Original research article

A hospital-based prospective assessment of the role of duplex ultrasonography in comparison with MDCT angiography in the assessment of Peripheral arterial disease

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Abstract

Aim: This study was aiming to evaluate the role of duplex ultrasonography in comparison with MDCT angiography in the assessment of Peripheral arterial disease.

Methods: The study group includes 50 patients with unilateral or bilateral chronic lower limb ischemic disease who have come to the Department of Radiology for CT angiograph and Doppler ultrasonography (US) was done for comparison.

Results: The study involved 50 patients, 22 men (44%) and 28 women (56%). They were between 33 and 75.0 years with mean 59.56 years and standard deviation ± 10.3. Out of them, there were 4 patients who had above-knee amputation of one leg. Out of the 50 patients, 5 were asymptomatic (Fontain’s stage 1), 15 had intermittent claudication when walking more than 200 m (Fontain’s stage 2a), 10 had intermittent claudication when walking more than 200m (Fontain’s stage 2b), 10 had rest pain (Fontain’s stage 3), and 10 had trophic changes, ulcers, or gangrene (Fontain’s stage 4). There were 32 patients who are chronic smokers 64%, 35 had diabetes 70%, 24 had hypertension 48%, and 4 are cardiac 8%.

Conclusion: Both MDCT angiography and duplex US have a good predictive value of chronic lower limb ischemia, but the combination of them has better diagnostic accuracy.

Keywords: Duplex ultrasound, Multidetector computed tomography angiography, peripheral arterial disease

Introduction

Systemic atherosclerosis is a condition which 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. Compromise of arterial flow due to the stenosis and occlusions can result in limb ischemia and is defined as any pathologic process causing obstruction to the blood flow in the arteries, exclusive of the coronary and cerebral vascular beds. 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].

The multidisciplinary team meeting (MDTM) has become an integral component in the management of patients [10, 11] including those with peripheral arterial disease (PAD), and discussion and review of imaging are central to this process. Decisions based on a consensus of opinion from each of the specialties involved in diagnosis, surgery, and endovascular intervention, allow the best strategies for

ISSN:0975 -3583,0976-2833 VOL13, ISSUE 08, 2022

imaging and treatment to be decided and expedited. This is particularly important to achieve the optimum outcome in complex cases, involving technically challenging and expensive interventions on high-risk patients. Furthermore, when novel procedures with the use of new devices are proposed, the responsibility for this becomes shared amongst the entire MDTM team. Indeed, trials of interventional procedures are now incorporating the MDTM decision-making process as a strategic part of patient selection [12]. Optimization of intravenous contrast with blood flow and CT scanning gives higher spatial resolution and coverage of more than 120 cm [13, 14]. Many display formats have been developed and may be used, including multi-planar reformation, maximum intensity projection, surface-shaded display, and, most recently, volume rendering [15].

This study was aiming to evaluate the role of duplex ultrasonography in comparison with MDCT angiography in the assessment of Peripheral arterial disease.

Methods

The study group includes 50 patients with unilateral or bilateral chronic lower limb ischemic disease who have come to the Department of Radiology for CT angiograph and Doppler ultrasonography (US) was done for comparison.

Inclusion criteria

- For any age and both gender
- Patient presented with clinically diagnosed/ suspected lower limb peripheral ischemic disease
- Patient-related factors including body habitus, body size and shape, co-morbidities, history of neurological disease, diabetes, smoking, and patient preference

Exclusion criteria

- Contraindication for MDCT
- Severe renal impairment (intolerance to iodinated contrast media)

Duplex ultrasonography

Duplex ultrasonography was done with Philips duplex ultrasound machine bandwidth frequency transducer with a range of 5–13 MHz for the lower limb artery and 3.5 MHz probe for the infrarenal aorta and iliac vessels. Patients were kept fasting for at least 6 h, to improve visualization of the aorto-iliac region. Duplex ultrasound criteria for the assessment of peripheral arterial disease patency of the vessel were determined by normal triphasic waveform pattern and color saturation, demonstrated throughout the lumen of the artery. A peak systolic velocity ratio of greater than 2 indicates a stenosis of greater than 50%. In order to eliminate interobserver variation, all Doppler studies were done by the same radiologist.

CT angiography

CT angiography was done with 28 slice multidetector CT Philips. Patients were placed in a supine position with the feet entering the gantry first. All multidetector row CT angiography examinations were performed by dedicated CT technologists. Post-processing reconstructions were performed by dedicated CT technologists, and images are interpreted by experienced radiologists. The images were analyzed on the basis of transverse images, MIP and VR images occlusion, calcification, plaque morphology, and collaterals.

Stenosis was graded as follows

- **Grade 1:** Normal vessel or mild vessel irregularities
- **Grade 2:** Moderate arterial stenosis (> 50% narrowing)
- **Grade 3:** Severe arterial stenosis (< 50% narrowing)
- **Grade 4:** Occlusion

Stenosis was scored by ANGIO scoring as follows

- **Score 0:** Minor or no plaque
- **Score 1:** Stenosis ≥ 50%
- **Score 2:** Complete occlusion

Image analysis

The following vascular segments were analyzed independently for the presence of hemodynamically significant stenosis or occlusion, plaque morphology, and collaterals: infrarenal aorta, common iliac artery, external iliac artery, common femoral artery, proximal superficial femoral artery, mid-superficial femoral artery, distal superficial femoral artery, origin of deep femoral artery, popliteal artery, anterior tibial artery, posterior tibial artery, and peroneal artery.

ISSN:0975 -3583,0976-2833 VOL13, ISSUE 08, 2022

Statistical analysis

The statistical analysis of data was done with the Statistical Package for Social Science, version 20 (SPSS Inc., Chicago, IL, USA). The inter observer agreement was expressed as a kappa (κ) statistic, and the P value < 0.05 was considered to indicate statistical significance. The κ coefficient represents the degree of the observer agreement.

Results

Table 1: Demographic and history of the studied group

Gender (n=50)	N%
Male	22 (44%)
Female	28 (56%)
Age (years), mean ± SD (min-max)	59.56 ± 10.3 (33.0–75.0)
DM	35 (70%)
Hypertension	24 (48%)
Cardiac	4 (8%)
Smoking	32 (64%)
Fontain Stage	
Fontain Stage 1	5 (2.5%)
Fontain Stage 2a	15 (7.5%)
Fontain Stage 2b	10 (5%)
Fontain Stage 3	10 (5%)
Fontain Stage 4	10 (5%)

The study involved 50 patients, 22 men (44%) and 28 women (56%). They were between 33 and 75.0 years with mean 59.56 years and standard deviation ± 10.3. Out of them, there were 4 patients who had above-knee amputation of one leg. Out of the 50 patients, 5 were asymptomatic (Fontain's stage 1), 15 had intermittent claudication when walking more than 200 m (Fontain's stage 2a), 10 had intermittent claudication when walking more than 200m (Fontain's stage 2b), 10 had rest pain (Fontain's stage 3), and 10 had trophic changes, ulcers, or gangrene (Fontain's stage 4). There were 32 patients who are chronic smokers 64%, 35 had diabetes 70%, 24 had hypertension 48%, and 4 are cardiac 8%.

Table 2: Reliability and agreement between CT and Doppler techniques in the detection of vascular occlusion

	CT, N = 50	Doppler, N = 50	Kappa agreement	$\chi 2$	P value
EIA					
Patent	38	40	0.87	0.22	0.89
Partial occlusion	10	7			
Total occlusion	2	3			
CFA					
Patent	45	42	0.88	0.75	0.6
Partial occlusion	3	5			
Total occlusion	2	3			
SFA upper 1/3					
Patent	44	40	0.82	0.9	0.60
Partial occlusion	3	6			
Total occlusion	3	4			
SFA middle 1/3					
Patent	46	38	0.76	2.4	0.30
Partial occlusion	2	5			
Total occlusion	2	7			
SFA lower 1/3					
Patent	46	44	0.86	0.35	0.8
Partial occlusion	2	4			
Total occlusion	2	2			
POP					
Patent	42	40	0.87	0.13	0.9
Partial occlusion	6	8			
Total occlusion	2	2			
Peroneal A					
Patent	46	42	0.88	1.1	0.60
Partial occlusion	2	4			
Total occlusion	2	4			
PTA					
Patent	36	35	0.93	0.17	0.9
Partial occlusion	8	10			

Total occlusion	6	5			
ATA					
Patent	38	42			
Partial occlusion	10	6	0.88	0.5	0.8
Total occlusion	2	2			

In Table 2, as regards the external iliac artery (EIA), we found that CT diagnosed total occlusion in 2 patients, partial occlusion in 10 patients, and patent EIA in 38 patients, while US diagnosed total occlusion in 3 patients, partial occlusion in 7 patients, and patent EIA in 40 patients. Kappa agreement was significant (0.87). As regards the common femoral artery (CFA), we found that CT diagnosed total occlusion in 3 patients, partial occlusion in 3 patients, and patent CFA in 44 patients, while US diagnosed total occlusion in 4 patients, partial occlusion in 6 patients, and patent CFA in 40 patients. Kappa agreement was significant (0.88). As regards the superficial femoral artery (SFA), we found that in the upper third, CT diagnosed total occlusion in 4 patients, partial occlusion in 4 patients, and patent SFA in 46 patients, while US diagnosed total occlusion in 5 patients, partial occlusion in 8 patients, and patent SFA in 41 patients. Kappa agreement was significant (0.82).

In the middle third, CT diagnosed total occlusion in 2 patients, partial occlusion in 2 patients, and patent SFA in 46 patients, while US diagnosed total occlusion in 7 patients, partial occlusion in 5 patients, and patent SFA in 38 patients. Kappa agreement was significant (0.76). In the lower third, CT diagnosed total occlusion in 2 patients, partial occlusion in 2 patients, and patent SFA in 46 patients, while US diagnosed total occlusion in 2 patients, partial occlusion in 4 patients, and patent SFA in 44 patients. Kappa agreement was significant (0.86). As regards the popliteal artery (POP A), we found that CT diagnosed total occlusion in 2 patient, partial occlusion in 6 patients, and patent POP A in 40 patients, while US diagnosed total occlusion in 2 patients, partial occlusion in 8 patients, and patent POP A in 40 patients.

Kappa agreement was significant (0.87). As regards peroneal A, we found that CT diagnosed total occlusion in 2 patients, partial occlusion in 2 patients, and patent peroneal A in 46 patients, while US diagnosed total occlusion in 2 patients, partial occlusion in 4 patients, and patent peroneal A in 42 patients. Kappa agreement was significant (0.88). As regards the posterior tibial artery (PTA), we found that CT diagnosed total occlusion in 6 patients, partial occlusion in 8 patients, and patent PTA in 36 patients, while US diagnosed total occlusion in 5 patients, partial occlusion in 10 patients, and patent PTA in 35 patients. Kappa agreement was significant (0.93). As regards the anterior tibial artery (ATA), we found that CT diagnosed total occlusion in 2 patient, partial occlusion in 10 patients, and patent ATA in 38 patients, while US diagnosed total occlusion in 2 patient, partial occlusion in 6 patients, and patent ATA in 42 patients. Kappa agreement was significant (0.88).

Discussion

CTA has displaced conventional catheter arteriography in a large range of applications and is predominantly used in the evaluation of atherosclerotic peripheral arterial occlusive disease in symptomatic patients who are candidates for intervention. Other disease entities including atheroembolism, aneurysmal disease, and arteritides including Buerger disease and Takayasu arteritis can be precisely evaluated by CTA [16]. Our study uses a quite different protocol as we used a detector configuration 160 × 1mm and 0.5-mm-thick section while gantry rotation period is 0.3 s. Also, they started their exams from the abdominal infrarenal aorta while we tried our best to start our exam from the arch of the aorta by butting the sure start at the arch and reducing the wait time. Ozkan *et al.* [17] examined the segmental distribution of atherosclerosis in 626 symptomatic patients with peripheral arterial disease. Peripheral arterial disease involved one segment in 36% of the patients, two segments in 42% of the patients, and three or more segments in 33.33% of the patients. He concluded that PAD was multi-segmental in most of the cases of the study group.

Osama *et al.* [18] studied the role of multi-slice CT angiography versus Doppler ultrasonography and conventional angiography in the assessment of aorto-iliac arterial disease and stated that as regards the degree of stenosis, there was an agreement between digital subtraction angiography (DSA) and multi-detector row CT angiography in nine lesions (82%), with discrepancy in two lesions (18%). The agreement between DSA and color-coded Doppler occurred in eight lesions (73%), while discrepancy occurred in three lesions (27%). This discrepancy was mainly due to the ability of multi-detector CT angiography to detect a small amount of contrast in the stenotic segment and the ability of the color coded Doppler to detect weak flow within a stenotic artery compared to digital subtraction angiography. He used a low amount of contrast material (120-150 ml) as he had a fast scanner. His gantry rotation period was 0.5 s. His examinations started at the level of the celiac artery. We all agreed with all these studies as we found no significant differences in the sensitivity and specificity between MDCT angiography and CCD in the detection of hemodynamically significant lesions.

Our results made us agreed with all the guidelines as we found that an experienced Doppler radiologist can make the best use of Doppler and avoid consuming time in other modalities especially when there are contraindications and also can help the vascular surgeon to make his decision in choosing intervention or medical treatment. Bueno *et al.* [19] examined 1720 segments on 40 patients; the utility of

ISSN:0975 -3583,0976-2833 VOL13, ISSUE 08, 2022

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.

We agreed with that as we noted that the sensitivity and specificity of the Doppler US are quite lower than CT angiography, but it is acceptable especially as we already stated that we can make use of Doppler to save time in critical cases and in cases where CT angiography is contraindicated. CT angiography has the advantages of being minimally invasive, requiring only a reasonable amount of the intravenous contrast and imaging surrounding soft tissues, fast, accurate, and safe and has the advantage of using MIP and 3D images for cases of peripheral vascular diseases for diagnosis, for grading, and for preoperative assessment of lower limb arterial disease. US is also a great non-invasive, fast, accurate, safe, and readily available tool for the assessment of lower limb arterial disease. It has an advantage over MDCT angiography that it provides us with hemodynamic data proximal, distal, and at the site of obstruction [20-23].

Conclusion

Both MDCT angiography and duplex US have a good predictive value of chronic lower limb ischemia, but the combination of them has a better diagnostic accuracy. We can make use of the new Doppler indices like PSV stenosis/PSV distal that make any mildly experienced radiologist have the ability to get appreciable information from the Doppler.

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ISSN:0975 -3583,0976-2833 VOL13, ISSUE 08, 2022

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