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Original Research Article

Lower extremity arterial doppler angiography: A prospective comparison to multi-detector computed tomography angiography

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Abstract

Introduction: Lower-extremity artery disease is a major contributor to morbidity and mortality in the middle-aged and elderly. Atheromatous narrowing or blockage of a leg artery or arteries is a common cause of this condition. Possible symptoms include claudication episodes, pain during rest, sores, and even gangrene.

Methods: In this prospective study, we will evaluate the precision of Duplex Ultrasound to that of MDCT angiography. Thirty-four patients with unilateral or bilateral lower limb ischemia illness who presented to the radiology division for CT angiography made up the study population. Department of Radiology, Kamineni Academy of Medical Sciences and Research Centre (KAMSRC), Hyderabad, was the location of the study and study between June, 2021 to May, 2022.

Results: Thirty individuals were enrolled in the study. Twenty-six patients were 40 or older, while another six were 60 or older. Two patients needed below-knee amputations. Even though 830 artery segments from 67 limbs were analysed using the two approaches, only 806 were available for comparison.

Conclusion: Therefore, due to its lack of danger, low cost, non-invasiveness, widespread availability, and excellent diagnostic accuracy, Duplex Ultrasound is an essential tool in the study of peripheral vascular disease.

Keywords: Arterial Doppler, angiography, multi-detector, tomography angiography

Introduction

Arterial disease of the lower extremities is a leading cause of death and disability among the middle-aged and elderly. It is typically brought on by the atheromatous constriction or blockage of a leg artery or arteries. Intermittent claudication, ischemic rest discomfort, ulceration, and gangrene are all possible symptoms. Treatment options for people with vascular disease in the lower extremities vary. Conservative management is typically used for individuals with intermittent claudication, while angioplasty, surgical revascularization, or amputation is used for those with limb-threatening ischemia. The severity of the ailment will determine what kind of treatment is chosen, which may be a combination of several approaches. Therefore, in order to come up with an effective treatment strategy for individuals with limb-threatening ischaemia, a thorough assessment is required.

When looking at artery disease in the legs, intra-arterial contrast angiography is the gold standard. The risks of ionizing radiation, nephrotoxicity from iodinated contrast agents, and artery puncture all apply. Magnetic Resonance Angiography, Computerized Tomography Angiography, and Duplex Ultrasonography are only few of the different imaging modalities that can be used. Although CT angiograms expose patients to potentially harmful levels of

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ionizing radiation and both contrast-enhanced while there is a risk connected with the contrast chemicals used in MR angiography and CT angiography, Duplex ultrasound poses no such danger.

Improvements in post-processing, transducer technology, image quality, signal strength, and spectrum analysis have increased the diagnostic value of Duplex Ultrasound for the non-invasive assessment of peripheral artery disease. The vascular tree can be imaged noninvasively using contrast material using Multi Detector CT Angiography, which has been supported by several investigations. Unfortunately, high-quality trials comparing Magnetic Resonance Angiography, Duplex ultrasonography, and Computed Tomography Angiography for the diagnosis of peripheral artery disease are lacking. With this prospective study, researchers hope to compare the diagnostic efficacy of Duplex Ultrasound and MDCT angiography for detecting and assessing the severity of obstructive artery lesions in the lower extremities.

Materials and Methods

In this prospective study, we will evaluate the precision of Duplex Ultrasound to that of MDCT angiography. Thirty-four patients with unilateral or bilateral lower limb ischemia illness who presented to the radiology division for CT angiography made up the study population. Department of Radiology, Kamineni Academy of Medical Sciences and Research Centre (KAMSRC), Hyderabad, was the location of the study and study between June, 2021 to May, 2022.

Inclusion criteria

- Any age group is considered.
- Lower limb arterial disease that is unilateral or bilateral.
- Lower limb arterial disease, either acute or persistent.

Exclusion Criteria

- Patients with gangrene and severe ulcerations.
- Patients who are immediately unstable after surgery and have sterile dressings on their lower limbs.
- Sufferers of contrast response.
- Patients with severe ischemia-related lower limb pain
- Contrast angiography was not performed on patients with renal insufficiency and contrast hypersensitivity.

Duplex ultrasound was performed using a Siemens Acuson Antares Ultrasound machine with a band wide frequency transducer in the range of 5-13MHz for the lower limb artery and a 3.5 MHz probe for the infrarenal aorta and iliac arteries. In order to better visualize the aorto-iliac region, patients were required to fast for a minimum of 6 hours before to the procedure. Rapid colour flow-assisted B-mode vessel mapping and lesion detection was achieved. The spectrum waveform was analysed, and the peak systolic velocity was measured, with the help of pulse Doppler. Plaque morphological characteristics and calcification can be identified using gray-scale sonography.

Results

Thirty patients participated in the trial. Twenty-six of these patients were aged 40 or older, while another six were aged 60 or more. Two individuals required amputations below the knee. In total, 830 artery segments from 67 limbs were analysed using the two methods, but only 806 were accessible for comparison. Twenty-four had atherosclerosis, seven had TAO, one had a traumatic acute thrombosis, and one had popliteal artery cystic adventitial disease. In addition to the rest pain and intermittent claudication experienced by 2, trophic alterations, ulceration, and gangrene were observed in 26 people. 18 had been smokers for a significant

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amount of time, 16 had developed diabetes, and 24 had high blood pressure.

Statistical Analysis

Two-way analysis of variance (ANOVA) and Kappa statistics were used to tabulate and interpret the results. Results for sensitivity, specificity, PPV, and NPV were compiled.

Table 1: Infra Renal Aorta

	CT positive	CT negative	Total
Doppler positive	1	0	1
Doppler negative	0	28	28
	1	28	29

Table 2: Kappa analysis common

	CT positive	CT negative	Total
Doppler positive	8	0	2
Doppler negative	2	29	28
	10	29	30

Table 3: Kappa analysis external iliac artery

	CT positive	CT negative	Total
Doppler positive	1	0	3
Doppler negative	8	28	27
	9	28	30

Table 4: Common Femoral Artery Region

	CT positive	CT negative	Total
Doppler positive	8	0	8
Doppler negative	2	30	22
	10	30	30

Table 5: Location near the Top of the Profunda Femoris

	CT positive	CT negative	Total
Doppler positive	2	30	6
Doppler negative	8	0	24
	10	30	30

Table 6: Anatomy of the Anterior Superficial Femoral Artery

	CT positive	CT negative	Total
Doppler positive	8	0	2
Doppler negative	0	28	28
	8	28	30

Table 7: Superficial Middle Femoral Artery

	CT positive	CT negative	Total
Doppler positive	28	0	1
Doppler negative	0	30	29
	28	30	30

Table 8: The Superficial Distal Artery of the Femur

	CT positive	CT negative	Total
Doppler positive	6	1	29

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Doppler negative	2	28	1
	8	29	30

Table 9: Duplex ultrasonography sensitivity, specificity, PPV, NPV in lower limb arterial system evaluation

	Sensitivity%	Specificity%	PPV%	NPV%
Aortoiliac region	86.4	100	100	97.01
Femoropoplite al region	100	95.02	92.01	100
Infrapopliteal region	76.01	81.06	66.03	86.05
Overall segments	92.01	91.62	82.31	95.78

Table 10: KAPPA numbers show agreement between modalities

Segment Analysed	Duplex and CT Angiography Agreement
Infrarenal aorta	Good
Common iliac artery	Perfect
External iliac artery	Perfect
Common femoral artery	Very good
Superficial femoral artery- prox	Good
Superficial femoral artery- mid	Perfect
Superficial femoral artery-distal	Very good
Proximal profunda femoris	Good
Popliteal artery	Perfect
Anterior tibial artery	Moderate
Posterior tibial artery	Good
Peroneal artery	Moderate
Dorsalis pedis	Perfect

Discussion

Thirty patients were included in the trial, three of whom required amputation below the knee. Bowel gas obstructed the infra renal aorta in 7 of 30 cases. Only one patient out of the 26 segments evaluated had substantial stenosis, while the remainder were either normal or had only minor effects on hemodynamics. The findings were validated by CT angiography. When assessing the infra renal aorta, Doppler showed a perfect 100% sensitivity, specificity, positive predictive value, and negative predictive value. When comparing Doppler and CT angiography, the level of agreement was extremely high according to kappa statistics. We were unable to assess 12 of a total of 68 common iliac artery segments because of gas in the intestines. Doppler detected 7 out of the 8 hemodynamically significant stenosis in the 56 segments that were studied. Only 1 patient with a calcific plaque had their stenosis undetected by the test. Overestimation of stenosis by CT angiography in arteries with calcific plaques could account for the patient's false negative result. This resulted in a decrease in Doppler's sensitivity to 87.5%. Nonetheless, kappa data revealed that Doppler and CT angiography had a high level of agreement. Six out of a total of 68 segments of the external iliac artery were obscured by intestinal gas. Doppler failed to detect hemodynamically significant stenosis in the same patient in the remaining 62 segments, most likely because CT angiography overestimated the stenosis produced by calcific plaque. Reduced sensitivity of 87.5% and full specificity were achieved. When comparing Doppler to CT angiography, the kappa value revealed a high level of agreement. Doppler has a 100% sensitivity and specificity for detecting 9 hemodynamically significant stenosis in the common femoral artery. When comparing Doppler and CT angiography, the level of agreement was extremely high according to kappa statistics.

Doppler achieved a perfect sensitivity and specificity in detecting 26 and 29 hemodynamically significant stenosis, respectively, in the proximal and middle superficial femoral artery. Sonographers had a hard time seeing the distal superficial femoral artery, therefore only 62 of a possible 68 segments were usable for comparison. Over an estimated 2

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segments with hemodynamically minor stenosis resulted in false positive with Doppler in the individuals under evaluation. These patients presented with monophasic flow in the distal SFA due to long segment disease in the proximal and intermediate SFA, which was misdiagnosed as hemodynamically severe stenosis.

Since the distal portion of Profunda femoris and its branches were inaccessible, only its proximal portion was assessed in the study. Doppler identified every segment with hemodynamically significant stenosis out of a total of 68. It also gave a false positive result for 6 segments with stenosis that was not hemodynamically significant. Increased flow through these segments to the distal leg in response to SFA blockage was responsible for the higher peak systolic velocities seen in these regions. Therefore, Doppler's 89.83% specificity in assessing the proximal profunda femoris was lower than its 100% sensitivity.

Doppler did not miss any hemodynamically important stenosis in the popliteal artery, but it overestimated 2 segments with hemodynamically inconsequential stenosis in those patients who had long segment disease in the proximal and mid-section of SFA, leading to monophasic flow in the distal SFA. Doppler had a sensitivity of 100% and a specificity of 92% when assessing the popliteal artery. Doppler flow evaluation and contrast-enhanced CT angiography were used to determine whether or not blood was flowing through the infra popliteal arteries.

Seven anterior tibial artery segments, six posterior tibial arterial segments, thirteen peroneal arterial segments, and five dorsalis pedis opacified with contrast in CT angiography, however Doppler did not detect blood flow in any of them. Many collateral vessels were present in the leg, making it difficult to pinpoint the precise location of the reformation of the infrapopliteal vessels in patients with blockage of the femoropopliteal region. Tracing the major arteries was challenging despite the fact that they are accompanied by venae commitants rather than collaterals.

Infrapopliteal vessels that were not opacified with contrast were nevertheless detectable by Doppler. There was no contrast opacification in the infrapopliteal arteries in three patients with proximal substantial stenosis, but monophasic flow was seen by Doppler. This may occur due of variations in the opacification of crural vessels in CT angiography or a lack of opacification distal to an occlusion28. This suggests that the frequency of CT angiography's false positive occlusions can be reduced when Doppler is utilised in tandem with the technique.

Thus, if CT angiography was used as the gold standard, Doppler's sensitivity in evaluating aortoiliac segments, femoropopliteal segments, and infrapopliteal segments was 87.5%, 100%, and 75.32%, respectively, and its specificity in evaluating these same regions was 100%, 96.01%, and 83.06%, respectively. Very good agreement was found between the two modalities in assessing the aortoiliac and femoropopliteal regions, whereas only moderate agreement was found in assessing the infrapopliteal vessels. The sensitivity and specificity of colour Doppler imaging have been studied previously and found to be variable. Doppler has several benefits over CT angiography, as this study demonstrated. CT angiography overstages the lesion when there are significant calcifications in the vessel, hence its diagnostic use is questioned in such cases. Doppler demonstrates this overstaging of MDCT by showing that the calcific plaque that appears to have created more than 50% stenosis has not, in fact, resulted in a stenosis that is hemodynamically significant. When CT fails to detect opacification with contrast in the infrapopliteal arteries due to proximal severe stenosis, Doppler can show blood moving through them. When artery occlusion must be ruled out quickly, as in the case of traumatic or iatrogenic injury, Doppler can be performed, whereas CT angiography is only routinely available at leading medical centres. When compared to CT angiography, Doppler's price is far more reasonable.

Conclusion

Duplex ultrasound is a high-resolution imaging modality that can assess the arterial health of the body's extremities. It is not likely to incorrectly label a whole limb as "normal," preventing a patient from receiving necessary follow-up care. Due to its high negative

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predictive value, Duplex Ultrasound can assist relieve minimally symptomatic patients of the financial burden of unnecessary diagnostic procedures. This information could be used to plan endovascular or surgical treatment for arterial disease based on the severity and kind of damage seen. Additionally, it may help clarify the importance of lesions seen by MDCT angiography that have mixed results. The diagnostic accuracy of Duplex Ultrasound is enhanced when combined with MDCT angiography. Therefore, Duplex Ultrasound is a crucial tool in the research of peripheral vascular disease since it is risk-free, inexpensive, non-invasive, readily available, and has a high diagnostic accuracy.

Conflict of Interest: None

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