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CORRELATION OF CT ANGIOGRAPHY AND DOPPLER ULTRASONOGRAPHY IN DIAGNOSING PERIPHERAL ARTERIAL DISEASE

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ABSTRACT:

BACKGROUND: *Doppler ultrasound (DUS) has limitations in evaluating peripheral arterial disease (PAD) in complex areas like the adductor canal, morbidly obese patients, and those with severe limb swelling or ulcers. Compared to computed tomographic angiography (CTA) and magnetic resonance angiography (MRA), DUS shows lower sensitivity. CTA and MRA offer excellent diagnostic capabilities for PAD.*

AIMS & OBJECTIVE: *This study aimed to assess the agreement between CT angiography and Doppler ultrasonography in diagnosing PAD.*

MATERIAL & METHODS: *A cross-sectional study was conducted at the Department of Radiology, Bolan Medical Complex, Quetta from March 20, 2021, to September 19, 2021. We included 100 patients (aged 20-60 years) referred for suspected PAD. Patients with diabetes, impaired kidney function, and pregnancy were excluded. DUS examinations were performed by on-duty radiologists, assessing blood flow in lower limb arteries from the distal external iliac/common femoral artery to the dorsalis pedis artery. Results were compared with the patients' subsequent CTA findings, performed by the radiology department's CT team. Both teams were blinded to the study to minimize bias.*

RESULTS: *CT angiography confirmed PAD in 58 (58%) patients. DUS identified 54 true positives and 7 false positives. Among patients with negative DUS findings, 4 were false negatives, and 35 were true negatives (p-value=0.0001). The agreement between CT angiography and DUS for PAD diagnosis was 89.0%, with a kappa value of 0.772.*

CONCLUSION: *This study demonstrates good agreement between CT angiography and Doppler ultrasonography in diagnosing peripheral arterial disease.*

KEY WORDS: *Peripheral arterial disease, ultrasound, angiography*

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INTRODUCTION:

Peripheral arterial disease (PAD) also known as peripheral vascular disease is a cardiovascular disorder which is common in elderly patients. It is usually taken for arterial occlusive disease due to arteriosclerosis, impeding the blood flow to the lower extremity. According to Transatlantic inter-society consensus conference for the management of PAD, if claudication symptoms worsen despite adequate conservative management then it is necessary to assess the whole arterial tree. The timely and accurate diagnosis of disease is necessary to improve the quality of life.[1]

Doppler ultrasonography (DUS), computerized tomographic angiography (CTA), conventional angiography, and MRI angiography (MRA) can provide more information about the precise anatomy and severity of ischemia. Although digital subtraction angiography (DSA) has been considered as gold standard for diagnosing peripheral arterial disease but it is invasive and stressful for the patients. Non- invasive imaging modalities available for diagnosing PAD are CTA and DUS.[2]

Doppler ultrasonography is an inexpensive and easy method to diagnose peripheral arterial disease. Absence of flow on color Doppler indicates occlusion of vessel. Increase in peak systolic velocities of vessels, monophasic or biphasic pattern and broadening of waveform spectrum signify peripheral arterial disease[3,4]. Evaluation of infra-popliteal vessels by Doppler ultrasonography is time consuming and may be technically challenging, so complete evaluation of lower limb vessels by Doppler ultrasonography may not be feasible in some patients. DUS has limited role in evaluation of complex anatomical sites as in adductor canal, in morbid obese patients, those with significant limb swelling or ulceration[5].When compared with computed tomographic Angiography (CTA) and magnetic resonance Angiography (MRA), doppler ultrasonography is less sensitive. CTA and MRA have got excellent diagnostic capabilities. Duplex ultrasonography is less sensitive imaging technique than CTA or MRA. CTA is a preferred imaging modality over duplex ultrasound and MRA because of various reasons. CTA is a faster procedure which takes less than 5 minutes as compared to MRA which takes almost 20-30 minutes and Doppler ultrasonography which takes 30-45 minutes. Infact the greatest limitation of Doppler ultrasound is the time required for evaluation of both limbs American Heart Association (AHA)/American College of Cardiology (ACC) guidelines support the use of CTA and MRA in the diagnosis of significant stenosis in patients with lower extremity PAD.[6] The agreement between CTA and Doppler is found to be 87% which signifies a good agreement for PAD between these two modalities.[7]

An ABI < 0.90 diagnoses significant lower extremity PAD ($>50\%$ stenosis) with a sensitivity of 79% and specificity of 96%.[8] A systematic review of diagnostic performance of CTA in PDA was evaluated in 10 studies and it comes out that the pooled sensitivity, specificity, and accuracy rates were 92%, 91%, and 91%, respectively.[9] Diagnostic Imaging of Peripheral Arterial Disease (DIPAD) trial found that clinical confidence was higher and less additional imaging was required with the initial use of either MRA or CTA when compared with duplex US and the total costs for CTA were significantly lower compared to MRA or duplex US (because of the need for additional imaging in the DUS group).[2,6]

The rationale behind my study is that the local literature is deficient in the CT angiographic diagnosis of peripheral arterial disease. International studies validating the usefulness of CTA in PAD

are also limited instead of focusing on the accuracy of invasive radiological investigations. Depending upon the results of my study, diagnosis of PAD by CTA can reliably be applied as a first line investigation instead of Doppler as it is faster, more accurate, widely accessible and relatively inexpensive method. My study will focus on the agreement between CTA and doppler in diagnosis of PAD keeping in view the wide-availability, accuracy and cost-effectiveness of CTA.

MATERIALS AND METHODS:

This was a cross-sectional study. It was conducted at the Department of Radiology, Bolan Medical college Hospital Quetta. The study period was from March 20, 2021, to September 19, 2021.The sample size was calculated using the WHO sample size calculator, targeting an agreement rate between CTA and Doppler of 87% (based on previous literature[7]), a 95% confidence level, and a precision of 7%. This calculation yielded a sample size of 100 participants. A non-probability, consecutive sampling approach was used.

Inclusion Criteria:

- Age: 20-60 years
- Gender: Both male and female
- Patients referred to the Radiology Department with clinical suspicion of peripheral arterial disease. This included patients admitted through the surgical emergency department, outpatient department (OPD), and outside referrals.

Exclusion Criteria:

- Patients with diabetes
- Patients with impaired renal function
- Pregnant women

DATA COLLECTION PROCEDURE:

Following ethical committee approval from Shifa International Hospital, patients meeting the inclusion criteria underwent arterial Doppler ultrasound of the lower limbs. Informed consent was obtained from all participants, and the procedure was explained in detail.

The Doppler exam was performed using a pulsed Doppler flowmeter and a linear array transducer by the on-duty radiologist in the Doppler room. The presence or absence of blood flow in the lower limb arteries was assessed, starting from the distal external iliac/common femoral artery to the dorsalis pedis artery.

These Doppler findings were then compared with the same patient's subsequent CTA results obtained by the CT team of the radiology department. Neither the Doppler nor the CT team was aware of the study design to minimize bias.

STATISTICAL ANALYSIS:

Data was entered into SPSS software version 16. Qualitative and quantitative variables were distinguished. Frequencies and percentages were calculated for qualitative variables like gender, CTA outcomes, and ultrasound (USG) outcomes. Mean and standard deviation were calculated for the quantitative variable of age.

Kappa statistics were used to assess the agreement between USG and CTA results.

Effect modifiers like age and gender were controlled through stratification. Post-stratification, a chi-square test was applied. A p-value ≤ 0.05 was considered statistically significant.

RESULTS:

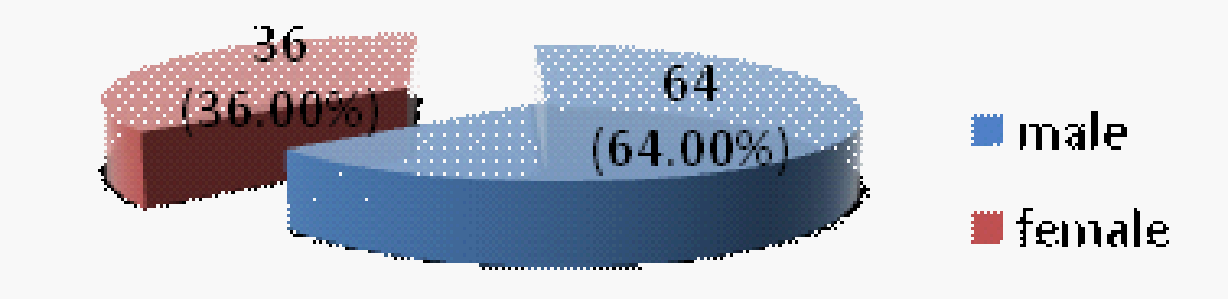

Figure-1: Distribution of patients according to Gender (n=100).

Table-1: Distribution of patients according to Age.		
Age (years)	No. of Patients	%age
20-40	46	46.0
41-60	54	54.0
Total	100	100.0
Mean ± SD = 42.33 ± 11.70 years		

Table-2: Agreement between CT angiography and Doppler ultrasonography in diagnosis of peripheral arterial disease.			
	Positive result on CT angiography	Negative result on CT angiography	P-value
Positive result on Doppler ultrasonography	54	07	0.0001
Negative result on Doppler ultrasonography	04	35	
• **Kappa Value = 0.772** • **Agreement between CT angiography and Doppler ultrasonography in diagnosis of peripheral arterial disease = 89.0%**			

Table 3: Stratification of age 20-40 years (n=46).			
	Positive result on CT angiography	Negative result on CT angiography	P-value
Positive result on Doppler ultrasonography	23	04	0.001
Negative result on Doppler ultrasonography	02	17	
• **Kappa Value = 0.735** • **Agreement between CT angiography and Doppler ultrasonography in diagnosis of peripheral arterial disease = 86.96%**			

Table 4: Stratification of age 41-60 years (n=54).			
	Positive result on CT angiography	Negative result on CT angiography	P-value
Positive result on Doppler ultrasonography	31	03	0.001
Negative result on Doppler ultrasonography	02	18	
• **Kappa Value = 0.76** • **Agreement between CT angiography and Doppler ultrasonography in diagnosis of peripheral arterial disease = 88.61%**			

Table 5: Stratification of Male gender (n=64).			
	Positive result on CT angiography	Negative result on CT angiography	P-value
Positive result on Doppler ultrasonography	38	3	0.001
Negative result on Doppler ultrasonography	03	20	
• **Kappa Value = 0.796** • **Agreement between CT angiography and Doppler ultrasonography in diagnosis of peripheral arterial disease = 90.63%**			

Table 6: Stratification of female gender (n=36).			
	Positive result on CT angiography	Negative result on CT angiography	P-value
Positive result on Doppler ultrasonography	16	04	0.001
Negative result on Doppler ultrasonography	01	15	
• **Kappa Value = 0.724** • **Agreement between CT angiography and Doppler ultrasonography in diagnosis of peripheral arterial disease = 87.11%**			

Age range in this study was from 20-60 years with mean age of 42.33 ± 11.70 years. Majority of the patients 54 (54.0%) were between 41 to 60 years of age as shown in Table 1.

Out of these 100 patients, 64 (64.0%) were male and 36 (36.0%) were females with ratio of 2:1 (Figure 1).

All the patients were subjected first to Doppler ultrasonography and then CT angiography. Doppler ultrasonography supported the diagnosis of peripheral arterial disease in 61 (61.0%) patients. CT angiography confirmed peripheral arterial disease in 58 (58.0%) cases. In doppler ultrasonography positive patients, 54 were true positive and 07 were false positive. Among 39, doppler ultrasonography negative findings, 04 were false negative whereas 35 were true negative (p-value=0.0001) as shown in Table 2. Agreement between CT angiography and Doppler ultrasonography in diagnosis of peripheral arterial disease was 89.0% with kappa value of 0.772. Stratification of agreement with respect to age groups has shown in Table 3 and 4 while Gender stratification is shown in Table 5 & 6.

DISCUSSION

Patients with symptomatic peripheral arterial disease (PAD) affecting the lower extremities are initially evaluated with an ankle brachial index (ABI) and segmental pressure measurements. An ABI < 0.90 diagnoses significant lower extremity PAD (>50% stenosis) with a sensitivity of 79% and specificity of 96%.[8] An ABI between 0.90–1.0 is considered borderline. The localization of the stenosis can be inferred by an abnormal decrease (>20 mmHg) in segmental lower extremity pressures. In the presence of calcified atherosclerosis, arteries may become stiff and non-compressible, which results in a falsely elevated ABI (often > 1.3). For patients with suspected PAD and a normal ABI at rest, it is valuable to obtain post-exercise ABI measurements which if less than 0.85 are consistent with PAD and is an independent predictor of mortality.[9] Imaging is then needed to confirm the location and degree of stenosis prior to revascularization or if the diagnosis of PAD is uncertain.

DUS has been successfully applied in patients with PAD.[10,11] Clinical studies have shown that the quality of DUS depends on the user's level of experience and that some arterial segments may be visualized more readily than others.[12] After the advancement of CT techniques, it is possible to cover entire limbs within a few seconds. Optimization of intravenous contrast with blood flow and CT scanning gives higher spatial resolution and coverage of more than 120cm. Computers with graphics project images in 3D, volume rendered images and curved planar images. Imaging of the entire arterial system is possible using CT angiography and has found excellent concordance with digital subtraction imaging.[11]I have conducted this study to determine agreement between CT angiography and Doppler ultrasonography in diagnosis of peripheral arterial disease.

Age range in this study was from 20-60 years with mean age of 42.33 ± 11.70 years. Majority of the patients 54 (54.0%) were between 41 to 60 years of age. Out of these 100 patients, 64 (64.0%) were male and 36 (36.0%) were females with ratio of 2:1.CT angiography confirmed peripheral arterial disease in 58 (58.0%) cases. In doppler ultrasonography positive patients, 54 were true positive and 07 were false positive. Among 39, doppler ultrasonography negative findings, 04

were false negative whereas 35 were true negative (p-value=0.0001). Agreement between CT angiography and Doppler ultrasonography in diagnosis of peripheral arterial disease was 89.0% with kappa value of 0.772. The agreement between CTA and Doppler is found to be 87% which signifies a good agreement for PAD between these two modalities.[7]

In a study [13], the agreement between DUS and DSA was very good ($\kappa > 0.8$) or good ($0.8 \geq \kappa > 0.6$) in most segments, but moderate ($0.6 \geq \kappa > 0.4$) in the tibio-peroneal trunk and the peroneal artery. Agreement between the two techniques was significantly better in the supragenicular ($\kappa = 0.75$ (95% confidence interval (CI): 0.70–0.80)) than in the infragenicular segments ($\kappa = 0.63$ (0.59–0.67)) ($p < 0.001$). Similarly, the technical success rate was significantly higher in the supragenicular segments (DUS: 100%; DSA: 99%) than in the infragenicular segments (both 93%) ($p < 0.001$). DUS was the best technique for imaging of the distal crural arteries (92% vs. 97%; $p < 0.001$) and DSA was the best technique for imaging of the proximal crural arteries (95% vs. 91%; $p < 0.01$).96

In another study[14] six hundred and nineteen arterial segments were studied with CT angiography and Doppler ultrasound. Of which 226 diseased segments were identified in CT angiography. Doppler overestimated narrowing by one grade in 47 segments, by two grade in 11 segments, by three grades in 30 segments and by four grades in 22 segments; underestimated by one grade in 28 segments, by two grades in 9 segments, by three grades in 5 segments and by four grades in 3 segments. Significant statistical difference exists between Doppler USG and CT angiography. Doppler showed good correlation with CT angiography in 74%, but, Doppler overestimated stenosis grade in a significant percentage. The sensitivity, specificity and accuracy of Doppler USG compared with CT angiography was 93.36%, 82.44%, and 86.42%.[14]

In a study, the sensitivity, specificity and accuracy of Doppler USG v/s CTA was 92.9%, 82.2% and 85.6%. It also showed 73.4% agreement between two studies. Region wise sensitivity was good in all regions (91-97%). There was wide difference in specificity (61-94%) and inconsistence specificity in distal run off arteries of lower limb (61%) and (73%) of upper limb arteries. Doppler USG can be first investigation of choice for investigation of patients with peripheral arterial system disease as it offers good sensitivity (92.9%) and high negative predictivity (95.5%). Another study[15] has shown that Aortoiliac group of vessels showed more than 80% total agreement between Doppler and MDCT angiography. Femoropopliteal group vessels showed more than 75% total agreement. Infrapopliteal group of vessels showed more than 50% total agreement. A small study that evaluated the diagnostic accuracy of "dynamic CTA" for lower-extremity PAOD found the sensitivity and specificity to be 98% and 97.1%, respectively, for diagnosing vessel stenosis, and 95.4% and 99.3%, respectively, for diagnosing vessel occlusion.[16] These figures may be compared with the standard CTA sensitivities and specificities of 96.6% and 92.2%, respectively, for vessel stenosis and 94.4% and 94.4%, respectively, for occlusion. The investigators demonstrated a clear improvement in diagnostic accuracy for PAOD with dynamic CTA over standard CTA, without increased radiation or contrast administration.[16]

A major limitation when introducing DUS for preoperative imaging is that it requires the participation of highly experienced technicians–especially for the visualisation of the infragenicular arteries.[17] However, as DUS has become a widespread imaging modality, experienced technicians become increasingly available–which happened when magnetic resonance angiography (MRA) or computed tomography angiography (CTA) were introduced. Another obstacle is related to the fact that some surgeons are uncomfortable without the printed DSA images at hand before and during the operation.[18] In addition, even in the most experienced centres, 5–20% of the patients are impossible to insonate sufficiently due to ulcers, oedema, pain, heavy arterial calcification and obesity.

Some reservations towards DUS may be met by establishing appropriate quality assurance, for instance, by having the first 50 examinations of every technologist confirmed by another imaging modality or by a more experienced technologist.[17] On the whole it is concluded that there is a good agreement between CT angiography and Doppler ultrasonography in diagnosis of peripheral arterial disease.

CONCLUSION:

This study concluded that there is a good agreement between CT angiography and Doppler ultrasonography in diagnosis of peripheral arterial disease, and has not only dramatically improved our ability of diagnosing peripheral arterial disease pre-operatively but also helps the surgeons for proper decision making. So, we recommend that CT angiography should be used a first line imaging modality in all suspected cases of peripheral arterial disease for accurate diagnosis pre-operatively and opting proper surgical approach.

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