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ORIGINAL RESEARCH

Role of doppler and CT angiography in upper limb vascular pathologies

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Abstract
Objective: Role of Doppler and CT Angiography in upper limb vascular pathologies.
Materials and methods: Total 105 (39 females and 66 males) patients with suspected upper limb vascular pathologies were studied with relevant history and clinical Examination. Doppler was performed on ultrasonography machine using a 7.5 MHz linear array transducer (Occasionally, a 5 MHz phased array transducer), CT angiography was performed on 128 slice MDCT machine using proper anatomical position and set protocols.
Results: The study included 105 patients with suspected upper limb vascular pathologies. Out of 96 patients of right upper limb examined, imaging findings of 93 were compared, since 3 patients were not included because of poor CT imaging quality and 99 patients of Left upper limb examined with Doppler Imaging were compared with CT angiography. Doppler imaging showed good diagnostic accuracy, specificity, sensitivity, PPV and NPV in examining large arteries of upper limb including Subclavian, axillary, and brachial arteries when correlated with CT angiography, while Radial and ulnar arteries showed comparatively low diagnostic accuracy, specificity, sensitivity, PPV and NPV when correlated with CT angiography, however both methods showed good agreement.
Conclusion: Doppler Imaging was found to have a high negative predictive value and could exclude a significant lesion, it could determine the nature and extent of arterial disease based on which treatment can be planned, thus doppler can be used as a screening method however combination of Doppler Imaging with MDCT angiography has better diagnostic accuracy.
Key words: (Doppler, CT angiography, vascular, occlusion, upper limb)

Introduction

Vascular disorders of the upper extremity are uncommon and are affected by a variety of pathologies ranging from acute traumatic injuries to chronic atherosclerotic disease, which generally evaluated by multi-modality imaging. Conventionally, digital subtraction angiography (DSA) of the upper extremity has been the primary modality for vascular assessments as of its higher spatial resolution and remains the gold standard. However, with the modern advances, modalities like Doppler, CT (computed tomography), and MRI (magnetic resonance imaging) are playing a major role in vascular imaging and are replacing DSA as a pure diagnostic imaging modality [1, 2].

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The choice between the CT and Doppler imaging techniques as an imaging modality of choice depends upon the indication and urgency of the study. Conventionally, CTA (CT angiography) has been the imaging modality in emergency settings like trauma, dissections, or embolism and Doppler as an initial modality of choice in these conditions [3, 4], With relative risks of iodinated contrast and radiation, there has been an increase in trend for Doppler as a preference of imaging modality for semi-urgent conditions, long-term follow-up. A correlation study between both modalities will help in the judicious and effective use of the technique as per the requirement of the patient. This study is the first of its kind, none of the studies has included both Doppler and CT angiographic modality in the evaluation of upper limb vascular pathologies.

Aims and objectives

Aim

Role of Doppler and CT Angiography in upper limb vascular pathologies.

Objectives

1. Evaluation of the role of Doppler and CT angiography in upper limb vascular pathologies.
2. To evaluate the correlation and advantages of Doppler as compared to CT angiography in the assessment of upper limb vascular pathologies.

Material and methodology

1. Study Design:

Type of Study: Single Centre Prospective study

Study Site and duration: Department of Radiology, Medical College & Civil Hospital, from October 2019 to August 2021.

Sample size: 105

Inclusion Criteria

1. Clinically suspected patients presenting with upper limb vascular pathologies including all age groups, either sex or clinical settings (indoor or outdoor).
2. Patient giving consent.

Exclusion Criteria

1. Patients not willing to give consent for the study.
2. Comatose/hemodynamically unstable patient.
3. Severe renal impairment.
4. Allergic to iodinated contrast.

Informed consent was taken from patients and were evaluated for clinical history and underwent basic physical assessment after which patients were subjected to Doppler and CT angiography examination.

Doppler imaging

Doppler imaging was done on RS-80 EVO and Accuvix XG Samsung ultrasonography machine using a 7.5 MHz (megahertz) linear array transducer. Occasionally, a 5 MHz phased array transducer was required for the assessment of subclavian and axillary arteries.

Patients were examined in a supine position with the head slightly elevated and the arm externally rotated. Colour flow assisted B-mode was used to rapidly map the vessel of interest and locate lesions and Pulse-Doppler was used to analyse spectral waveform and to measure peak systolic velocity.

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Details of Scanner control adjustments and criteria for doppler assessment- The colour box was not too large as the image frame rate may become too low, the colour pulse repetition frequency was optimized so that the peak systolic velocity is in the upper region of the colour scale, Stenosis will be rapidly identified as an area of aliasing, The colour wall filter was set correctly, the angle of insonation was kept close to 60 degrees to the vessel axis, The patency of the vessel was determined by normal triphasic waveform pattern and colour saturation demonstrated throughout the lumen of the artery and Complete Occlusion was diagnosed, when no saturation and no Doppler waveform colour was seen in the occluded segment of an artery with monophasic waveform changes in a proximal and distal segment to the site of occlusion [5,6,7].

CT angiography imaging protocol

CT Angiography was done on Siemens MDCT (multidetector CT) 128 slice SOMATOM. A 20 gauge or larger IV (intravenous) cannula was placed on the non-affected side of the forearm. In the case where both arms were affected central venous access was used. Patients were positioned supine and arm raised over the head, with hand-placed in anatomical position with fingers straight and extended. In trauma patients, scans were performed with the patient's arms by the side.

The CTA protocol is detailed in Table 1. In patients with thoracic outlet syndrome (TOS), scanning was performed in two sets, first with Adson manoeuvre (arm abducted in external rotation and head turned to the same side) and then second set of scanning was performed in neutral position only if the first set was positive for vascular compression at the thoracic outlet [2,8].

Table 1: CT angiography protocol for upper limb pathologies

Parameter	Details
Position	The extremity of interest over the head with the palm ventral and fingers extended and straightened (whenever possible)
Scan range	Carina to fingertips
Delayed scan	Just above the elbow to fingertips
Trigger	Bolus tracking, trigger at aortic arch (180 HU) or manual trigger immediately at opacification of the brachial artery in mid-arm
Contrast agent	Iohexol 350 mg/ml
Amount and rate	100–125 ml at 4-5 ml/s
Saline flush	40 ml at 4 ml/s
Slice thickness	1 mm with 0.7 mm reconstruction interval
Window width/window level	600/80
Pitch	Variable

All transverse source images were transferred to workstations for the reconstructions. Sliding maximum intensity projections were obtained with coronal, and sagittal projections of each data set. Whole-volume maximum intensity projections with the segmentation of bone and vessel wall calcifications and Volume rendered images were obtained.

All CT angiography examinations and post-processing reconstructions were performed by dedicated CT technologists which were interpreted by experienced radiologists.

Image analysis

The following vascular segments were analysed independently for the presence of vascular pathologies:

- Subclavian artery (SA)

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- Axillary artery (AA)
- Brachial artery (BA)
- Radial artery (RA)
- Ulnar artery (UA)

Doppler Imaging and CT angiography findings were evaluated for the presence of occlusion, narrowing, pseudo aneurysm and hematoma. The results of both studies were then compared and statistically analysed, using CT angiography as the standard for abnormalities.

Statistical analysis

Data of each patient were recorded including CT Angiography and doppler imaging relevant to the study. The imaging data were analysed by the reviewing radiologist and findings were recorded.

Agreement between Colour Doppler and CT angiography findings were evaluated using Cohen's Kappa [9]. Diagnostic performance of colour Doppler in the detection of positive findings was assessed in terms of its sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV).

The degrees of association between the measurable data were calculated using Cohen's kappa index depending upon the normality of the distribution. P values < 0.05 was considered significant [10].

Observation and results

The study included 105 (39 females and 66 males) patients with suspected upper limb vascular pathologies which were classified under main groups as follows:

1. Trauma
2. Thromboembolism
3. Others, it included vascular malformation, venous thrombosis, and haemodialysis vascular access-related injury, AVF (Arteriovenous Fistula), etc.

The demographic distribution of patients in terms of frequency and percentage is mentioned in table 2, Of the patients enrolled, there were 39 females (37.1 %) and 66 males (62.9%).

Table 2: Distribution of the Patients in Terms of Age (n = 105)

Age	Frequency	Percentage
≤20 Years	19	18.1%
21-30 Years	18	17.1%
31-40 Years	20	19.0%
41-50 Years	12	11.4%
51-60 Years	22	21.0%
61-70 Years	11	10.5%
71-80 Years	3	2.9%

Risk Factors

47 patients had no risk factors while 37 had diabetes mellitus, 42 had hypertension, 23 had hyperlipidemia, 22 had smoking, 13 had alcohol use and 2 had chronic kidney disease. Patients presenting symptoms and distribution of pathologies are mentioned in table 3 and table 4.

Table 3: Patients presenting with following symptoms

Symptoms	Yes	No
Bleeding	12 (11.4%)	93 (88.6%)
Color Change	32 (30.5%)	73 (69.5%)

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Coldness	26 (24.8%)	79 (75.2%)
Gangrene	9 (8.6%)	96 (91.4%)
Intermittent Claudication	28 (26.7%)	77 (73.3%)
Pain	64 (61.0%)	41 (39.0%)
Paresthesia	23 (21.9%)	82 (78.1%)
Swelling	35 (33.3%)	70 (66.7%)
Ulcer	16 (15.2%)	89 (84.8%)

Table 4: Distribution of the Patients in Terms of Pathology (n = 105)

Pathology	Frequency	Percentage
Trauma	43	41.0%
Thromboembolic	53	50.4%
Others	9	8.6%

Observations on CT angiography

Out of 105 patients, 95 were subjected to bilateral upper limb CT angiography, 9 were evaluated by left upper limb and 1 patient underwent right upper limb CT angiography.

CT positive findings were absent contrast opacification in affected arterial segments, abrupt narrowing of the vessel and pseudoaneurysm in acute traumatic cases, in thromboembolic and atherosclerotic disease positive findings included wall thickening, luminal narrowing, faint contrast opacification.

Normal CT angiography findings were considered CT negative.

Table 5: Distribution of the Patient in Terms of CT Angiography findings in bilateral upper limbs (CI- confidence interval)

CT Angiography		RIGHT (n = 96)		LEFT (n = 104)	
		Frequency(percentage)	95% CI	Frequency(percentage)	95% CI
SA	Negative	85 (88.5%)	80.0-93.9%	83 (79.8%)	70.6-86.8%
	Positive	11 (11.5%)	6.1-20.0%	21 (20.2%)	13.2-29.4%
AA	Negative	91 (94.8%)	87.7-98.1%	93 (89.4%)	81.5-94.3%
	Positive	5 (5.2%)	1.9-12.3%	11 (10.6%)	5.7-18.5%
BA	Negative	72 (75%)	64.9-83.0%	67 (64.4%)	54.4-73.4%
	Positive	24 (25%)	17.0-35.1%	37 (35.6%)	26.6-45.6%
RA	Negative	74 (77.1%)	67.2-84.8%	68 (65.4%)	55.3-74.3%
	Positive	22 (22.9%)	15.2-32.8%	36 (34.6%)	25.7-44.7%
UA	Negative	70 (72.9%)	62.3-81.2%	66 (63.5%)	53.4-72.5%
	Positive	26 (27.1%)	18.8-37.3%	38 (36.5%)	27.5-46.6%

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Observations on doppler imaging

Out of 105 patients, 93 were subjected to bilateral Doppler examination, 3 were evaluated by right upper limb Doppler and 6 patients underwent left upper limb Doppler examination. Doppler examination of 3 patients couldn't be performed because of loss to follow up.

Positive Doppler imaging findings seen in our study were monophasic waveform, luminal narrowing, velocity changes and absent colour flow.

In vascular traumatic injury Doppler flow imaging findings, most seen were like occlusive arterial disease such as luminal occlusion with low velocity monophasic waveform, colour flow changes and other findings included pseudo aneurysm. In addition to Doppler flow changes, periarterial soft tissue changes at the site of injury were noted.

Normal and hemodynamically insignificant Doppler imaging findings were considered negative.

Table 6: Distribution of the Patients in Terms of Doppler Findings in bilateral upper limbs

Doppler		RIGHT (n = 96)		LEFT (n = 99)	
		Frequency(percentage)	95% CI	Frequency(percentage)	95% CI
SA	Negative	88 (91.7%)	83.8-96.1%	84 (84.8%)	75.9-91.0%
	Positive	8 (8.3%)	3.9-16.2%	15 (15.2%)	9.0-24.1%
AA	Negative	92 (95.8%)	89.1-98.7%	87 (87.9%)	79.4-93.3%
	Positive	4 (4.2%)	1.3-10.9%	12 (12.1%)	6.7-20.6%
BA	Negative	75 (78.1%)	68.3-85.7%	66 (66.7%)	56.4-75.6%
	Positive	21 (21.9%)	14.3-31.7%	33 (33.3%)	24.4-43.6%
RA	Negative	73 (76%)	66.0-83.9%	64 (64.6%)	54.3-73.8%
	Positive	23 (24%)	16.1-34.0%	35 (35.4%)	76.2-45.7%
UA	Negative	71 (74%)	63.8-82.1%	63 (63.6%)	53.3-72.9%
	Positive	25 (26%)	17.9-36.2%	36 (36.4%)	27.1-46.7%

Comparison of doppler and CT angiography findings

In table 7 and 8, the green cells on the diagonal represent cases where both the methods agreed and the red shaded cells represent cases where the two methods disagreed.

Table 7: Comparison of Right upper limb arteries Doppler with CT Angiography (n = 93)

RIGHT			CTA			Cohen's Kappa	P value
			Negative	positive	Total		
SA	Doppler	negative	82 (88.2%)	3 (3.2%)	85 (91.4%)	0.825	<0.001
		positive	0 (0.0%)	8 (8.6%)	8 (8.6%)		
		total	82 (88.2%)	11 (11.8%)	93 (100%)		
AA	Doppler	negative	88 (94.6%)	1 (1.1%)	89 (95.7%)	0.883	<0.001
		positive	0 (0.0%)	4 (4.3%)	4 (4.3%)		

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		total	88 (94.6%)	5 (5.4%)	93 (100%)		
BA	Doppler	negative	69 (74.2%)	3 (3.2%)	72 (77.4%)	0.912	<0.001
		positive	0 (0.0%)	21 (22.6%)	21 (22.6%)		
		total	69 (74.2%)	24 (25.8%)	93 (100%)		
RA	Doppler	negative	67 (72%)	3 (3.2%)	70 (75.3%)	0.795	<0.001
		positive	4 (4.3%)	19 (20.4%)	23 (24.7%)		
		total	71 (76.3%)	22 (23.7%)	93 (100%)		
UA	Doppler	negative	63 (67.7%)	5 (5.4%)	68 (73.1%)	0.757	<0.001
		positive	4 (4.3%)	21 (22.6%)	25 (26.9%)		
		total	67 (72%)	26 (28%)	93 (100%)		

Table 8: Comparison of Left upper limb arteries Doppler with CT Angiography (n = 99)

LEFT			CTA			Cohen's kappa	P value
			negative	positive	Total		
SA	Doppler	negative	78 (78.8%)	6 (6.1%)	84 (84.8%)	0.798	<0.001
		positive	0 (0.0%)	15 (15.2%)	15 (15.2%)		
		total	78 (78.8%)	21 (21.2%)	99 (100%)		
AA	Doppler	negative	85 (85.9%)	2 (2.0%)	87 (87.9%)	0.754	<0.001
		positive	3 (3.0%)	9 (9.1%)	12 (12.1%)		
		total	88 (88.9%)	11 (11.1%)	99 (100%)		
BA	Doppler	negative	62 (62.6%)	4 (4.0%)	66 (66.7%)	0.912	<0.001
		positive	0 (0.0%)	33 (33.3%)	33 (33.3%)		
		total	62 (62.6%)	37 (37.4%)	99 (100%)		
RA	Doppler	negative	59 (59.6%)	5 (5.1%)	64 (64.6%)	0.802	<0.001
		positive	4 (4.0%)	31 (31.3%)	35 (35.4%)		
		total	63 (63.6%)	36 (36.4%)	99 (100%)		
UA	Doppler	negative	57 (57.6%)	6 (6.1%)	63 (63.6%)	0.784	<0.001
		positive	4 (4.0%)	32 (32.3%)	36 (36.4%)		
		total	61 (61.6%)	38 (38.4%)	99 (100%)		

Table 9: Kappa statistics segment analysed agreement of duplex with CT angiography

Segment analysed	Right		Left	
Subclavian artery	0.825	**Near Perfect agreement**	0.798	**Substantial agreement**
Axillary artery	0.883	**Near Perfect agreement**	0.754	**Substantial agreement**
Brachial artery	0.912	**Near Perfect agreement**	0.912	**Near Perfect agreement**
Radial Artery	0.795	**Substantial agreement**	0.802	**Near Perfect agreement**
Ulnar Artery	0.757	**Substantial agreement**	0.784	**Substantial agreement**

Discussion

The characteristic of normal wave-forms in the upper limb artery is triphasic with a sharp systolic peak, followed by a brief diastolic flow reversal and minimal forward flow at the end of diastole [11].

Colour flow and Doppler wave-forms in vascular disease [3] of upper extremity arteries provide vital information for (1) the presence of hemodynamically significant stenosis (>50%), occlusion, (2) adequacy of collaterals and distal reformation, and (3) vascular injury.

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Loss of the diastolic flow reversal is definite evidence of significant proximal vascular obstruction. Reduction in the peak systolic velocity and broadening and filling in the spectral window are other supportive signs of proximal obstruction.

Out of 96 segments of right SA examined, imaging findings of 93 segments were compared, since 3 segments were not included because of poor CT imaging quality. The sensitivity, Specificity, PPV, NPV, and accuracy of Doppler Imaging were 73%, 100%, 100%, 96%, and 97% respectively. Both methods agreed in 96.8% of the cases and disagreed in 3.2% of the cases. There was Near Perfect agreement between the two methods, and this agreement was statistically significant (Cohen's Kappa = 0.825, p = <0.001).

The disagreements observed between the two methods were as follows: 3 (3.2%) cases with hemodynamically significant findings on CT angiography were missed by Doppler Imaging.

Our study findings were in concordance with the result of an earlier study conducted by Eikelboom et al. [12] published in 1983 Which showed ultrasonic duplex scanning of the Subclavian artery has a sensitivity of 0.73 and a specificity of 0.91 for the detection of an obstructive lesion of 50% or more at the site of the ostium and negative predictive value of respectively 0.97.

Out of 96 segments of right AA examined, imaging findings of 93 segments were compared with CT angiography and both methods agreed in 98.9% of the cases and disagreed in 1.1% of the cases. The sensitivity, Specificity, PPV, NPV, and diagnostic accuracy of Doppler Imaging were 80%, 100%, 100%, 99%, and 99% respectively. There was Near Perfect agreement between the two methods, and this agreement was statistically significant (Cohen's Kappa = 0.883, p = <0.001).

The disagreements observed between the two methods were as follows: 1 (1.1%) the case was classified as false negative by Doppler Imaging, probably due to calcific plaque.

Out of 96 segments of right BA examined, imaging findings of 93 segments were compared with CT angiography and both methods agreed in 96.8% of the cases and disagreed in 3.2% of the cases. The sensitivity, Specificity, PPV, NPV, and accuracy of Doppler Imaging were 88%, 100%, 100%, 96%, and 97% respectively. There was Near Perfect agreement between the two methods, and this agreement was statistically significant (Cohen's Kappa = 0.912, p = <0.001).

The disagreements observed between the two methods were as follows:3 (3.2%) cases showed false-negative findings in Doppler Imaging probably due to calcific plaques.

Out of 96 segments of right RA examined, imaging findings of 93 segments were compared with CT angiography and both methods agreed in 92.5% of the cases and disagreed in 7.5% of the cases. The sensitivity, Specificity, PPV, NPV and accuracy of Doppler Imaging was 86 %, 94 %, 83 %, 96%, and 92 % respectively. There was substantial agreement between the two methods, and this agreement was statistically significant (Cohen's Kappa = 0.795, p = <0.001).

The disagreements observed between the two methods were as follows: 4 (4.3%) cases showed false-positive results and 3 (3.2%) cases showed false-negative results.

Out of 96 segments of right UA examined, imaging findings of 93 segments were compared with CT angiography and both methods agreed in 90.3% of the cases and disagreed in 9.7% of the cases. The sensitivity, Specificity, PPV, NPV and accuracy of Doppler Imaging was 81 %, 94 %, 84 %, 93 %, and 90% respectively. There was substantial agreement between the two methods, and this agreement was statistically significant (Cohen's Kappa = 0.757, p = <0.001).

The disagreements observed between the two methods were as follows: 4 (4.3%) cases showed false-positive and 5 (5.4%) cases showed false- negative results.

Out of 99 segments of Left SA examined with Doppler Imaging were compared with CT angiography and both methods agreed in 93.9% of the cases and disagreed in 6.1% of the

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cases. The sensitivity, Specificity, PPV, NPV, and accuracy of doppler imaging were 71%, 100%, 100%, 93%, and 94% respectively. There was substantial agreement between the two methods, and this agreement was statistically significant (Cohen's Kappa = 0.798, p = <0.001).

The disagreements observed between the two methods were as follows: In 6 (6.1%) cases with hemodynamically significant findings on CT angiography were missed by Doppler imaging.

Out of 99 segments of Left AA examined (Doppler) were compared with CT angiography and both methods agreed in 94.9% of the cases and disagreed in 5.1% of the cases. The sensitivity, Specificity, PPV, NPV, and accuracy of Doppler Imaging were 82%, 97%, 75%, 98%, and 95% respectively. There was substantial agreement between the two methods, and this agreement was statistically significant (Cohen's Kappa = 0.754, p =<0.001).

The disagreements observed between the two methods were as follows: In 3 (3.0%) cases Doppler Imaging overestimated the result as compared to CT angiography. In 2 (2.0%) cases hemodynamically significant findings were missed on the doppler.

Out of 99 segments of Left BA examined (Doppler), were compared with CT angiography and both methods agreed in 96.0% of the cases and disagreed in 4.0% of the cases. The sensitivity, Specificity, PPV, NPV, and accuracy of Doppler Imaging were 89%, 100%, 100%, 94 %, and 96 % respectively. There was Near Perfect agreement between the two methods, and this agreement was statistically significant (Cohen's Kappa = 0.912, p = <0.001).

The disagreements observed between the two methods were as follows: In 4 (4.0%) cases Doppler imaging missed significant hemodynamic findings.

Out of 99 segments of Left RA examined (Doppler), were compared with CT angiography and both methods agreed in 90.9% of the cases and disagreed in 9.1% of the cases. The sensitivity, Specificity, PPV, NPV, and accuracy of Doppler Imaging were 86%, 94%, 89%, 92 %, and 91 % respectively. There was Near Perfect agreement between the two methods, and this agreement was statistically significant (Cohen's Kappa = 0.802, p = <0.001).

The disagreements observed between the two methods were as follows: 4 (4.0%) cases were overestimated on Doppler Imaging. In 5 (5.1%) cases Doppler Imaging showed false-negative results.

Out of 99 segments of Left UA examined (Doppler), were compared with CT angiography and both methods agreed in 89.9% of the cases and disagreed in 10.1% of the cases. The sensitivity, Specificity, PPV, NPV, and accuracy of Doppler Imaging were 84%, 93%, 89 %, 90 %, and 90 % respectively. There was substantial agreement between the two methods, and this agreement was statistically significant (Cohen's Kappa = 0.784, p = <0.001).

The disagreements observed between the two methods were as follows: 4 (4.0%) cases were classified as false-positive and in 6 (6.1%) cases Doppler Imaging showed false-negative results.

In our study Doppler imaging showed good diagnostic accuracy, specificity, sensitivity, PPV and NPV in examining large arteries of upper limb including Subclavian, axillary, and brachial arteries when correlated with CT angiography except subclavian arteries which showed low sensitivity value.

In Radial and ulnar artery imaging diagnostic accuracy, specificity, sensitivity, PPV and NPV value of Doppler imaging was comparatively low when correlated with CT angiography, however both methods showed good agreement.

Earlier studies evaluating Doppler Imaging have shown varying degrees of sensitivity and specificity. We have observed a similar trend in our result as shown in table 10.

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Table 10:

Study	Number of patients	Sensitivity	Specificity
K Taneja et al [3]	19	90%	100%
d P. Bynoe et al. [13]	198	94-95 %	96-97%
y C. Berger et al. [14] ιinvasive methods	328	90-95 %	97-100 %
Eikelboom et al. [12]	82	Vertebral artery (80%) Subclavian artery (73%)	83% 91%

This study showed few advantages of Doppler over CT angiography. When extensive calcifications are present in the vessel, CT angiography is of questionable diagnostic value as it over stages the lesion. It can show the time duration of occlusion – as acute thrombus distends the vessels while chronic occlusion narrows the vessel calibre.

There is no radiation hazard with Doppler compared to CT angiography. Since no iodinated contrast is required, it is safely performed in patients with renal failure (such patients were excluded from the study in whom Doppler alone was done to evaluate the upper limb arteries).

Conclusion

This prospective study was designed to evaluate the role of Doppler and CT Angiography in upper limb vascular pathologies.

Doppler showed good diagnostic accuracy and correlation with CT angiography findings.

Among large arteries of arm highest sensitivity value was noted for brachial artery pathologies and lowest sensitivity was seen in subclavian arteries.

Specificity of Doppler imaging was almost in range of (97-100 %) for larger arteries of arm including subclavian, axillary, and brachial artery which showed good diagnostic role of Doppler in ruling out patient without significant hemodynamic abnormality. In ulnar and radial artery diagnostic performance of Doppler was slightly less when compared to those seen in arteries of arm. Overall diagnostic accuracy of Doppler imaging was above 90 percent in all vascular segments analysed and showed good specificity and negative predictive value which make it diagnostic tool in analysis of upper vascular pathologies.

CTA is the most common imaging modality in the evaluation of upper extremity acute trauma or acute occlusion. Its status as a first-line imaging modality for upper extremity is due to faster scan times, easy and round-the-clock availability, evaluation of concurrent osseous and soft tissue injuries, familiarity by surgeons as well as radiologists.

Doppler Imaging was found to have a high negative predictive value and could exclude a significant lesion, thus helping to avoid other costly diagnostic modalities in a mildly symptomatic patient. It could determine the nature and extent of arterial disease based on which treatment can be planned.

Doppler Imaging as an initial screening modality and has many advantages, portability, and the ability to do a bedside cost-effective examination. Vessel wall, lumen pathologies, and flow dynamics can be assessed with vascular ultrasound and Colour Doppler. Disadvantages of Doppler imaging include its operator dependence, inability to assess central vessels especially in obese patients or with extensive superficial injuries. Also, it can be time-consuming if there is any variant anatomy.

A combination of Doppler Imaging with MDCT angiography has better diagnostic accuracy.

Bibliography

1. Dave RB, Fleischmann D. Computed Tomography Angiography of the Upper Extremities. Radiol Clin North Am 2016;54:101-14. 10.1016/j.rcl.2015.08.008 [PubMed] [CrossRef] [Google Scholar].

ISSN: 0975-3583,0976-2833 VOL14, ISSUE 03, 2023

2. Bozlar U, Ogur T, Norton PT, et al. CT angiography of the upper extremity arterial system: Part 1-Anatomy, technique, and use in trauma patients. AJR Am J Roentgenol 2013;201:745-52. 10.2214/AJR.13.11207.
3. Taneja K, Jain R, Sawhney S, Rajani M. Occlusive arterial disease of the upper extremity: color Doppler as a screening technique and for assessment of distal circulation. Australas Radiol. 1996 Aug;40(3):226-9. DOI: 10.1111/j.1440-1673.1996.tb00391.x. PMID: 8826723.
4. Hellinger JC, Epelman M, Rubin GD. Upper extremity computed tomographic angiography: state of the art technique and applications in 2010. Radiol Clin North Am 2010;48:397-421, ix. 10.1016/j.rcl.2010.02.022.
5. Allan PL, Dubbins PA, Poznaik MA, McDicken WN. Clinical Doppler ultrasound. 2nd ed. Edinburgh: Churchill Livingstone, 2006:1-99.
6. Penelope Allisy – Roberts Jerry Williams, Farr"s Physics for medical imaging, second edition, 2008.
7. Carol M. Rumack, Stephanic R Wilson, J. William Charboneau. "Text book of diagnostic ultrasound".3rded.Elseveir Mosby publication;2005,p.993-1017.
8. Almutairi A, Sun Z, Poovathumkadavi A, et al. Dual Energy CT Angiography of Peripheral Arterial Disease: Feasibility of Using Lower Contrast Medium Volume. PLoS One 2015;10:e0139275. 10.1371/journal.pone.0139275 [PMC free article].
9. https://en.wikipedia.org/wiki/Cohen%27s_kappa.
10. Biau DJ, Jolles BM, Porcher R. P value and the theory of hypothesis testing: an explanation for new researchers. Clin Orthop Relat Res. 2010 Mar;468(3):885-92. doi: 10.1007/s11999-009-1164-4. PMID: 19921345; PMCID: PMC2816758.
11. Dargon PT, Moneta GL. Upper-Extremity Arterial Evaluations. Journal for Vascular Ultrasound. 2012;36(2):92-102. doi:10.1177/154431671203600202.
12. Ackerstaff RGA, Hoeneveld H, Slownowski JM, Moll FL. Eikelboom BC. Ultrasonic Duplex scanning in atherosclerotic disease of the innominate, subclavian and vertebral arteries. A comparative study with angiography. Ultrasound Med. Biol. 1984; 10: 409-18.
13. Anderson SW, Foster BR, Soto JA. Upper extremity CT angiography in penetrating trauma: use of 64-section multidetector CT. Radiology 2008; 249: 1064–1073.
14. Berger AC, Kleinert JM. Non-invasive vascular studies: Comparison with arteriography and surgical findings in the upper extremity. J. Hand Surg. 1992; 17A: 206-10.