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Value of Multi-detector CT Angiography in Chronic Ischemia of Lower Limbs in Comparison with the Doppler ultrasound

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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 mild 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 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 30 patients with chronic lower limbs ischemia of both limbs during the period from September 2015 to September 2016 at the Department of Diagnostic Radiology of Al-Imamein Al-Kadhimein Medical City, Baghdad, Iraq. DUS was done for all the patients and then MDCTA was done.

Results Thirty patients (20 males and 10 females) with a mean age of 57.1 ± 8.5 (range: 33 –80) years were included in this study. MDCTA detects 69 lesions (41 occluded segments and 28 stenotic segments) and DUS detects 58 lesions (35 occluded segments and 43 stenotic segments). In MDCTA, 8 patients (26.7%) had lesion in only one arterial segment, 13 patients (43.3%) had two segment lesions, 3 patients (10%) had three segment lesions, 4 patients (13.3%) with four lesions and only two patients (6.7%) had lesions in five arterial segments. Regarding the findings of the DUS one segment lesion was detected in 13 patients (43.3%), two segment lesions in 11 (36.7%), three segment lesions in 2 (6.7%), four segment lesions in 3 (10.0%) and only five segment lesions in only one patient (3.3). Furthermore, the measure of agreement between both MDCTA and DUS in the number of lesions detected revealed a good agreement between both tests, (Kappa = 0.81) with a percent agreement of (86.6%).

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

Keywords Multi-detector CT Angiography, chronic ischemia of lower limbs, doppler ultrasound

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List of abbreviations: ATA = Anterior tibial artery, CLI = Chronic limb ischemia, CFA = Common femoral artery, CT = Computed tomography, DFA = Deep femoral artery, DUS = Duplex ultrasonography, MRI = Magnetic resonance angiography, MDCTA = Multi-detector computed tomography angiography, PAD = Peripheral arterial disease, PeA = Peroneal artery, POPA = Popliteal artery, PTA = Posterior tibial artery, SFA = Superficial femoral artery, TCA = Trans-catheter angiography

Introduction

Peripheral arterial disease (PAD) is one of the most common cardiovascular diseases in developed countries [(1)] and is an emerging issue in developing countries [(2,3)]. It is a manifestation of systemic atherosclerosis that commonly affects the lower extremities and is defined as any pathologic process causing obstruction to blood flow in the arteries [(4)]. Chronic limb ischemia (CLI) is the end result of PAD. Among aging people, and with elevating incidence of both diabetes and chronic kidney disease, chronic ischemic limb is likely to be more prevalent [(5)]. Existence of PAD is an extensive atherosclerosis marker [(6)]. The diagnosis of PAD and the subsequent treatment decisions rely on clinical exam and non-invasive imaging [(7)]. Clinical symptoms depend most of all upon the degree of vascular stenosis/occlusion, the location of lesions in

particular vascular segments, the degree of advancement of collateral circulation [5,8-10]. In the early stages, PAD is mostly silent. With the progression of disease, it may manifest as intermittent claudication, pain at rest [11]. Most individuals with lower extremity PAD are asymptomatic and do not experience recognizable ischemic symptoms until late in the disease progression [12]. Imaging is necessary for planning interventions in patients with lower extremity PAD [4].

Trans-catheter angiography (TCA) is considered as the "gold standard" for the assessment of occlusive vascular diseases of the aorta and lower extremity arteries [13]. However, this method is known to be invasive and has a definite morbidity. Computed tomography (CT) scan has enormously improved during last decade [14,15]. Duplex ultrasonography (DUS) has been used as the initial imaging modality in mild symptomatic PAD [16]. Color Doppler allows the rapid identification of normal and abnormal segments of vessel [17]. 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 [18]. It has the advantage of visualizing the arterial lumen and arterial wall calcifications [19]. Also, it aids in good assessment of unusual lesions and identification for larger number of arterial segments, specially lesions with occlusive pathologies [20-23]. 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 [24]. The advantage of CTA is that it is noninvasive (unlike TCA), disadvantages are exposure to radiations, needs for potentially nephrotoxic contrast agents [25].

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.

Methods

This was a prospective comparative study done from September 2015 through September 2016 in Radiology Department of Al-Imamein Al-Kadhimein Medical City, Baghdad,Iraq. Thirty patients (20 males and 10 females) with chronic ischemic lower limbs were included regardless of their age or gender. Data were collected form patients referred from medical and cardiovascular surgery wards.

Inclusion criteria were patients with symptomatic chronic ischemic limbs.

Exclusion criteria were patient 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 history of allergy to iodinated contrast medium.

Examination protocols

Doppler ultra-sonography examinations

Patients were examined using HD11XE (Philips medical system, Netherland). 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) were examined using a 7.5 MHz probe. The diagnostic segment was diagnosed according to the diameter reduction less than or equal/ more than 50%.

Multi-detector CT angiography

Both limbs of the patient were examined in the CT unit using (somatome definition 64 slices, Siemens medical system, Germany). 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 low osmolar non-ionic contrast medium (Iohexol 350 mg I/ml). MDCTA was performed by using a thin section slice of 0.6 mm.

The criteria of analysis

1) Assessment of collateral vessels; 2) opacification or non-opacification of the

examined part; 3) Presence or absence of stenotic segments; 4) presence or absence of an occlusion with estimating its length; 5) 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 the statistical package for social sciences (SPSS). 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 – 1.00	Very good, Almost perfect

Results

Thirty patients were enrolled in this study, with a mean age of 57.1 ± 8.5 (range: 33-80) years. Males were 20 represented two thirds of the studied group, (66.7%) and females were 10 represented the remaining (33.3%).

According to the findings of the CT angiography and DUS, there were a total of 69 (16.4%) and 58 (13.8%) lesions detected, respectively, in both lower limbs of the 30 patients, which indicated the higher number of lesions visualized using CT angiography than DUS, however, the difference was statistically non-significant, (P= 0.34). whilst, according to the CTA 8 patients (26.7%) had a single arterial segment lesion, 13 patients (43.3%) had two segmental lesions, 3 patients (10%) had three lesions, 4 patients (13.3%) with four lesions and only two patients (6.7%) had five artery segmental lesions. In regards to DUS findings single lesion was found in 13 patients (43.3%), two lesions in 11 (36.7%), three lesions in 2 (6.7%), four lesions in 3 (10.0%) and just five lesions in a single patient (3.3%), (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 agreement percentage of (86.6%).

Additionally, the distribution of the visualized lesions according to the type of lesion visualized and the arterial segment affected is shown in (Table 3), where the findings of CT angiography revealed that out of the 69 arterial lesions visualized to have 41 segments (68.3%) were occluded and the remaining 28 segments (46.6%) were found to be stenosed. The duplex ultrasonography revealed 35 (58.3%) occluded and 23 (38.3%) stenosed arterial segments out of the 58 total lesions detected by this test, these findings are summarized in table 3.

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	%
One	8	26.7%	13	43.3%
Two	13	43.3%	11	36.7%
Three	3	10.0%	2	6.7%
Four	4	13.3%	3	10.0%
Five	2	6.7%	1	3.3%
Total	30	100%	30	100%
Measure of Agreement for number of lesions detected				
Kappa		0.81		
Percent agreement		86.6%		
P.value < 0.001, significant at ≤ 0.05				

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

Artery	Occlusion				Stenosis			
	CT angiography		Doppler Ultrasound		CT angiography		Doppler Ultrasound	
	No.	%	No.	%	No.	%	No.	%
CFA	2	6.7	2	6.7	4	13.3	3	10
DFA	0	0	0	0	2	6.7	1	3.3
SFA	8	26.7	6	20	5	16.7	4	13.3
POPA	7	23.3	7	23.3	4	13.3	3	10
PTA	8	26.7	7	23.3	4	13.3	5	16.7
ATA	10	33.3	8	26.7	5	16.7	4	13.3
Per. A	6	20	5	16.7	4	13.3	3	10
Total	41	68.3	35	58.3	28	46.6	23	38.3

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 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.

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

* P. value is significant at ≤ 0.05

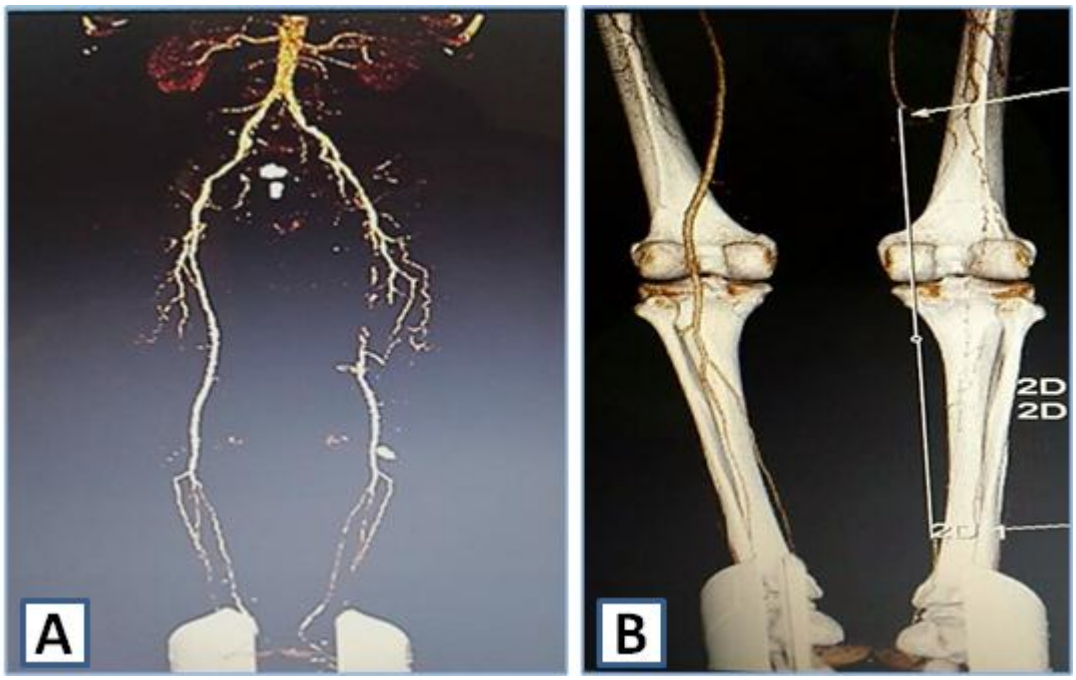

Figure 1. A: MDCTA of 60 years old male patient showing occlusion of the Left superficial femoral artery. B: MDCTA (posterior view) of 54 years old male patients presented with lower limb ischemia shows occlusion of left side distal superficial femoral, popliteal and posterior tibial arteries

Discussion

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 [26]. Management strategies are ruled by disease severity. Imaging is vital for planning the intervention of PAD specifically the lower limbs [4,27].

Non-invasive imaging procedures, including DUS, magnetic resonance angiography (MRA), and MDCTA are available for grading lower limb arterial disease [6,7]. The DUS has been proved as a high specific and sensitive test for identification of significant hemodynamic lesions with more than 50% stenosis or occlusion [28]. 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 [29-33]. CT angiography assessing the extent of PAD and provides plan and guide for vascular interventions [34].

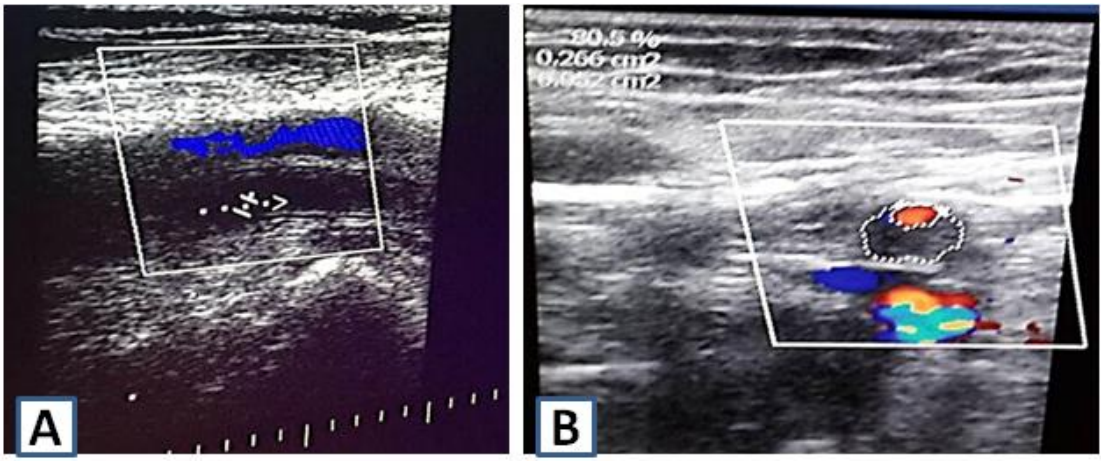

Figure 2. A: Doppler US of the Left superficial femoral artery shows no flow in color Doppler and no spectral wave in a 60 years old male patient showing occlusion of the artery. B: Color Doppler shows area of stenosis of the left femoral artery in a 54 years old male patient with lower limb ischemia

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 [32].

In the present study, the MDCTA findings revealed a total of 41 occluded and 28 stenosed segments with a total lesions of 69, these findings show no great difference compared to that of DUS examination where DUS detected 58 lesions of all examined arterial segments, these lesions included 35 occlusions and 23 stenosis and according to the number of affected segments detected by MDCTA and DUS findings indicated good agreement between both tests with 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 deep anatomic position and small vascular diameter of some arterial segments which may compromise intonations seen in the peroneal artery and this show the additional value and complementary role of the CT angiography as a diagnostic tool for lower limb peripheral arterial lesions [27,28,34].

The findings in regard to the good performance and good agreement rate between MDCTA and DUS go with that reported in previous study of Pollak et al. [35] who compared MDCTA vs DUS and found that overall, the technique for imaging vessel stenosis by using DUS is less sensitive than MDCTA and need longer time for evaluation of two lower extremities this considered the greatest limitation of DUS. Another study by Algazzar et al. [30], revealed results differ from ours in term of no statistically difference between MDCTA and DUS, and this difference might be due to population difference, 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 person, 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 [27,28].

This study concluded that MDCTA is a fast, accurate, safe and a minimally-invasive imaging modality, which may be used in cases of peripheral vascular diseases for diagnosis, grading and for 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.

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Authors contribution

All the three authors were collaborated together in collecting data and writing the thesis.

Conflict of interest

No conflict of interest is present.

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