

## Multidetector computed tomography and color Doppler used for assessment of peripheral vascular disease of the lower limb arteries

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### Abstract

**Aim:** Color Doppler (CD) ultrasonography and CT angiography are useful and competitive techniques used for examination and diagnostic purposes in peripheral arterial disease. The aim of this study was to compare these two main imaging methods in diagnosing peripheral vascular disease of lower extremities: MDCT angiography vs. CD ultrasonography.

**Methods:** In this prospective study, 160 patients with peripheral vascular disease were subject of examination with CD ultrasonography and MDCT angiography at the Department of Radio-Diagnosis at the Orthodox Diagnostic Center in Tirana, Albania. The data was analyzed by comparing these two methods according to wall calcification, wall thickening, stenosis and the presence of collaterals.

**Results:** There was an important difference between Doppler and MDCT techniques upon examination of the lower limb arteries. Detection of calcification, stenosis and collaterals were significantly higher in MDCT ( $P < 0.001$ ). Conversely, Colour Doppler technique resulted more effective in detection of wall thickening.

**Conclusion:** The role of imaging examination is important in the management of the patients with peripheral vascular disease. CT angiography is rather used before vascular surgery and is required in peripheral vascular disease due to limitations of CD ultrasonography. Doppler ultrasonography can be useful and an effective tool to detect the lesions to a comparable extent even when intervention is not necessary.

**Keywords:** CD ultrasonography, color Doppler, multidetector computed tomography (MDCT), peripheral vascular disease (PAD).

## Introduction

Among various common blood vessel disorders, peripheral arterial disease (PAD) is a very frequent disease that affects arteries of the lower extremities. This condition, which is caused by a decrease of blood flow due to stenosis and occlusions of the vessels, may result in claudicatio intermittens, ischaemia, rest pain, local tissue loss and risk of limb amputation (1). Patients suffering from PAD may be either symptomatic or with no symptoms at all, and are highly exposed to mortality, acute myocardial infarction (AMI) and stroke (1). PAD disrupts the function of the lower extremity and consequently the life quality. Atherosclerosis is the main cause of arterial disease in lower extremities. Thromboembolism, acute thrombotic occlusion, micro embolism, trauma, vasculitis and Buerger's disease are infrequent causes (1). Although atherosclerosis usually might be asymptomatic for a certain time period, it causes two important conditions; the first is the atherosclerotic plaque, which causes stenosis or complete occlusion of the lumen and the second concerns aneurysm due to compensating arterial processes. Early diagnosis and proper treatment of this condition result in the limb protection and also its function restoration (2).

Arteriography as the standard examination technique for PAD provides an accurate anatomical description of obstructive arterial lesions even without estimation of the haemodynamic function. Technical improvements of duplex scan and CT have made possible the replacement of arteriography for the evaluation of limb ischemia.

Ultrasonography can evaluate blood velocity through a vessel, whereas color Doppler imaging technique determines localization of arterial stenosis or occlusion. Use of color Doppler technique is a very useful interventional procedure for endovascular disorders. This technique helps to make evaluation, quantification and the follow-up of the arterial disease by providing a detailed vascular

view that leads to the radiological or surgical procedure if necessary (3). Color Doppler imaging technique is a safe and non-invasive, cost-effective and reliable procedure for examination of lower limb arteries.

Compared to duplex, CT angiography of lower extremities is a new examination technique. The introduction of multidetector-row- CT (MDCT) since 1998, allowed for the first time scanning of the entire lower extremity blood vessels in a single CT examination with a single contrast medium injection at the adequate spatial resolution (3).

PAD, otherwise known as peripheral artery occlusive disease (PAOD), is an obstructive arterial disease of the limbs. Patients affected by this health condition may have important systemic morbidities. On the other hand, atherosclerosis of lower extremities is used as a marker for the systemic atherosclerotic disease (4).

In general, the infra-inguinal segment is frequently involved by acute occlusion of peripheral arteries. Acute thrombosis, embolism lodged at bifurcations and inclusion of the arterial segments which lead to disorders of distal flow and reduced tissue perfusion, are caused mainly as a result of impairment of blood flow and intraluminal strictures. The most important clinical signs of occlusion are claudicatio intermittens, paleness, pulselessness, paraesthesia, poikilothermia and gangrene. The identification of artery pulse loss helps to detect location of the occlusion (4,5).

CD ultrasonography technique is frequently used for the evaluation of severity and extent of PAD. This examination combines a local anatomical image, obtained in B-mode, with information about the direction pattern and magnitude of arterial and venous flow. The severity of stenosis can be subsequently derived from the peak systolic and end diastolic velocity measurements (5,6).

The aim of this study was to evaluate and compare the efficacy of multidetector (32-row) computed tomography (MDCT) and CD ultrasonography

used to describe lower limb arterial tree in PAOD and to assess the advantages and disadvantages of volume rendered images and raw images.

## Methods

This was a prospective study over a 4-year period: from January 2011 to December 2014. Overall, 160 consecutive cases of peripheral arterial occlusive disease were included in this study, which referred for diagnosis with CD ultrasonography and MDCT angiography to the department of Radio-Diagnosis at the Orthodox Diagnostic Center in Tirana, Albania. On the other hand, patients with acute and chronic kidney disease, individuals under 18 years of age and patients with contrast allergy were excluded from this study.

CD ultrasonography was performed using Toshiba Nemio and GE E9 equipment and the arterial system of the lower limb was scanned with a linear phased array (6-12MHZ) transducer (7).

During CD ultrasound procedure, the patient stays in the supine position to expose both the lower limbs on the scanning couch. In this study, the distal common femoral artery was imaged and the Doppler waveform assessment was done visually for any loss of triphasic flow or rounding of the waveform due to significant iliac disease. In the presence of these findings, the iliac arteries were assessed for the evidence of atherosclerotic disease using the curvilinear probe and the abdominal vascular setting. The scan was continued distally from the common femoral artery assessing the superficial femoral artery and popliteal artery in the longitudinal plane, using the linear probe and the lower limb arterial scan pre-set. The extent and severity of the arterial disease was assessed using triplex mode by measuring the peak systolic velocity from the Doppler waveform just proximal to and through the stenosis. The severity of the disease was subsequently categorized using standard criteria established in the international literature (7).

Confirmation of a complete occlusion was based on reduction of the colour scale, as well as by employment of the power Doppler. Furthermore, arteries were examined for calibre, lumen, flow velocity and spectral wave pattern. Next, the information for each patient was categorized based on the level of atherosclerotic disease (7). From this point of view, patients with at least one stenosis in the lower limbs with 50%-70% block were considered as having moderate disease; patients with at least one stenosis measured between 70%-99% were considered as having significant disease; and patients with an occlusion were considered as part of the occlusive group (7).

On the other hand, the MDCT angiography was conducted following assessment by an arterial color Doppler. In this examination, the scan direction was craniocaudal from the level of infrarenal aorta to the pedal arch. In this study, all scans were performed using GE Medical Systems 32 slice MDCT with 120KVp and 300mAs with 1.25mm section thickness and reformation (7). Contrast study was performed by employment of 100-150ml of 350mg/ml non-ionic iodinated contrast, injected using pressure injector at the rate of 3-4ml/s. In addition, volume rendering and maximum intensity projection images were obtained from raw images from all the cases. Finally, images were analyzed for calcification, wall thickening, extent pattern of luminal narrowing and the collateral flow, as performed also in recent studies conducted elsewhere (7).

## Results

Overall, this study included 160 consecutive patients. Of these, 135 (85%) were males and 25 (15%) were females.

Regarding the age distribution, most of the patients belonged to the age-group 61-70 years (n=48, or 30% of the patients), followed by the age-group 51-60 years (n=44, or 27.5% of the patients). On the other hand, 46 (28.75%) patients were less than 50 years of age and further 46 (28.75%) patients

were older than 70 years of age.

The majority of the patients had grade III claudication based on the modified Boyd classification with 80 (50%) patients, followed by grade II with 53 patients and grade IV with 27 patients. There were 21 patients with PAD with presence of gangrene and all of them had a history of

smoking. Diabetes mellitus was the most common co-morbidity associated with PAD (90 patients), followed by hypertension (37 patients), hyperlipidaemia (16 patients) and Takayasu arteritis (5 patients).

Table 1 presents the distribution of patients with stenosis by age-group.

**Table 1. Age distribution of patients with arterial stenosis**

Age-group	Number of patients with stenosis	Percentage
20-30	4	2.5
31-40	6	3.75
41-50	12	7.5
51-60	44	27.5
61-70	48	30
71-80	43	27
81-90	3	1.75
<b>Total</b>	<b>160</b>	<b>100</b>

Regarding the comparison between MDCT and color Doppler technique in terms of detection of calcification extent in the blood vessels, in our study we observed an agreement of 89% between these two methods ( $P<0.001$ ). Hence, there was evidence of a high degree of compatibility concerning the extent of calcification in the blood vessels detected by these two examination methods, and this finding was highly statistically significant.

When comparing the extent of calcification in the vessels detected by MDCT versus Volume Rendering images, we obtained an agreement of 84% between the two methods, a finding which was also highly statistically significant ( $P<0.001$ ).

Furthermore, the extent of wall thickening in the vessels detected by color Doppler USG versus MDCT was also rather congruent ( $\kappa=0.74$ ,  $P<0.001$ ). This means that the majority of the cases with wall thickening were similarly detected by both methods of examination.

In addition, the extent of stenosis detection was likewise in agreement between both methods, with a kappa index of 81% ( $P<0.001$ ).

However, the observed agreement for the extent of stenosis in the vessels detected by MDCT compared to volume rendering images was lower ( $\kappa=71\%$ ), a finding which was nevertheless highly statistically significant ( $P<0.001$ ).

On the other hand, the agreement regarding the extent of collaterals was only moderate between the two methods ( $\kappa=0.62$ ) – yet, this finding was also statistically significant ( $P<0.001$ ).

Conversely, the agreement with regard to assessment of iliac arteries was very high ( $\kappa=99\%$ ,  $P<0.001$ ).

Finally, there was a satisfactory degree of agreement regarding the assessment of aorta involvement between the two methods of examination ( $\kappa=0.80$ ,  $P<0.001$ ).

## Discussion

PAD poses a serious disease and is associated with increased co-morbidity among older people including diabetes mellitus and hypertension (7). As a matter of fact, PAD is the third leading cause of death in the world after cancer and heart disease. Based on

the prevalence and clinical significance, it is very important to enable a prompt diagnosis of this condition and determine the necessary treatment regimen. Noninvasive procedures for the assessment of PAD are safe and do not involve any interventions (7).

It has been convincingly argued that vascular imaging bears an important role in vascular surgery because it is more affordable for the patients involved, by choosing a disease free interval, and helping with the exact information about accurate extent of the disease before any intervention planned in the near future (7).

From this point of view, Doppler ultrasound, Duplex Sonography, combining high resolution imaging and doppler spectrum analysis are considered as non-invasive, accurate and cost-effective methods for a prompt and correct diagnosis of PAD (7).

Currently, MDCT is considered as the best option for imaging the vascular tree before vascular surgery. This procedure is safe, valid and reliable.

Main findings from our study include a high degree of agreement between MDCT and color Doppler ultrasound.

In our study, 135 (85%) patients were males and 25 (15%) patients were females. Similar sex distribution has been reported in previous studies conducted elsewhere in which males have been shown to be more prone to PAD (7).

As for the age distribution, in our study, the age-group 51-80 years included about 85% of all of the patients. This finding is also similar to other studies which have

reported an excess PAD rate among middle aged and elderly individuals (3,7,8).

Smoking habit is considered as an important risk factor for PAD occurrence. Hence, a previous study conducted in South India has indicated a PAD risk 2.7 times higher among smokers compared to non-smokers (9). Furthermore, smoking has been linked to intermittent claudication in several studies (7,9).

Regarding the comparison of MDCTA and color Doppler, our study indicated that MDCTA was a better technique for detection of hemodynamically significant stenosis of lower limb arterial system. This finding is compatible with previous studies published in the international literature (5-7).

Therefore, based on our study findings, we conclude that MDCT is a more appropriate method than color Doppler in detecting the presence of occlusion, particularly in the infra-popliteal segment, which is in line with previous studies (7).

The main advantage of the CT is related to the indication of the extent of the disease from the abdominal aorta till the arteries of feet (7). This supports and guides planning and treatment approach among the cases involved.

Doppler is also an effective non-invasive instrument, safe, reliable and cost-effective. In conclusion, among patients with mild PAD in whom the CT contrast is contraindicated, ultrasound is the best technique to perform. Conversely, CT is recommended for use in patients with moderate to severe PAD who require intervention.

**Conflicts of interest:** None declared.

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