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A study of characterizing vascular involvement in patients with lower limb ischemic arterial diseases using multidetector CT angiography

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Abstract

Background: Peripheral arterial disease (PAD) is one of the most common cardiovascular diseases in developed countries and is an emerging problem in developing countries. Duplex ultrasonography (DUS) has been used as the initial imaging modality in mildly symptomatic PAD. Multi-slice helical CT angiography of arteries of the thigh represents a reliable means for the detection of relevant stenoses in patients with peripheral occlusive artery disease. **Objective:** To assess the value of multi-detector computed tomography angiography (MDCTA) and to compare it with DUS to diagnose chronic ischemia of lower limbs. **Methods:** A prospective comparative study was conducted on 40 patients with chronic lower limb ischemia of both limbs during the period from 2022 to September 2024 at the Department of Radio-diagnosis at NCMCH, Panipat, Haryana. DUS was done for all the patients, and then MDCTA was done. **Results: 40** patients (20 males and 20 females) with a mean age of 54.03 ± 11.33 (range: 33–80) years were included in this study. MDCTA detects 86 lesions (52 occluded segments and 34 stenotic segments), and DUS detects 70 lesions (40 occluded segments and 30 stenotic segments). In MDCTA, 75 (16.4%) and 64 (13.8%) lesions were detected, respectively, in both lower limbs of the 40 patients, which indicated the higher number of lesions visualized using CT angiography than DUS; however, the difference was statistically nonsignificant (P = 0.31). While, according to the CTA, 10 patients (25%) had a single arterial segment lesion, 17 patients (42.5%) had two segmental lesions, 4 patients (10%) had three lesions, 6 patients (15%) had four lesions, and only 3 patients (7.5%) had five artery segmental lesions. In regards to DUS findings, a single lesion was found in 18 patients (45%), two lesions in 13 (32.5%), three lesions in 3 (7.5%), four lesions in 3 (10.0%), and just five lesions in a single patient (2.5%) (Table 2). Moreover, the measure of agreement between both CTA and DUS in the number of lesions found revealed a good agreement between the two tests (Kappa = 0.81) with an agreement

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percentage of 86.6%. **Conclusion:** Multi-detector CT angiography is a fast, accurate, safe, and minimally invasive imaging modality that may be used in cases of PAD for diagnosis, grading, and preoperative assessment of lower limb arterial disease.

Keywords

Multi-detector CT angiography, chronic ischemia of the lower limbs, doppler ultrasound

Introduction

Systemic atherosclerosis is a condition that progresses with age and decreases quality of life and life expectancy. Lower extremity peripheral arterial disease (PAD) is a common manifestation of systemic atherosclerosis in the elderly [1, 2]. Peripheral arterial disease (PAD) is the most common condition affecting the arteries of the lower extremity. Any pathologic process that causes obstruction to the blood flow in the arteries, excluding the coronary and cerebral vascular beds, can compromise arterial flow, leading to limb ischemia. These individuals have a two- to fourfold higher risk of coronary heart disease and stroke [3, 4]. Peripheral arterial disease affects a large segment of the adult population. Less than 20% of patients with peripheral arterial disease have typical symptoms of intermittent claudication, whereas another third have atypical exertional leg symptoms [5]. Management strategies are governed by the severity of the disease. Imaging is necessary for planning the interventions in patients with lower extremity peripheral arterial disease [6, 7].

Non-invasive imaging modalities, including duplex ultrasonography, multidetector computed tomography angiography (MDCTA), and magnetic resonance angiography (MRA), are available for grading lower extremity arterial disease. Duplex ultrasonography has a high specificity of 95% and a somewhat lower sensitivity of 88% for detecting hemodynamically significant lesions (> 50% stenosis or occlusion) [8].

Computed tomography angiography is increasingly attractive due to the rapid technical developments. Shorter acquisition times, thinner slices, higher spatial resolution, and improvement of multidetector computed tomographic (CT) scanners enable scanning of the whole vascular tree in a limited period with a decreasing (but still substantial) amount of contrast medium [9]. An angiographic scoring system, named the ANGIO score, was developed by a team of clinicians and scientists specializing in vascular disease. This system was designed to be usable with both CT angiography (CTA) and conventional angiography as a global language [10]. The arteries were scored 0, 1, or 2 according to the degree of stenosis or occlusion: 0, no stenosis or stenosis below 50%; 1, non-occlusive stenosis of at least 50%; and 2, complete occlusion of the artery [11]. Owing to the limited spatial resolution, the infrapopliteal arteries were scored only 0 or 2 for the reproducibility assessment, according to the presence or absence of complete occlusion, and were assessed along their course, proximal to the ankle joint. Values for all arteries from both lower limbs were added to produce an overall score for the patient. More severe PAD was expected to result in a higher ANGIO score [11].

ISSN: 0975-3583,0976-2833 VOL15, ISSUE 11, 2024

Trans-catheter angiography (TCA) is considered the "gold standard" for the assessment of occlusive vascular diseases of the aorta and lower extremity arteries [12]. However, this method is known to be invasive and has a definite morbidity. A computed tomography (CT) scan has enormously improved during the last decade [13]. Duplex ultrasonography (DUS) has been used as the initial imaging modality in mildly symptomatic PAD [14]. Color Doppler allows the rapid identification of normal and abnormal segments of the vessel [15]. Multi-slice helical CT angiography of arteries of the thigh represents a reliable means for the detection of relevant stenosis in patients with peripheral occlusive artery disease [16]. It has the advantage of visualizing the arterial lumen and arterial wall calcifications [17]. Also, it aids in good assessment of unusual lesions and identification for a larger number of arterial segments, especially lesions with occlusive pathologies [18]. The CTA is accurate in about 87% in visualizing >50% stenotic lesions and visualizing total obstruction in about 96%, and to be 92% to 97% sensitive and of 93% to 97% regarding specificity [19]. The advantage of CTA is that it is noninvasive (unlike TCA); disadvantages are exposure to radiation and the need for potentially nephrotoxic contrast agents [20]. This study aimed to assess the value of multi-detector computed tomography angiography (MDCTA) and to compare it with DUS in reaching the diagnosis of lower limb chronic ischemia.

Material and Method

This cross-sectional observational study was conducted in the Department of Radiodiagnosis at NCMCH, Panipat, Haryana, from 2022 to 2024. A cross-sectional observational study was done in 40 patients. 40 patients (20 males and 20 females) with chronic ischemic lower limbs were included regardless of their age or gender. Data were collected from patients referred from medical and cardiovascular surgery wards. Inclusion criteria were patients with symptomatic chronic ischemic limbs. Exclusion criteria were patients having previous interventional radiological procedures, arterial stenting or grafting, a history of significant lower limb trauma with raised renal indices, an acute lower limb ischemia, and patients with a history of allergy to iodinated contrast medium.

Examination protocols

Doppler ultrasonography examinations

Patients were examined using HD11XE. The examination was done beginning at the common femoral artery (CFA), superficial femoral artery (SFA), deep femoral artery (DFA), popliteal artery (POPA), anterior tibial artery (ATA), posterior tibial artery (PTA), and peroneal artery (PeA), which were examined using a 7.5 MHz probe. The diagnostic segment was diagnosed according to the diameter reduction less than or equal to or more than 50%.

Multi-detector CT angiography

Both limbs of the patient were examined in the CT unit using. CT angiography was performed following target injection of 100-120 ml of contrast medium at a flow rate of 3-3.5 ml/s by using bolus tracking. The contrast medium used was low-osmolar

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non-ionic contrast medium (Iohexol 350 mg/mL). MDCTA was performed by using a thin section slice of 0.6 mm.

The criteria of analysis

- Assessment of collateral vessels
- opacification or non-opacification of thetenotic segments
- presence or absence of an occlusion with estimating its length
- The arterial tree was then divided into 7 segments: CFA, SFA, DFA, POPA, ATA, PTA, and PeA.

Statistical analysis

Patients' data were entered and analyzed using SPSS-24. Measure of Agreement (Kappa) (as shown in Table 1) was used to assess the performance and agreement of CT angiography and duplex ultrasonography, and the percent agreement was calculated. The significance level was assessed using Pearson's chi square test. Level of significance: a P value ≤ 0.05 was considered as statistically significant.

Table 1. Lower limb ischemia Benchmark scales to Kappa's value

Kappa value	Interpretation
< 0.20	Poor
0.21-0.40	Fair
0.41-0.60	Moderate
0.61-0.80	Good
0.81-1.0	Very good

Observation and Results

Thirty patients were enrolled in this study, with a mean age of 54.03 ± 11.33 (range: 33-80) years. Males were 20 and represented half of the studied group (50%), and females were 20 and represented the remaining (50%).

Table 2. Number and proportions of patients according to the number of affected segments detected by CT angiography and Doppler ultrasonography

Number of affected segments	CT Angiography		Duplex ultrasonography	
	No. of patients	%	No. of patients	%
1	10	25	18	45
2	17	42.5	13	32.5
3	4	10	3	7.5
4	6	15	5	12.5
5	3	7.5	1	2.5

ISSN: 0975-3583,0976-2833 VOL15, ISSUE 11, 2024

Kappa - 0.81

Percent agreement: 86.6%

[P.value < 0.001, significant at ≤ 0.05]

According to the findings of the CT angiography and DUS, there were a total of 75 (16.4%) and 64 (13.8%) lesions detected, respectively, in both lower limbs of the 40 patients, which indicated the higher number of lesions visualized using CT angiography than DUS; however, the difference was statistically nonsignificant (P = 0.31). While, according to the CTA, 10 patients (25%) had a single arterial segment lesion, 17 patients (42.5%) had two segmental lesions, 4 patients (10%) had three lesions, 6 patients (15%) had four lesions, and only 3 patients (7.5%) had five artery segmental lesions. In regards to DUS findings, a single lesion was found in 18 patients (45%), two lesions in 13 (32.5%), three lesions in 3 (7.5%), four lesions in 3 (10.0%), and just five lesions in a single patient (2.5%) (Table 2). Moreover, the measure of agreement between both CTA and DUS in the number of lesions found revealed a good agreement between the two tests (Kappa = 0.81) with an agreement percentage of 86.6%.

Table 3. Distribution of lower limb arterial lesions detected by CT angiography and doppler ultrasound according to the type of lesion and artery segment

	Occlusion				**Stenosis**			
Artery	**CT angiography**		**Doppler Ultrasound**		**CT angiography**		**Doppler Ultrasound**	
	No.	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**
CFA	**3**	6.7	**3**	**6.7**	**5**	**13.3**	**4**	**10**
DFA	**0**	**0**	**0**	**0**	**2**	**6.7**	**2**	**3.3**
SFA	**9**	**26.7**	**7**	**20**	**6**	**16.7**	**5**	**13.3**
DOPA	**8**	**23.3**	**8**	**23.3**	**5**	**13.3**	**4**	**10**
PTA	**12**	**26.7**	**8**	**23.3**	**5**	**13.3**	**6**	**16.7**
ATA	**13**	**33.3**	**9**	**26.7**	**6**	**16.7**	**5**	**13.3**
Per. A	**7**	**20**	**5**	**16.7**	**5**	**13.3**	**4**	**10**
Total	**52**	**68.3**	**40**	**58.3**	**34**	**46.6**	**30**	**38.3**

Additionally, the distribution of the visualized lesions according to the type of lesion visualized and the arterial segment affected is shown in Table 3. Here, the findings of CT angiography revealed that out of the 86 arterial lesions visualized to have 52 segments (68.3%) were occluded and the remaining 34 segments (46.6%) were found to be stenosed. The duplex ultrasonography revealed 40 (58.3%) occluded and 30 (38.3%) stenosed arterial segments out of the 70 total lesions detected by this test; these findings are summarized in Table 3.

ISSN: 0975-3583,0976-2833 VOL15, ISSUE 11, 2024

Table 4. Measure of agreement between CT angiography and Doppler ultrasonography in detection of type of arterial lesions

Measure of Agreement (Kappa)	Kappa	Percent agreement	P-value
In occlusion	0.82	85.70%	< 0.001
In Stenosis	0.75	78.50%	0.003
For all lesions	0.79	82.70%	< 0.001

The measure of agreement between CT angiography and duplex ultrasonography regarding the type of lesions detected showed that there was a good agreement between both tests in detection of both occlusion and stenosis of the examined arterial segments, with higher percent agreement in occlusive lesions than stenosis [(Kappa = 0.82), (percent agreement = 85.7%) and (Kappa = 0.75), (percent agreement = 78.5%), respectively, and for the detection of all lesions (Kappa = 0.79) with an agreement percentage of 82.7%) as shown in Table 4.

The following figures (1 and 2) show selected images of some patients presented with lower limb ischemia participated in the current study.

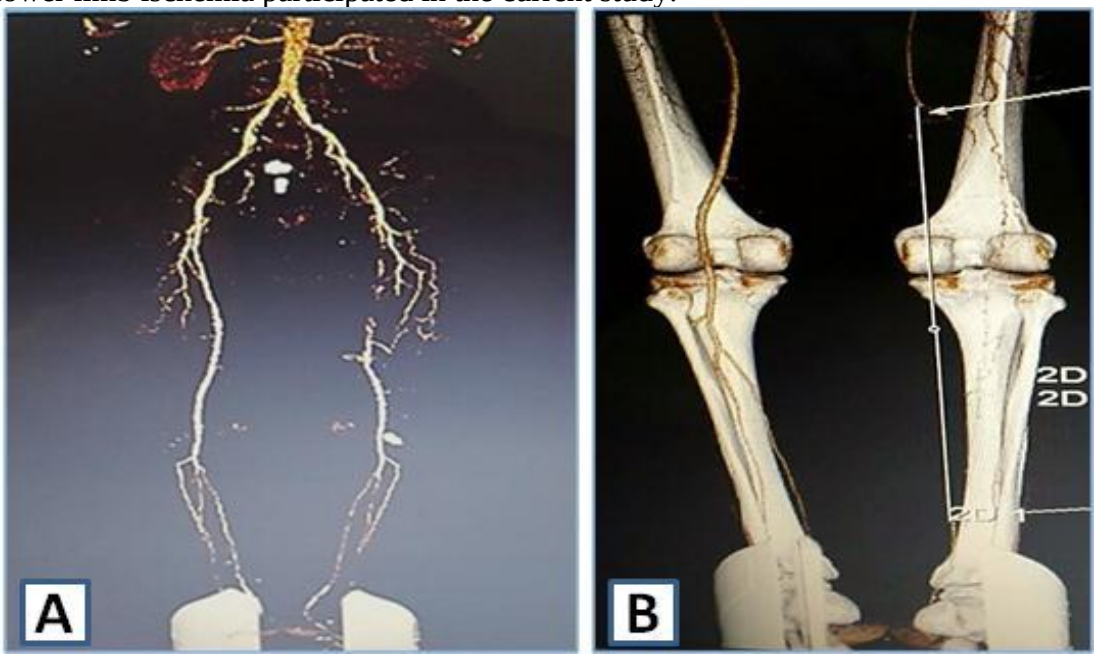

Figure 1. A: MDCTA of 60 years old male patient showing occlusion of the Left superficial femoral artery. B: MDCTA (posterior view) of 57 years old male patients presented with lower limb ischemia shows occlusion of left side distal superficial femoral, popliteal and posterior tibial arteries

ISSN: 0975-3583,0976-2833 VOL15, ISSUE 11, 2024

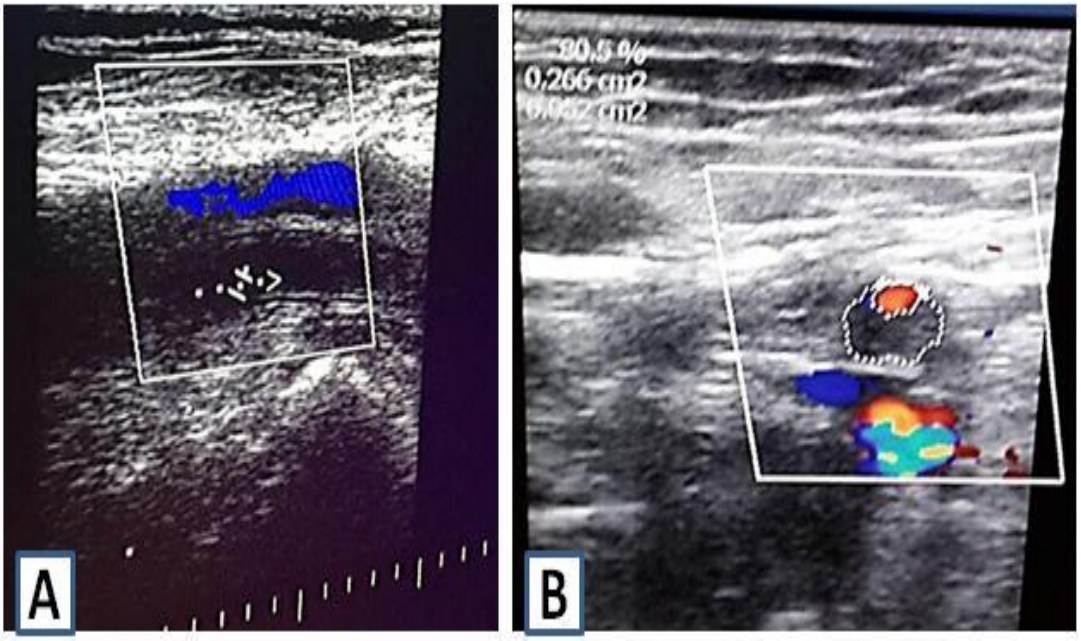

Figure 2. A: Doppler US of the Left superficial femoral artery shows no flow in color Doppler and no spectral wave in a 61 years old male patient showing occlusion of the artery. B: Color Doppler shows area of stenosis of the left femoral artery in a 57 years old male patient with lower limb ischemia

Discussion

Multidetector computed tomography angiography (MDCTA) remains the most widely available and most effective modality for the detection, characterization, and evaluation of peripheral arterial disease. Chronic ischemic lower limb is a disease manifested via a wide range of clinical presentations, starting from being asymptomatic through intermittent claudication to critical limb ischemia [20]. Management strategies are ruled by disease severity. Imaging is vital for planning the intervention of PAD, specifically the lower limbs [21-22].

Non-invasive imaging procedures, including DUS, magnetic resonance angiography (MRA), and MDCTA, are available for grading lower limb arterial disease [23]. The DUS has been proven to be a highly specific and sensitive test for the identification of significant hemodynamic lesions with more than 50% stenosis or occlusion [24]. CT angiography continues to be attractive due to the continuous fast technical improvement, thinner slices, higher spatial resolution, short acquisition time, and availability of scanning of the whole vascular tree in a limited time with a reduction in the quantity of contrast medium [25–26]. CT angiography assesses the extent of PAD and provides a plan and guide for vascular interventions [27].

Various imaging techniques are used in the diagnosis of PAD. The usual is DUS and conventional angiography. The gold standard conventional angiography is responsible for complications in 1 to 2% of patients. For this reason, non-invasive techniques have been recently developed [28]. In the present study, the MDCTA findings revealed a total of 52 occluded and 34 stenosed segments with a total lesions of 86. These findings show no great difference compared to that of the DUS examination, where DUS detected 70 lesions of all examined arterial segments; these lesions

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included 40 occlusions and 30 stenosis, and according to the number of affected segments detected by MDCTA and DUS findings, there was good agreement between both tests with a larger number of lesions detected on CT angiography than DUS. The cause behind this slightly lower number of lesions visualized in DUS may be due to the deep anatomic position and small vascular diameter of some arterial segments, which may compromise intonations seen in the peroneal artery, and this shows the additional value and complementary role of the CT angiography as a diagnostic tool for lower limb peripheral arterial lesions [29-30]. The findings in regard to the good performance and good agreement rate between MDCTA and DUS go with that reported in the previous study of Pollak et al. [28], who compared MDCTA vs. DUS and found that overall, the technique for imaging vessel stenosis by using DUS is less sensitive than MDCTA and requires a longer time for evaluation of two lower extremities; this is considered the greatest limitation of DUS.

Another study by Algazzar et al. [26] revealed results differ from ours in terms of no statistically significant difference between MDCTA and DUS, and this difference might be due to population differences, patients' inclusion criteria, and the difference in age groups of the patients in both studies. Some studies limit the use of DUS in evaluating lower limb arterial pathologies as the procedure is totally operator dependent, it requires highly trained people, and it also lacks the arterial imaging capability of MDCTA that the vascular surgeons need for preoperative planning and assessment, it can document only a small arterial segmental lesion in each image [21, 23].

Bueno et al. [30] examined 1720 segments on 40 patients; the utility of Doppler US and MRA was evaluated by using CA as a reference point. When the detection of stenosis ≥ 50% was taken as the sole criterion, sensitivity and specificity values were calculated, respectively, to be 81.4% and 99% for Doppler ultrasonography and 91 and 99% for MRA. In the same study, total occlusion sensitivity and specificity values were calculated respectively as 90% and 97% for Doppler US and 95.4% and 98% for MRA. The latter study demonstrated a relatively low sensitivity value for Doppler ultrasonography in the detection of significant stenosis in the lower limb arteries whereas the specificity value was quite acceptable.

This study concluded that MDCTA is a fast, accurate, safe, and minimally invasive imaging modality that may be used in cases of peripheral vascular diseases for diagnosis, grading, and preoperative assessment of lower limb arterial disease. The limiting factors that prevent the widespread usage of MDCTA are the limited number of multidetector row CT machines and the limited experienced stuff that can perform such a recent examination. Interpretation of the images by a radiologist with experience in vascular imaging combined with experience in multi-detector row CT imaging is mandatory. DUS is a reliable, non-invasive method of investigating the lower limb arterial system. It has an advantage over MDCTA that it provides us with hemodynamic data proximal, distal, and at the site of obstruction. The limiting factor for color DUS imaging is that this examination is totally operator dependent. It requires highly trained personnel, which is not always available. It also lacks the arterial imaging capabilities of MDCTA that surgeons need for preoperative planning. It can only document a small arterial segment in each image. This leads us to the conclusion that MDCTA may replace color DUS in many cases.

ISSN: 0975-3583,0976-2833 VOL15, ISSUE 11, 2024

Conclusion

Multi-detector CT angiography is a fast, accurate, safe, and minimally invasive imaging modality that may be used in

cases of PAD for diagnosis, grading, and preoperative assessment of lower limb arterial disease.

Conflict of interest

No conflict of interest is present.

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References

1. Abdel Razek AA, Denewer AT, Hegazy MA et al. (2014) Role of computed tomography angiography in the diagnosis of vascular stenosis in head and neck microvascular free flap reconstruction. Int J Oral Maxillofac Surg 43: 811–815
2. Algazzar MA, Elzawawi MS, Alhawary KE et al. (2014) Role of multi-detector computed tomography angiography in the evaluation of lower limb ischemia. Int J of Med Imaging. 2(5):125–130
3. Kandasamy G, Maithrayee A, Kailasanathan N (2015) Lower limb arteries assessed with Doppler angiography. a prospective comparative study with multi-detector CT angiography. Inter J Latest Res Sci Technol 4(6):70-83
4. Shirol RJ, Shetty A, Chethan TK (2015) Role of MDCT in evaluation of peripheral vascular disease of the lower limb arteries and comparison with color Doppler. J Evol Med Dental Sci 4(54):9336–9346
5. Kasapis C, Gurm HS (2009) Current approach to the diagnosis and treatment of femoral popliteal arterial disease. A Systematic Review. Curr Cardiol Rev 5(4):296–311
6. Abdel Razek AAK, Elrakhawy MM, Yossof MM et al. (2018) Inter-observer agreement of the Coronary Artery Disease Reporting and Data System (CAD-RADSTM) in patients with stable chest pain. Pol J Radiol 83:e151–e159
7. Collins R, Burch J, Cranny G et al. (2007) Duplex ultrasonography, magnetic resonance angiography, and computed tomography angiography for diagnosis and assessment of symptomatic lower limb peripheral arterial disease. A Systematic Review. BMJ 334:1257–1261
8. Met R, Bipat S, Legemate DA et al. (2009). Diagnostic performance of computed tomography angiography in peripheral arterial disease. A systematic review and metaanalysis. JAMA 301(4):415–424
9. Laswed T, Rizzo E, Guntern D et al. (2008) Assessment of occlusive arterial disease of abdominal aorta and lower extremities arteries: value of multidetector CT angiography using an adaptive acquisition method. Eur Radiol 18(2):263–272

ISSN: 0975-3583,0976-2833 VOL15, ISSUE 11, 2024

10. Razek AA, Gaballa G, Megahed AS et al. (2013) Time-resolved imaging of contrast kinetics (TRICKS) MR angiography of arteriovenous malformations of the head and neck. Eur J Radiol 82:1885–1891
11. Keeling A, Carroll T, McDermott M et al. (2017) Clinical correlates of size and number of collateral vessels in peripheral artery disease. Vasc Med 4:223–230
12. Malden ES, Picus D, Vesely TM, et al. Peripheral vascular disease: evaluation with stepping DSA and conventional screen-film angiography. Radiology. 1994; 191(1): 149-53. doi: 10.1148/radiology.191.1.8134562.
13. Rubin GD, Zarins CK. MR and spiral/helical CT imaging of lower extremity occlusive disease. Surg Clin North Am. 1995; 75(4): 607-19.
14. Falluji N, Mukherjee D. Critical and acute limb ischemia: an overview. Angiology. 2014; 65(2): 137-46. doi: 10.1177/0003319712470966.
15. Weragoda J, Weerasinghe MC, Seneviratne R, et al. Gaps in awareness of peripheral arterial disease in Sri Lanka: a cross-sectional study. BMC Public Health. 2016; 16(1): 1073. doi: 10.1186/s12889-016-3748-8.
16. Puls R, Knollmann F, Werk M, et al. [Multi-slice spiral CT: 3D CT angiography for evaluating therapeutically relevant stenosis in peripheral arterial occlusive disease]. Rontgenpraxis. 2001; 54(4): 141-7.
17. Laissy JP, Pernes JM. [Imaging of the lower limb arteries: when, how, and why]?. J Radiol. 2004; 85(6 Pt 2): 845-50.
18. Burrill J, Dabbagh Z, Gollub F, et al. Multidetector computed tomographic angiography of the cardiovascular system. Postgrad Med J. 2007; 83(985): 698–704. doi: 10.1136/pgmj.2007.061804.
19. Antithrombotic Trialists' (ATT) Collaboration, Baigent C, Blackwell L, et al. Aspirin in the primary and secondary prevention of vascular disease: collaborative meta-analysis of individual participant data from randomized trials. Lancet. 2009; 373(9678): 1849-60. doi: 10.1016/S0140-6736(09)60503-1.
20. Szymczak M, Oszkinis G, Majchrzycki M. The impact of walking exercises and resistance training upon the walking distance in patients with chronic lower limb ischaemia. Biomed Res Int. 2016; 2016: 7515238.doi: 10.1155/2016/7515238.
21. 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. doi: 10.2174/157340309789317823.
22. Collins R, Burch J, Cranny G, et al. Duplex ultrasonography, magnetic resonance angiography, and computed tomography angiography for diagnosis and assessment of symptomatic, lower limb peripheral arterial disease: systematic review. BMJ.2007; 334(7606): 1257. doi: 10.1136/bmj.39217.473275.55.
23. 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(6): 738-43. doi: 10.1161/01.CIR.0000137913.26087.F0.
24. Androulakis AE, Giannoukas AD, Labropoulos N, et al. The impact of duplex scanning on vascular practice. Int Angiol. 1996; 15(4): 283-90.
25. Met R, Bipat S, Legemate DA, et al. Diagnostic performance of computed tomography angiography in peripheral arterial disease: a systematic review and meta-analysis. JAMA. 2009; 301(4): 415-24. doi: 10.1001/jama.301.4.415.

ISSN: 0975-3583,0976-2833 VOL15, ISSUE 11, 2024

26. Algazzar MAA. Role of multi-detector computed tomography angiography in the evaluation of lower limb ischemia. Int J Med Imaging. 2014; 2(5): 125-30.
27. Duran C, Bismuth J. Advanced imaging in limb salvage. Methodist Debakey Cardiovasc J. 2012; 8(4): 28-32.
28. Pollak AW, Norton P, Kramer CM. Multimodality imaging of lower extremity peripheral arterial disease: current role and future directions. Circ Cardiovasc Imaging. 2012; 5(6): 797-807. doi: 10.1161/CIRCIMAGING.111.970814.
29. HeijenbrokKal MH, Kock MC, Hunink MG. Lower extremity arterial disease: multidetector CT angiography meta-analysis. Radiology. 2007;245(2): 433-9.
30. Bueno A, Acín F, Cañibano C et al. (2010). Diagnostic accuracy of contrast-enhanced magnetic resonance angiography and duplex ultrasound in patients with peripheral vascular disease. Vasc Endovascular Surg 44:576–585