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COMPARATIVE STUDY OF PERIPHERAL ARTERIAL SYSTEM BY DOPPLER AND CT ANGIOGRAPHY

Radiology

Dr. Dhaval Patel Third Year Resident, Department of Radiology, Sheth V.S.General Hospital & Smt. NHL Medical Collage, Ellisbridge, Ahmedabad-380006.

Dr. Avni Patel* MD, Assistant Professor, Department of Radiology, Sheth V.S.General Hospital & Smt. NHL Medical Collage, Ellisbridge, Ahmedabad-380006. *Corresponding Author

Dr. Dharita S Shah MD, DMRE, Head of Department, Department of Radiology, Sheth V.S.General Hospital & Smt. NHL Medical Collage, Ellisbridge, Ahmedabad-380006.

ABSTRACT

Introduction: Diseases of peripheral arterial system are one of common causes of limb pain.
Method to evaluate: We compare the efficacy of MDCTA and duplex ultrasound to diagnose peripheral arterial disease in lower limb and lower limb and to conclude find out CTA can be used as a screening tool.
Aim: The aim of our study was to compare findings and evaluate the efficiency of duplex Doppler and MDCT angiography in assessment of diseases of peripheral arterial system
Materials and Methods: The prospective study was conducted from July 2018 to December 2018. 50 patients are included in study. In all 50 patients the assessment of condition of each segment of vessel of diseased limb was analyzed with duplex Doppler and CT angiography.

KEYWORDS

Angiography;peripheral vascular disease

MATERIALS AND METHODS

The prospective study was conducted at our hospital from July 2018 to December 2018, including Both Outpatient and indoor patients with clinically suspected as PAD having with predetermined inclusion and exclusion criteria.

65 patients selected for this study, out of them, 11 were excluded basis of inclusion and exclusion criteria. 4 patients were needed emergency orthopedic surgery for complete occlusion based on Doppler examination, and they were excluded from the study. 50 patients (median age-47.5, min-3, max-80) (F: M=20:80) were evaluated initially with duplex Doppler . CT angiography for peripheral arterial system is performed within 2 days in all patients after necessary preparation.

PATIENTS:

Inclusion criteria:

To be eligible to participate in this study, the following criteria must have been met:

1. Patients could be male or female of any age group with clinically suspected PAD.
2. The patient had to be willing to comply with protocol design.

Exclusion criteria:

Patients were excluded from the study if they met any of the following criteria:

1. Unable to provide informed consent or parental consent in case of a minor
2 Any contraindication to CT scan.

There were 14 patients with upper limb complains (15 upper limbs) and 36 patients with lower limb complaints (72 lower limbs). One patient had unilateral above knee amputation and two patients, unilateral below knee amputation.

DUPLEX DOPPLER:

All 50 patients were evaluated with Samsung RS80A ultrasound system .Patient made to lie on USG couch in supine position for evaluation of iliac, femoral, tibial and dorsalis pedis arteries and popliteal artery evaluated in prone position. Upper limbs evaluated in supine position. With peripheral arterial system setup and linear array (6-12MHz) transducer, all vessels were evaluated in cross section and longitudinal sections in B Mode, Color flow imaging, Power mode and Pulse wave study. At times when iliac vessels could not be scanned, curvilinear (3-9MHz) transducer was used. Examination started from proximal to distal end of limbs.

CT ANGIOGRAPHY:

All 50 patients were examined with a 64–detector row CT scanner (SOMATOM Sensation 64; Siemens, Germany). All patients were placed in the supine position.

Those patients who had complaints in lower limbs positioned with their feet entering the gantry first.

After an initial scout image (tube voltage, 120 kV; tube current, 50 mAs) was obtained, the scanning range was planned for each individual to encompass the aortoiliac and lower extremity arteries. The mean scanning coverage was 1140 mm (range, 1032–1245 mm).

The delay time between the start of contrast material administration and the start of scanning was obtained for each patient individually by using a bolus tracking technique for optimal intraluminal contrast enhancement.

A nonionic iodinated contrast medium (Omnipaque 370mg iodine per milliliter) was administered from peripheral IV line via a 20–22-gauge needle. The volume of contrast medium 1 - 1.5 ml/kg was adjusted for the scanning length of each patient to establish a bolus duration that was equivalent to the scanning duration.

The contrast medium was administered with an automated injector at a flow rate of 4 mL/sec and followed by a 30-mL flush of saline administered at the same flow rate.

CT angiography was performed in all patients without any complications,Both axial source images ,3D ,MIP and VRT reconstructed images were analysed. Arterial segments were graded based on the criteria as below (table1)

TABLE 1

GRADE	CRITERIA
1	Normal patency
2	Moderate (≤50% diameter) stenosis
3	Focal severe (≥50% diameter) stenosis
4	Multiple severe(≥50% diameter) stenosis
5	Occlusion

Radiation dose on average for CT angiography varied from 6-16mSV.

OBSERVATION AND RESULTS

The present study included 50 patients (15 upper limbs, 72 lower limbs) on whom both duplex Doppler and CT angiography was done. 645 segments were studied with CT angiography. On Doppler USG,

only 619 segments were evaluated (23 iliac and 3 subclavian artery segments could not be evaluated). So, 619 segments and 9 grafts were evaluated with Doppler USG and CT angiography. Results from the study compared and analysed as mentioned below:

Assessment of Degree of Stenosis with Doppler USG and CT Angiography

TABLE 2

		CT ANGIOGRAPHY					
DOPPLER USG	Grade	1	2	3	4	5	Total
	1	324	4	4	4	3	339
	2	25	4	4	0	1	34
	3	1	0	7	8	5	21
	4	21	7	4	24	12	68
	5	22	9	3	20	103	157
	Total	393	24	22	56	124	619

Note.—Data are numbers of arterial segments depicted with both Doppler USG and CT angiography that were evaluated for stenosis.

Doppler versus CT Angiography

At consensus reading, 619 segments were identified on both Doppler and multi–detector row CT angiograms images. On CTA images, 226 diseased segments (36.51%) were identified: 24 with moderate stenosis, 22 with focal severe stenosis, 56 with diffuse severe stenoses, and 124 with occlusion. In 47 segments (25 of which were considered normal at CT angiography but were diagnosed as mildly stenosed at Doppler USG), the degree of stenosis was overestimated at Doppler USG by one grade; in 11 segments, the degree of stenosis was overestimated by two grades; by three grades in 30 segments and by four grades in 22 segments. The degree of stenosis was 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 (Table 3,4).

At consensus reading, the sensitivity, specificity, and accuracy of Doppler USG compared with CT angiography were 93.36%, 82.44%, and 86.42%, respectively. Comparing the results of Doppler USG with CT angiography, there was agreement in 74.64% (462 of the 619 segments).

If one considers the iliac segments as a separate group (Fig), the sensitivity of Doppler USG was 96.55%, with a specificity of 94.79% and accuracy of 95.2%; In the femoropopliteal tract (common, superficial femoral, and popliteal arteries) (Fig), the sensitivity of Doppler USG was 88.88%, the specificity was 92.95%, and the accuracy was 91.58%. In the distal tract (anterior and posterior tibial arteries, dorsalis pedis artery) (Fig), sensitivity, specificity, and accuracy were 96.15%, 61.53%, and 78.84%, respectively. For the upper limb vessels overall sensitivity, specificity and accuracy were 90.47%, 72.54%, and 77.77% respectively.

Relative comparison with previous studies reflects near similar sensitivity ratio between CT angiography and DSA, however there is lower specificity of Doppler with CTA in comparison with CTA and DSA. Findings are tabulated in (table4).

COMPARISON WITH PREVIOUS STUDIES: table 3

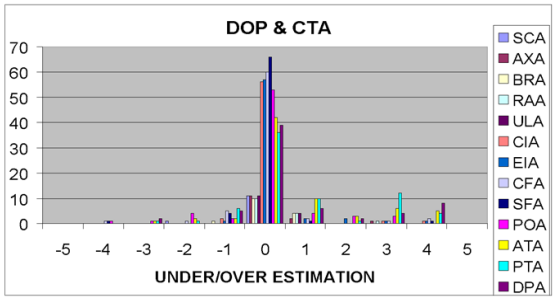
	Sensitivity %	Specificity %	Accuracy %	Agreement	Study	Done by
Doppler vs DSA	86(74-91)	97(94-99)	na		meta analysis	Koelemay et al(19)
	98	81		k=0.81	PSV considered	Sensier et al (23)
	na	na		k=0.81	CFI considered	McCarthy et al(21)
CTA vs DSA	96	97	na		n=39, 16 MDCT	Jurgen K et al(36)
	96	93	94	Na	n=50,4 MDCT	Carlo Catalano et al(28)
	92	93	na	Na	Meta analysis	Majanka H. Heijenbrok-Kal et al(38)
	na	na	na	78%	n=35, ?MDCT	B Tins et al(29)
	na	na	88-96%	Na	n=17, 16 MDCT	Thomas Schertler et al(31)
Doppler vs CTA	93	82	86	75%	n=50, 64 MDCT	Our Study

Na- not available; MDCT –multi detector computed tomography; CTA- CT angiography, DSA-Digital Subtraction Angiography.PSV-Peak systolic velocity, CFI-Color flow imaging, ?-not known.

DOPPLER UNDER/OVER ESTIMATION VERSUS CT ANGIOGRAPHY: Table 4

	On Doppler	UNDER ESTIMATION						OVER ESTIMATION				
S.NO	ARTERY	-5	-4	-3	-2	-1	0	+ 1	+ 2	+ 3	+ 4	+ 5
1	SCA	0	0	0	1	0	11	0	0	0	0	0
2	AXA	0	0	0	0	0	11	2	0	1	0	0
3	BRA	0	0	0	0	1	10	4	0	0	0	0
4	RAA	0	0	0	0	0	10	4	0	1	0	0
5	ULA	0	0	0	0	0	11	4	0	0	0	0
6	CIA	0	0	0	0	2	56	0	0	1	1	0
7	EIA	0	0	0	0	1	57	2	2	1	1	0
8	CFA	0	1	0	1	5	60	2	0	1	2	0
9	SFA	0	1	0	0	4	66	2	0	0	1	0
10	POA	0	1	1	4	2	53	4	3	3	0	0
11	ATA	0	0	1	2	2	42	11	3	6	5	0
12	PTA	0	0	1	1	6	36	10	1	12	4	0
13	DPA	0	0	2	0	5	39	6	2	4	8	0
	TOTAL	0	3	5	9	28	462	49	11	30	22	0

Note:--0-findings agreed -5,-4,-3,-2,-1 -numbers of grades of under grading;+1,+2,+3,+4,+5- numbers of grades of over estimation.



Note:--0-findings agreed -5,-4,-3,-2,-1 -numbers of grades of under grading;+1,+2,+3,+4,+5- numbers of grades of over estimation.

There was good agreement between Doppler USG and CT angiography of arteries of upper limbs and proximal outflow arteries of lower limb. Doppler overestimated stenosis grade in distal runoff vessels of lower limbs.

Assessment of Degree of Stenosis with Doppler USG and CT Angiography in Patients with History of Trauma

There were 6 patients with history of trauma (2 upper limbs, 8 lower limbs), 74 arterial segments; all segments were evaluated with Doppler

USG and CT angiography.

H/O TRAUMA DOP * CTA Crosstable					
		CTA			
		1	3	5	Total
DOPPLER	1	54	0	2	56
	2	2	0	0	2
	3	1	0	2	3
	4	2	3	1	6
	5	4	0	3	7
	Total	63	3	8	74

The sensitivity, specificity, and accuracy of Doppler USG compared with CT angiography in patients with history of trauma were 81.81%, 85.71%, and 85.13%, respectively. Comparing the results of Doppler USG with CT angiography, there was agreement in 77.02% (57 of the 74 segments).

Assessment of Arterial Grafts with Doppler USG and CT Angiography

There were 4 patients with arterial grafts evaluated for (all were lower limbs), 9 arterial grafts (8 occluded, 1 patent) were correctly identified with both Doppler USG and CT angiography, suggesting 100% agreement. However, further studies required.

Assessment of Arterial Aneurysms with Doppler USG and CT Angiography

There were 2 patients with history of trauma developed pseudoaneurysms from popliteal artery; both were identified correctly with Doppler USG and CT angiography

Basic demographic analysis showed most of the patients were within 45-65 yrs of age with mean 45.6 yrs, however previous studies by Ju¨rgen K. Willmann et al(66 yrs), Carlo Catalano et al (67yrs). Male sex had a significant association in lower limb vascular disease (external iliac artery p=0.01, common iliac artery p=0.007, superficial femoral artery p=0.021) and female sex had significant association in upper limb vascular disease (Brachial artery p=0.046, Radial artery p=0.035).

Severely calcified vessel segments are not optimally evaluated by CTA doppler can be useful for evaluation of such segments.

Results from correlation showed Doppler over estimates stenosis mainly in distal tibial vessels when compared to CT angiography. This is possibly due to difficulty to detect tandem lesions in multi segmental occlusive arterial disease or more proximal lesions causing reduced flow in distal vessels interpreted as severe narrowing by Duplex Doppler examination. However excellent sensitivity (93%) and good specificity (82%) shows duplex Doppler can be the first investigation with more negative predictive value (95.5%) in excluding disease of peripheral arterial disease.

Considering treatment part most of the patients with good distal flow demonstrated by CT angiography followed by conservative line of management (36%), short or long segmental vascular occlusion of large outflow artery are treated with grafting (18%). Diseases of distal vessels involving tibial arteries are managed with amputation (10%) depend up on clinical condition.

CONCLUSION AND RECOMMENDATIONS

Comparison of Doppler and CT angiography is of clinical significance in the present era of increased awareness about radiation and its hazards, availability, cost implications and betterment of life. Duplex Doppler, a non invasive modality using the principle of SONAR (Sound Navigation and Ranging) and DOPPLER is widely available, low cost, no radiation but limited by small window, operator dependency, inconsistent results and most time consuming for rapid analysis of vessels.

CT angiography after the recent rapid development it becomes the reality to scan the entire length of a lower limb in single shot, with optimized contrast injection. Excellent vascular anatomy depiction in the form of MIP, VRT and 3D source images is possible with dedicated workstations loaded with graphics.

Doppler USG and CT angiographic findings showed good correlation (74%) in most of the vessels, however Doppler overestimates in a significant percentage (18%). However there is excellent sensitivity (93%) specificity (82%) accuracy (85%) and negative predictive value (95%).

RECOMMENDATIONS:

1. Duplex Doppler can be used as the first investigation in patients presented with vascular symptoms in peripheral arterial system.
2. For multi segmental arterial disease, and distal vessel disease CT angiography scores over Duplex Doppler, hence it has to be preferred.
3. Doppler is equally sensitive and accurate with CT angiography in post operative vascular changes and grafts evaluation.
4. Duplex Doppler and CT angiography findings and correlation in patients with trauma causing vascular narrowing has no difference with stenosis caused by peripheral arterial disease. However duration for investigation has to be considered when revascularization procedures considered minimizing ischemic injury.

Abbreviation

MDCT- multidetector computed tomography
CTA- computed tomography angiography
PAD- peripheral arterial disease
CT - computed tomography
USG -ultra sonography
MSV- millisivert.

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