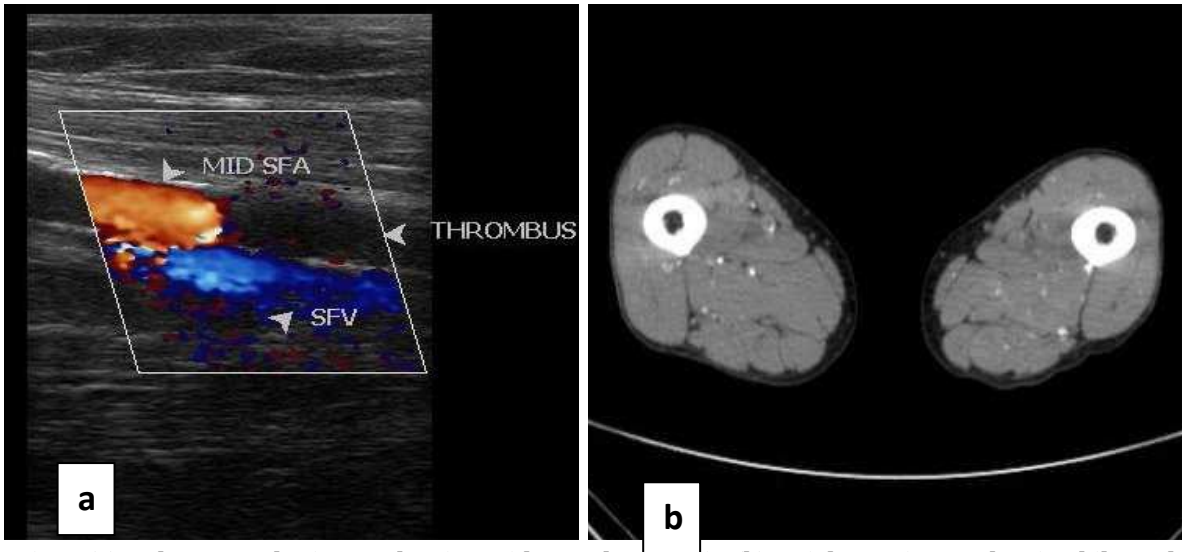

Fig 3: (a) Colour Doppler image showing mid SFA thrombosis, (b) Axial CTA image showing bilateral SFA occlusion with collaterals.

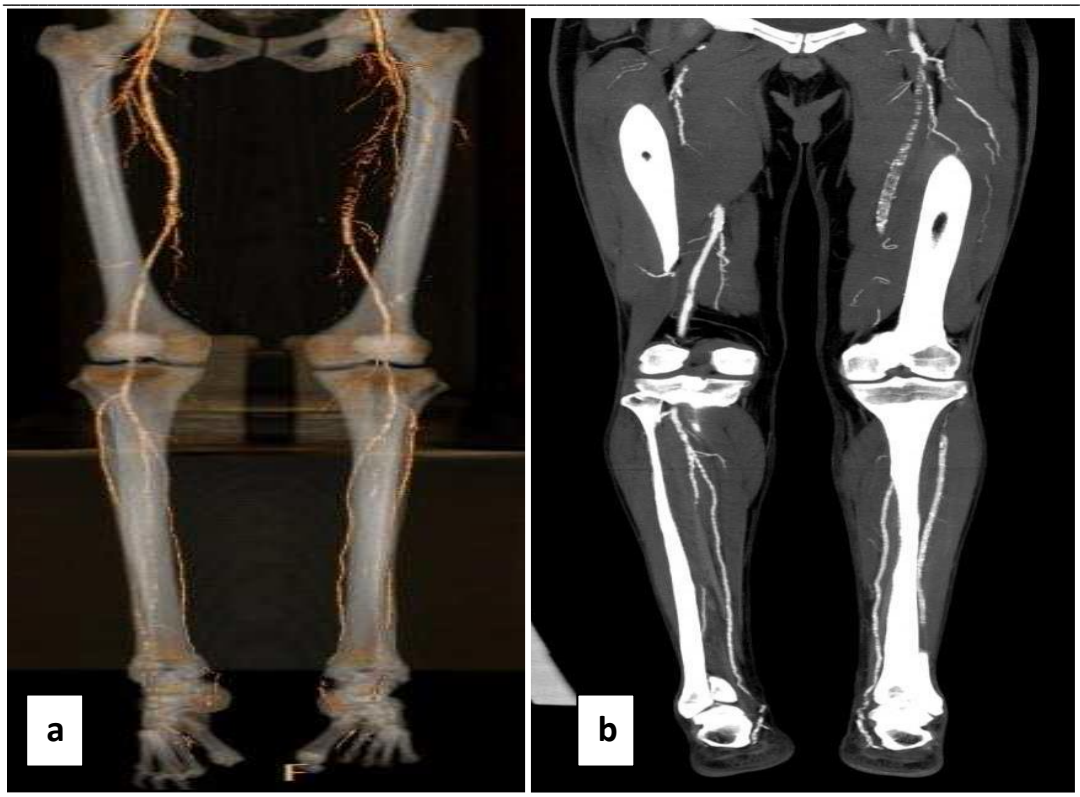

Fig 4: (a) Volume Rendered 3D CT angiographic image of bilateral lower limb arterial system showing long segment occlusion of left SFA, (b) Coronal reformatted CTA image showing left SFA occlusion with wall calcifications.

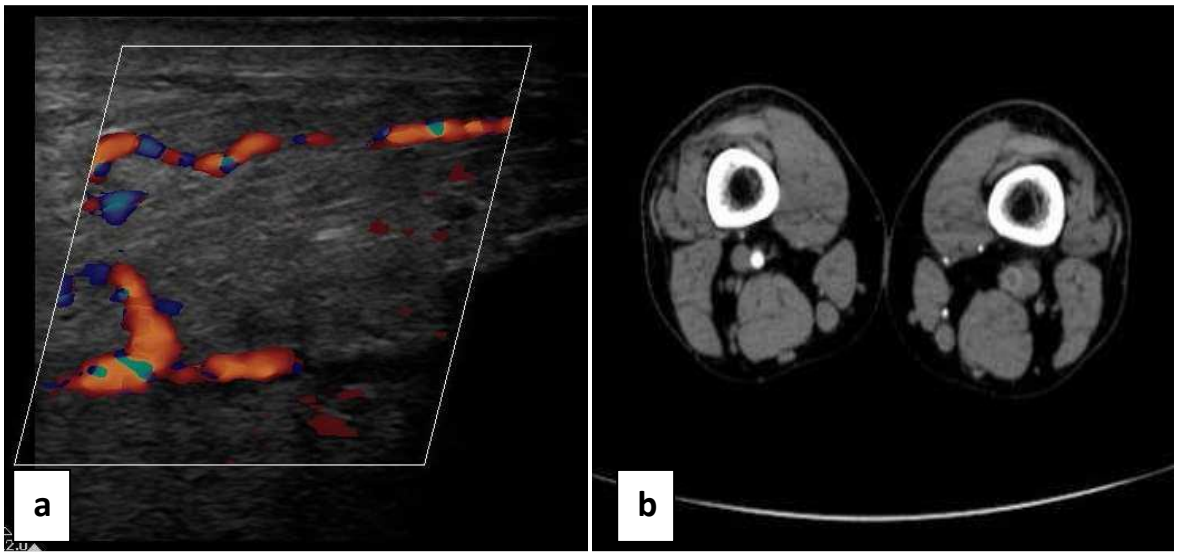

Fig 5: (a) Colour Doppler image showing collateral circulation, (b) Axial CTA image showing left popliteal artery thrombosis with collaterals.

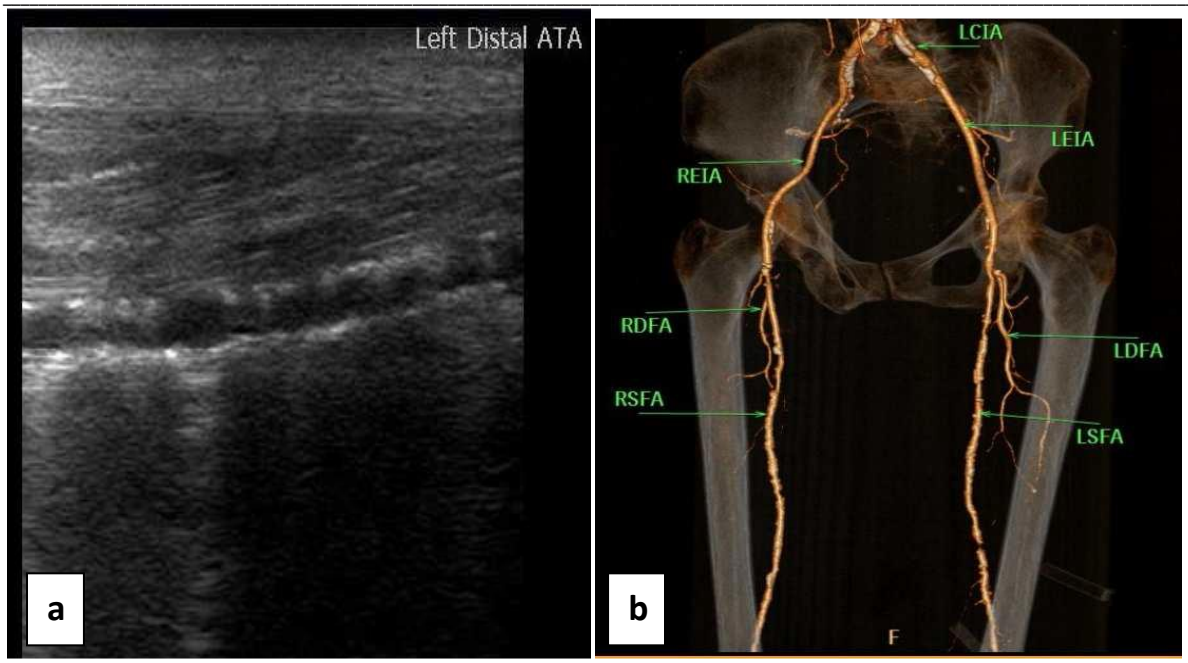

Fig 6: (a) Grey scale ultrasound image showing wall calcifications in the left anterior tibial artery, (b) Volume Rendered 3D CT angiographic image of bilateral lower limb arterial system showing severe atherosclerotic disease with calcified plaques and multisegmental stenosis.

Discussion

Peripheral vascular disease is increasing in its incidence due to various predisposing factors such as smoking, diabetes mellitus, hypertension, and hypercholesterolemia [8]. Atherosclerosis (84%) was the most common cause of peripheral vascular disease followed by TAO (16%) in the present study which is comparable to a study by Rosamond W et al [9].Digital subtraction angiography (DSA) is considered as a gold standard investigation in the evaluation of peripheral vascular disease. The role of DSA has now been challenged by recent advances in technology like Duplex Ultrasonography, MDCT Angiography (MDCTA), and magnetic resonance angiography (MRA). Duplex Ultrasonography is the initial imaging modality of choice in suspected cases of peripheral arterial disease. There are few limitations such as time consumption, operator dependence, obesity, edema, and evaluation of distal vasculature.

MDCT angiography with multiplanar reconstruction techniques aids in the accurate assessment of the stenotic segments, better detection of collateral flow, and reproduction of the lower limb arterial tree as shown in Figure 4 & Figure 5.Grade I & Grade II stenosis were accurately detected by duplex ultrasonography whereas CT angiography was more accurate in the detection of grade III & IV stenosis. Vessel wall calcification was better detected by MDCTA than DUS. The following results were comparable with a previous study done by Netam SS et al [10]. In our study, we also found that the PSV ratio was higher before the level of stenosis and as the grade of the stenosis increases the spectral wave form pattern progressively worsens from the normal triphasic to biphasic in mild to moderate stenosis to monophasic in moderate to severe stenosis. Both Duplex Ultrasonography and MDCT angiography have a good predictive value of lower limb peripheral vascular disease, but the combination has better diagnostic accuracy. The present study along with the previously existing data emphasizes the combined use of DUS and MDCT angiography for diagnosis, grading, and preoperative assessment of lower limb peripheral arterial disease.

Conclusion

The diagnostic accuracy of Duplex Ultrasonography was proved to be nearly accurate as MDCT angiography in the detection of hemodynamically significant stenosis. MDCT angiography better delineated the length of stenotic segments and collateral flow compared to duplex ultrasonography in both supra and infra-popliteal segments. As duplex

ultrasound is nearly accurate to MDCT, and in lieu of its wide availability, cost-effective, not requiring iodinated contrast media and non-ionizing, also its role in post recanalization procedure assessment duplex ultrasound is a preferred imaging modality of choice in assessing the flow and severity of the disease.

References

1. Algazzar MA, Elzawawi MS, Alhawary KE. Role of multi-detector computed tomography angiography in the evaluation of lower limb ischemia. Int J of Med Imaging. 2014; 2(5):125–130.
2. Choudhary VA, Patil SS, Shah VR. Evaluation of Peripheral Arterial Disease of Lower Extremity by Doppler Imaging. Int J Sci Stud. 2016;3(11):163-168.
3. Catalano C, Fraioli F, Laghi A, Napoli A, Bezzi M, Pediconi F. Infrarenal aortic and lower-extremity arterial disease: Diagnostic performance of multi-detector row CT angiography. Radiology. 2004;231:555-63.
4. Kasapis C,Gurm HS: Current Approach to the Diagnosis and Treatment of Femoral Popliteal Arterial Disease. A Systematic Review. Curr Cardiol Rev. 2009; 5(4): 296–311.
5. Bueno A, Acin F, Canibano C, Fernandez-Casado JL, Castillo E. Diagnostic accuracy of contrast-enhanced magnetic resonance angiography and duplex ultrasound in patients with peripheral vascular disease. Vasc Endovascular Surg. 2010;44:576-85.
6. Rajpal K, Nawale A, Borde A. Role of CT Angiography & Colour Flow Imaging (USG) in Evaluation of Peripheral Arterial Diseases. International Journal of Science and Research. 2016;5:580-91.
7. Qenawy OK, Tantawy WH, Karem A, Abdalla AKH, Sayed AAA. Comparative study between multi-detector CT angiography and digital subtraction angiography in evaluation of peripheral arterial occlusive disease. Egypt J RadiolNucl Med 2015; 46(4): 1003-10.
8. Selvin E, Erlinger TP. Prevalence of and risk factors for peripheral arterial disease in the United States: Results from the National Health and Nutrition Examination Survey, 1999-2000. Circulation 2004;110:738-43.
9. Rosamond W, Flegal K, Furie K, Go A, Greenlund K, Haase N, et al. American Heart Association Statistics Committee and Stroke Statistics Subcommittee. Heart disease and stroke statistics-2008 update: a report from the American Heart Association Statistics Committee and Stroke Statistics Subcommittee. Circulation. 2008; 117 (4):e25-146.
10. Netam SS, Singh R, Kumar S. CT Angiography Evaluation of Peripheral Vascular Disease and Comparison with Color Doppler Ultrasound. Journal of Evolution of Medical and Dental Sciences 2015; 4:14504-514.

Conflict of Interest: Nil
Source of support:Nil