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Comparison of color Doppler and digital subtraction angiography in occlusive arterial disease in patients with lower limb ischemia

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ABSTRACT:

OBJECTIVE: The medical world has seen a surge in patients grappling with infragenicular peripheral arterial occlusive disease. This condition is most commonly caused by two factors - Buergers Disease and Atherosclerotic disease - afflicting middle-aged smokers belonging to low socio-economic backgrounds. In some cases, this might also be caused by factors such as trauma, thromboembolism, or vasculitis. While Color Doppler (CD) is a reliable method to assess the supragenicular arterial system, the deeper positioning of infragenicular arteries often proves challenging for proper examination using this modality. The study's objective is to assess the efficacy of both techniques and determine which method provides more accurate and reliable results in diagnosing infragenicular arterial disease. This research is expected to contribute to the advancement of medical imaging and improve the diagnosis and treatment of infragenicular arterial disease.

METHODS: The Radiodiagnosis department of Mayo Hospital in Lahore, Pakistan, was the site of this research, which was planned as a prospective experiment. Lower limb ischemia in 50 individuals was recorded. By using CD and DSA, the participants and their afflicted lower limbs were assessed for the location and grading of artery lesions into normal, severe stenosis, and occlusion. 150 vascular segments in total underwent blind analysis of the data. Data were examined using kappa statistics and two-way contingency tables.

RESULTS: In our investigation, we found that color doppler exhibited a sensitivity of 83%, specificity of 92%, PPV of 66%, and NPV of 96% in the disease of the infragenicular artery system.

CONCLUSIONS: A normal spectral waveform and color flow in a Color Doppler examination of the inferior genicular arteries can rule out the need for arteriography. However, the reduced positive predictive value (PPV) of Color Doppler (66%) highlights the limitations of this diagnostic tool. In such cases, DSA proves to be a more reliable and beneficial diagnostic method for patients who exhibit abnormal or absent color flow and/or spectral wave shape. In these instances, DSA provides a clearer and

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more detailed assessment of the arterial structure, improving the accuracy of the diagnosis. Thus, the use of DSA in conjunction with Color Doppler examination can lead to a more comprehensive and accurate diagnosis of infragenicular arterial disease.

KEYWORDS: arterial, digital subtraction angiography, color doppler

INTRODUCTION: The clinical phrase for peripheral arterial disease, excluding coronary arteries, should be used to refer to stenosis, occlusion, and disorders of the aorta and its branch arteries that cause aneurysms. Peripheral arterial disease is more common as people age [1]. According to population surveys, the peripheral arterial disease affects 20% of adults over the age of 60. Additionally, those who smoke, have diabetes, and have coronary artery disease have higher incidence rates. The symptoms of intermittent claudication are stable in the majority of patients, although 20% may have worsening symptoms as critical limb ischemia develops. Age over 50, diabetes, smoking and high cholesterol are the main risk factors for peripheral vascular disease. [2,3]

In addition to the commonly known causes of peripheral arterial disease such as atherosclerosis and Buerger's disease, it can also be caused by various other conditions. These include entrapment syndromes, congenital anomalies, arteritis, fibromuscular dysplasia, thromboembolic incidents, aneurysmal disease, trauma, adventitial cysts, and endocrine disorders. [4,5,6] Given its low cost, accessibility, noninvasive nature, lack of contrast allergy, and time-saving capabilities, ultrasound arterial color Doppler (CD) is often the first choice in the diagnostic evaluation of patients with peripheral artery occlusive disease. [7,8] The non-invasive nature of CD makes it an attractive option for many patients, and its low cost and widespread availability make it an accessible and practical choice for healthcare providers. The ability to diagnose peripheral artery occlusive disease quickly and effectively using CD can provide significant benefits to patients and healthcare providers alike.

Additionally, it offers two-dimensional grayscale pictures for the evaluation of the arterial tree's gross morphology. Waveform analysis may also be used to evaluate and quantify the arterial flow pattern and hemodynamic condition. [9] Additionally, it can distinguish between stenosis and total blockage and determine the duration of the disease in an artery. However, CD has its limits since it is very operator dependent and demands expertise. [10] If present, further calcification hinders seeing the artery lumen and offers no useful information. Infragenicular arteries in the lower limbs are an example of a deep-seated artery that may not be accessible for inspection, particularly if edema is present. Digital subtraction-angiography (DSA), on the other hand, is another frequently utilized technique for diagnosing PAOD. [11,12] Its benefits include superior stenosis and occlusion determination, operator independence, greater anatomical features, and improved visualization of deep-seated arteries such as infra genicular arteries. [13,14,1,5] It can also identify the sluggish flow of tiny veins and collaterals much better than ultrasound. [16] DSA is an invasive treatment; therefore, it has drawbacks including the possibility of radiation exposure, contrast-related nephrotoxicity, and allergic responses. It also takes the ability to execute and interpret the operation. There are additional post-procedure complications such as thromboembolism, aneurysms, and hematoma development. [17,18] The purpose of this prospective comparative study was to put Color Doppler to the test, comparing its results to that of the gold standard - digital subtraction arteriography (DSA) - in assessing peripheral arterial occlusive disease (PAOD) of the infragenicular arteries in the lower extremities. Controlled studies and clinical trials have demonstrated

remarkable consistency between the findings of CD and DSA. The CD has also become a widely used tool in measuring re-stenosis after peripheral interventions, often replacing follow-up angiography in research. This study aims to determine the effectiveness of CD in accurately diagnosing PAOD.

METHODS: This was prospective research that was conducted on a total of 50 patients with lower limb ischemia over the course of 12 months, from February 2022 to January 2023, at the Mayo Hospital in Lahore's Department of Radiodiagnosis. The patient's demographic information, comorbidities, cardiovascular risk factors, and peripheral artery disease clinical stage were collected. 150 segments, or three segments for each patient, were investigated using color doppler and DSA. The anterior, posterior, and peroneal arterial segments of the tibia were among the 150 peripheral arterial segments that were examined in the research. Kappa values and two-way contingency tables were utilized in the study to evaluate the outcomes. The research received ethics committee approval, and patient permission was obtained for catheter angiography.

The research used cutting-edge diagnostic tools to assess the target limb's infragenicular arterial segments. High-resolution B-mode ultrasonography was performed using the ALOKA SSD 4000, and duplex scanning was performed using a 7.5-MHz linear transducer. The inspection was thorough, beginning at the aortic bifurcation and going all the way down to the foot level of the target limb's arterial tree. Color-coded duplex sonography, Doppler measurements, and wave-form analysis were used throughout the examination to make sure that every feature of the target limb's arterial segments was carefully examined. The objective was to conduct a precise and thorough study of the arterial segments in order to identify any arterial occlusive disease and assess its severity. A total of 50 patients and 150 infragenicular arterial segments were included in the study. The use of advanced ultrasonography equipment and comprehensive examination protocol allowed for a detailed evaluation of the infragenicular arterial segments and provided valuable insights into the diagnosis and treatment of peripheral arterial disease. For the anterior, posterior, and peroneal arterial segments, CD findings were seen. The results were shown on a standardized spreadsheet that included the lesion's length and location as well as the peak systolic velocity ratio (PSVR) for the relevant section. Significant stenosis (defined as 50% or more) was defined as a PSVR of 2 or above. According to the CD investigation, the target place for the intended operation was identified.

In the presence of the anesthesiologist, the patient's signed and informed permission was obtained before the operation. The inguinal area was draped after being coated with betadine. The Seldginger method is used to palpate and puncture the femoral artery. The concerned vessel was located using a guide wire and then a catheter. Through the use of a catheter, the contrast was injected into the affected channel, and the filling of the vessel was recorded using the bolus chased technique. The degree and extent of lesions in the arterial segments were evaluated visually by examining them from an anterior-posterior (AP) perspective. As there was no access to quantitative angiography software, the visual assessment was used to determine the degree and length of the lesions. Results were recorded and contrasted with color Doppler results. Stenosis of 50% or more was considered substantial.

Several groups of patients were excluded from participating in the study. These included pregnant women, individuals with blood disorders or abnormal bleeding tendencies, patients with a history of sensitivity to contrast agents, those who had undergone endovascular procedures, and mentally retarded patients. The

data collected from the study were analyzed using the SPSS software version 26. This software was utilized to organize and evaluate the data, providing valuable insights into the results of the study. By excluding certain patient groups, the study aimed to ensure the accuracy and reliability of the results, providing a comprehensive and representative analysis of the infragenicular arterial disease diagnosis using Color Doppler and Digital Subtraction Arteriography.

RESULTS: In this study, both male and female patients were included, with the majority of cases being male. The age range of the participants was between 25 and 70 years, with the largest group falling between the ages of 51 and 60. The patients' average age was 47.

Intermittent claudication and rest discomfort were among the patients' most commonly reported complaints. To better understand the patient's medical history, a detailed evaluation of the patient's history was conducted during the study. The assessment sought to identify the main risk factors for peripheral arterial disease. The major risk factors identified were smoking, hyperlipidemia, hypertension, and diabetes (as seen in Table 1). The bulk of the lesions were discovered in the anterior tibial artery, according to the study's findings, which were followed by those in the posterior tibial artery. This information provides valuable insights into the pattern and distribution of peripheral arterial disease, which can help healthcare providers to make informed decisions regarding diagnosis and treatment.

Table 1: Showcase of Risk Factor-Aware Patient Distribution

Risk factor	**Patients (%)**
Hyperlipidemia	25 (50)
IHD	5 (10)
Diabetes mellitus	23 (46)
Alcohol	13 (26)
Smoking	40 (80)
Hypertension	25 (50)

Table 2: Distribution of Patients Indicated by Stenosis Percentage on Color Doppler and DSA

Stenosis (%)	**CD patients (%)**	**DSA patients (%)**
1-19%	5 (10)	5 (10)
20-49%	10 (20)	15 (30)
50-99%	16 (32)	20 (40)
Total occlusion	19 (38)	10 (20)
TOTAL	**50 (100)**	**50 (100)**

Table 3: Showcase of Patient Distribution Based on PSV Ratio on Color Doppler

PSV ratio	**Patients (%)**
<2:1	15 (30)
2-4:1	12 (24)

>4	4 (8)
Total Occlusion	**19 (38)**
Total	**50 (100)**

Table 4: Color Doppler and DSA Comparison for Detection of Significant Stenosis in Infragmental Segments

	Not significant (less than50%)	Significant (more than 50%)	**Total**
DSA	20(40%)	30(60%)	**50**
COLOR DOPPLER	15(30%)	35(70%)	**50**

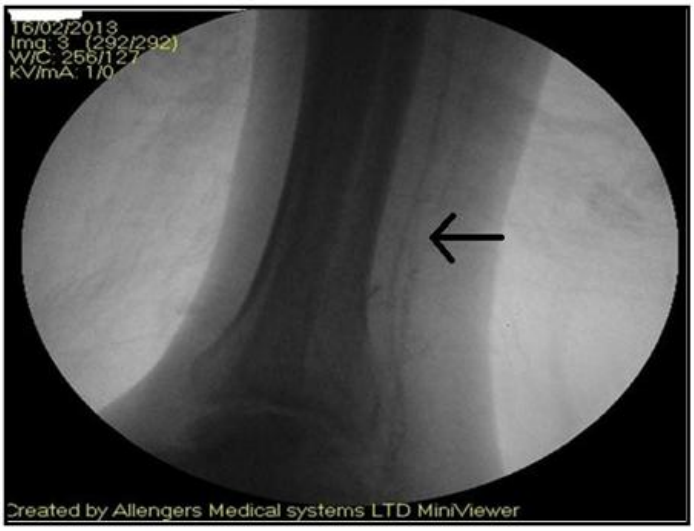

Figure 1: Partial PTA Filling

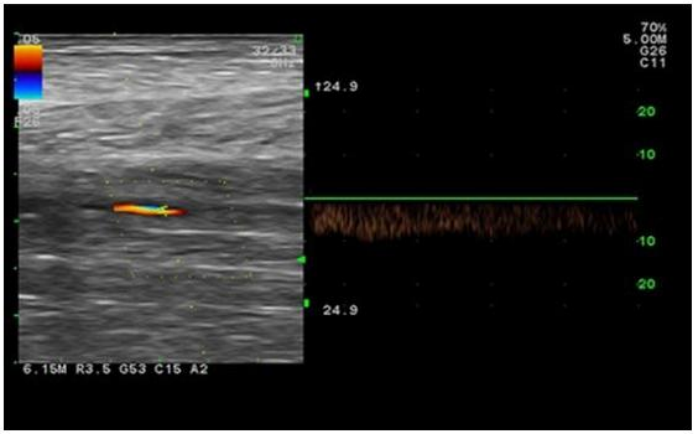

Figure 2: ATA with dampened monophasic flow

Based on the results of the Color Doppler examination, patients were categorized based on the percentage of stenosis observed. The results showed that 10% of patients had stenotic lesions ranging from 1-19%, 20% had stenosis ranging from 20-49%, 32% had stenosis ranging from 50-99%, and 38% showed total occlusion (as seen in Table 2). Digital subtraction angiography was found to be more specific in picking up complete occlusions, with 60% of the patients showing significant stenosis (50% or more) and 40% showing non-significant stenosis. (Table 4) When evaluating patients based on their PSV (peak systolic velocity) ratio, 30% had a ratio of less than 2, 24% had a ratio between 2 and 4, 8% had a ratio greater than 4, and 38% exhibited total block. (Table 3)

DISCUSSIONS: In our investigation, we discovered that there were 116 real negative segments and 4 false negative segments when the patient was examined using color Doppler ultrasound. According to our research, color Doppler ultrasonography for infragenicular arterial segments has sensitivity values of 83%, specificity values of 92%, PPV values of 66%, and NPV values of 96%, which are equivalent to those obtained in earlier studies. [19,20] A study has shown that duplex imaging has a higher overall performance in detecting peripheral vascular disease compared to angiography. The study found that the use of duplex imaging was highly effective in detecting vascular disease. The results showed that the sensitivity of duplex imaging was 92%, which means that it was able to accurately detect 92% of all cases of vascular disease. The specificity of duplex imaging was also high, at 99%, meaning that it was able to accurately identify 99% of all cases where there was no disease present. The positive predictive value of duplex imaging was 91%, meaning that in 91% of cases where the test showed that there was a disease present, this was confirmed by further examination. The negative predictive value was 100%, which means that all cases where the test showed that there was no disease present were indeed confirmed as disease-free. The study also found that the kappa value for duplex imaging was 0.87, with a 95% confidence interval ranging from 0.81 to 0.93. This indicates that the results of the study were highly reliable and consistent. [21] Additionally, it was discovered that even in the most seasoned clinics, between 5 and 20 percent of patients could not be adequately insulated on color Doppler because of ulcers, edema, discomfort, heavy calcification, and obesity.

In another study, it was concluded that CD is a superb technique for the noninvasive evaluation of patients with PAOD in the aortoiliac and femoropopliteal segments. [22] False positive occlusions were caused by arteries that were visible utilizing DSA but had no discernible blood flow on color Doppler. This may be because the vessel's blood flow is moving very slowly and most of the blood is being diverted by collaterals. This is known to be caused by diffuse proximal disease. Other factors include respiratory activity, overlaying intestinal gas, or a severely calcified artery wall.

False-negative results in detecting occlusions were found to be caused by segments that were not visible on DSA but could be seen on color Doppler. The non-visualization with DSA may have been due to a segment being filled with non-opacified blood, which is particularly common in distal sections to an occlusion. This can result in an overestimation of the length of the occluded segment, thereby decreasing the sensitivity of color Doppler. Another explanation might be that the collateral channel was unintentionally sampled by Doppler while the primary arterial segment that was blocked was still unknown.

False positive stenosis was caused by arteries that seemed normal on DSA but were stenosed on color Doppler. Uniplanar angiography has this drawback since the artery may seem normal whether the plaque is on the anterior or posterior wall.

False negative stenosis resulted from a section that color Doppler recorded as stenosed but which DSA found to be normal. Due to Doppler's high degree of subjectivity, it's possible that a lesion was overlooked by uniplanar DSA or that an error was made in its reporting. It could also be impacted by inadequate visualization.

Therefore, CD (COLOR DOPPLER) may make it easier to pre-angiographically assess the type and severity of artery disease in the lower limbs. In turn, this reduces the frequency of needless diagnostic arteriographies in individuals whose symptoms don't warrant surgical or endovascular treatment. A normal CD essentially eliminates severe lesions.

Due to the inability to see segments that are patent on CD when using arteriography as the "gold standard," findings might be misleadingly low. [23] In patients whose symptoms do not require surgical or endovascular intervention, a high negative predictive value (NPV) of the color Doppler method can reliably rule out significant lesions in the blood vessels, reducing the need for diagnostic angiographies. The research showed that even when angiograms display normal segments, they may still be normal if the color Doppler scan also indicates normal blood flow. This suggests that color Doppler has advanced from being an additional diagnostic tool to a crucial part of the diagnostic process for patients with chronic peripheral artery disease of the lower extremities.

CONCLUSIONS: Due to its cheap cost, non-invasive nature, lack of radiation risk, lack of contrast-related responses, and lack of nephrotoxicity, ultrasound should be used as the first modality to assess patients with arterial insufficiency. In this study, we found that the inferior genicular arteries had a high NPV (96%) of color Doppler assessment, suggesting that the absence of abnormal spectral wave shape and abnormal color flow in these arteries may render arteriography unnecessary. DSA, on the other hand, is undeniably helpful in patients who display abnormal/absent color flow and/or spectral waveform because of the decreased PPV (66%) of Color Doppler.

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