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ORIGINAL ARTICLE

ACCURACY OF DOPPLER ULTRASOUND COMPARED TO CAROTID CT ANGIOGRAPHY IN THE DIAGNOSIS OF CAROTID ARTERY STENOSIS

Chra Nejmaddin Abdula, Sameeah Abdulrahman Rashid

Department of Radiology, Rizgary Teaching Hospital- Kurdistan Higher Council of Medical Specialties, Hawler, Kurdistan region, Iraq

ABSTRACT

Background: Carotid artery stenosis incidence is increased globally with modernization of lifestyles. Screening of carotid artery stenosis is important in reducing co-morbidities and mortalities. To compare the clinical value of the Doppler ultrasound and carotid computerized tomography angiography for carotid artery stenosis.

Materials & Methods: Present study was comparative cross-sectional study implemented in Radiology department of Cardiac center in Erbil city in duration of ten months from 1st of January to 31st of October, 2023 on sample of 100 patients with cardiovascular diseases. The diagnosis of carotid artery stenosis was made using Doppler and CTA according to the international criteria.

Results: There was no significant differences between computerized tomography angiography findings and Doppler ultrasound techniques regarding the degree of carotid artery stenosis (p=0.06), while regarding individual vascular stenosis diagnosis there was a significant difference between Doppler US techniques and computerized tomography angiography findings (p=0.03).

Conclusion: The Doppler ultrasound examination is a valid non-invasive diagnostic tool of carotid artery stenosis.

KEY WORDS: Carotid artery stenosis; Doppler ultrasound; Computed Tomography Angiography.

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INTRODUCTION

The carotid artery stenosis defined as narrowing or blockage of carotid artery related to plaques, and increase risk of cerebrovascular diseases.[1] The carotid stenosis is categorized into mild, moderate and severe stenosis in regard to proportion of blockage. Prevalence of carotid artery stenosis was increased by modernization of lifestyle, physical inactivity and unhealthy diet.[2] In spite of low carotid stenosis prevalence, it is related to high death rates.[3] Estimated prevalence of severe carotid stenosis is about 0.1-3.1% and responsible for 0.7% of stoke risk.[4] The optimal approach in asymptomatic carotid artery stenosis (aCAS More than half of internal carotid artery stenosis results in about 19% mortality rate in about one to eight years follow up duration.[5] Main risk factors of carotid artery stenosis are advanced age, male gender, hypertension, smoking and alcohol consumption[6,7], medication, or endovascular surgery. The aim of this study was to assess the prevalence and risk factors for ACS and carotid plaque (CP Carotid artery stenosis is presented clinically from mild to severe symptoms, transient ischemic attack and stroke.[8]

Non-invasive Doppler ultrasonography is regarded as the imaging diagnostic modality of carotid artery stenosis in addition to computed tomography angiography, magnetic resonance angiography and invasive digital subtraction angiography which is considered as gold standard test of carotid stenosis.[9] Epidemiologically, Doppler ultrasonography is the best screening tool as it is reliable, low cost and available.[10] It was shown that 80% of patients underwent carotid artery revascularization following Doppler ultrasonography.[11] On other hand, invasive

Corresponding Author:

Dr. Chra Nejmaddin Abdula
Radiologist
Radiology Department, Rizgary Teaching Hospital
Kurdistan Higher Council of Medical Specialties,
Hawler, Kurdistan region, Iraq
E-mail: chranajmaddin@gmail.com

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digital subtraction angiography was applied for assessing the severity of carotid artery stenosis.[12] Standard ultrasound examination composed of grayscale B-mode imaging, color Doppler imaging and spectral Doppler velocity evaluation.[13,14] Spectral Doppler examination involved peak-systolic velocity (PSV) and end-diastolic velocity (EDV) measurements.[15] Although popularity and non-invasiveness of Doppler ultrasound examination in carotid artery stenosis, its validity is variable and dependable on skills of radiologist and equipment efficiency.[16] Second choice in diagnosis the carotid artery stenosis is the computerized tomography angiography (CTA) for its high accuracy. Final choice is the digital subtraction angiography which is regarded as invasive due to high radiation exposure dose. In some literature, the CTA has the higher sensitivity in detection of coronary artery stenosis[17], while other authors found low degree of concordance between CTA and ultrasonography in regard to stenosis diagnosis.[18] On other hand, some studies applied hemodynamic measurements for ultrasound examination in carotid artery stenosis found more valid results than those acquired by digital subtraction angiography.[19,20]

The aim of present study was to compare the clinical value of the Doppler ultrasound and carotid CTA for carotid artery stenosis.

MATERIALS AND METHODS

A comparative cross-sectional study implemented in Radiology department of Cardiac center in Erbil city in duration of ten months from 1st of January to 31st of October, 2023. All patients with known cardiovascular diseases presented for Radiology department were enrolled in the study. Adult patients with cardiovascular diseases were the inclusion criteria. Exclusion criteria were pregnant women, allergy to contrast material and patients refused to participate in the study.

The data was collected directly by researchers and filled in a prepared questionnaire that included basic characteristics (age, gender, body mass index, residence, ethnicity, socioeconomic class, cause of admission, disease duration and time interval between Doppler ultrasound and Carotid CTA), risk factors of cardiovascular diseases, co-morbidities of cardiovascular diseases.

Doppler ultrasonography findings of carotid arteries (stenosis and degree of stenosis) and computerized tomography angiography findings of carotid arteries (stenosis and degree of stenosis). The diagnosis of carotid artery stenosis was done by radiologist according to the international criteria. [7] The computerized tomography angiography was (ICT 256 multislice CT) and Ultarsound machine was HD11 XE Philips. The Doppler ultrasonography and computerized tomography angiography were implemented by radiologists in the hospital

Ethical issues were subjected to Ethical Committee of Kurdistan Board for Medical Specializations, approval of hospital authorities, oral informed consent and following up the patients. A sample of 100 patients with cardiovascular diseases was selected after eligibility to inclusion and exclusion criteria.

The patient's data were entered and analyzed statistically by statistical package of social sciences program-26 with suitable tests like chi square and fishers' exact tests for statistical relationships and two by two tables were used to measure validity findings. Significance level was ≤ 0.05.

RESULTS

In this study, 100 patients with cardiovascular diseases (CVDs) were enrolled with mean age (61.2 years); 32% of them were in age of 70 years and more. Male patients with CVDs were more than females (65% vs. 35%). Mean body mass index was (28.2 Kg/m^2); 33% of them were obese. Near half of patients with CVDs were rural residents and the Kurdish origin represented 63% of patients. The socioeconomic class of studied patients was categorized into low (26%), medium (47%) and high (27%). The causes of admission were preoperative assessment (38%), history of neurological deficit (26%) and combined causes (36%). Mean duration of illness was (1.9 week); 51% of patients had one week duration of illness. Mean time interval between Doppler US and carotid CTA was (1.4 day); 66% of patients had one day time interval.

The common risk factors of CVDs reported for patients were hypertension (83%), smoking (58%), diabetes mellitus (53%), hypercholesterolemia (50%) and obesity (41%). Common co-morbidities of patients with CVDs were myocardial infarction (66%), peripheral vascular disease (54%), chronic obstructive pulmonary disease (29%) and atrial fibrillation (27%).

As shown in Table 1; there were no significant differences between CTA findings and each of both Doppler ultrasound techniques (PSV & EDV) regarding degree of carotid artery stenosis ($p=0.06$), while regarding stenosis assessment showed a significant difference between each of Doppler US techniques from CTA findings ($p=0.03$).

As shown in Table 2; there was a highly significant difference in general stenosis findings between Doppler US by PSV and CTA ($p<0.001$) with validity findings of Doppler US by PSV in diagnosis of stenosis were (94.4% sensitivity, 89.7% specificity and 93% accuracy).

As shown in Table 3; there was a highly significant difference in general stenosis findings between Doppler US by EDV and CTA ($p<0.001$) with validity findings of Doppler US by EDV in diagnosis of stenosis were (78.9% sensitivity, 100% specificity and 85% accuracy).

Table 1: Carotid artery stenosis findings in regard to Doppler and CTA techniques.

Variable	Techniques						P
	Doppler by PSV		Doppler by EDV		CTA		
	No.	**%**	**No.**	**%**	**No.**	**%**	
Stenosis degree							
Normal	479	79.8	512	85.3	485	80.8	0.06 NS
50-69%	57	9.5	33	5.5	49	8.2	
70-99%	64	10.7	55	9.2	66	11.0	
Stenosis							
No stenosis	469	79.8	512	85.3	488	81.3	**0.03** S
Stenosis	121	20.2	88	14.7	112	18.7	

NS=Not significant, S=Significant.

Table 2: Carotid artery stenosis general findings in regard to Doppler by PSV and CTA techniques.

Doppler US by PSV	CTA				P
	Abnormal		Normal		
	No.	%	No.	%	
Abnormal	67	94.4	3	10.3	<0.001 S
Normal	4	5.6	26	89.7	
Sensitivity (94.4%), Specificity (89.7%), PPV (95.7%), NPV (86.7%), Accuracy (93%), S=Significant.					

Table 3: Carotid artery stenosis general findings in regard to Doppler by EDV and CTA techniques.

Doppler US by EDV	CTA				P
	Abnormal		Normal		
	No.	%	No.	%	
Abnormal	56	78.9	0	-	<0.001 S
Normal	15	21.1	29	100.0	
Sensitivity (78.9%), Specificity (100%), PPV (100%), NPV (65.9%), Accuracy (85%), S=Significant.					

DISCUSSION

Different imaging modalities are used in assessment of carotid artery stenosis. Selecting the best option is dependable on accuracy, cost-effectiveness, availability and safety of the imaging modality.[21]

This study found that common risk factors of CVDs reported for patients were hypertension (83%), smoking (58%), diabetes mellitus (53%), hypercholesterolemia (50%) and obesity (41%). These findings are close to results of recent retrospective cross-sectional study carried out in Kurdistan region/ Iraq which reported that hypertension, physical inactivity, diabetes mellitus, dyslipidemia and smoking are the main modifiable risk factors of cardiovascular diseases.[22] Our study found that common co-morbidities of patients with CVDs were myocardial infarction (66%), peripheral vascular disease (54%), chronic obstructive pulmonary disease (29%) and atrial fibrillation (27%). These findings are similar to results of different literatures.[23]

In present study, there were no significant differences between CTA findings and each of both Doppler ultrasound techniques (PSV & EDV) regarding degree of carotid artery stenosis. This finding coincides with results of recent substudy results of ANTIQUE study carried out in Czech which reported comparable results of PSV and EDV Doppler ultrasound measurements of carotid artery stenosis grading to computerized tomography angiography results. [24] In our study, the stenosis assessment showed significant differences between each of Doppler US techniques from CTA findings. This finding is similar to results of

previous study conducted in United Kingdom which revealed better validity findings of CTA in carotid artery stenosis than Doppler US measurements.[25]

The current study found that validity findings of Doppler US by PSV in diagnosis of stenosis as compared to CTA were (94.4% sensitivity, 89.7% specificity and 93% accuracy). These validity findings are close to results of recent Romanian study which reported sensitivity of (90.32%) and specificity of (93.75%) for Doppler US by PSV in diagnosis of carotid artery stenosis. [26] In our study, the validity findings of Doppler US by EDV in diagnosis of stenosis as compared to CTA were (78.9% sensitivity, 100% specificity and 85% accuracy). These findings are consistent with results of previous cohort study carried out in United States of America which reported higher sensitivity and accuracy of Doppler-US by PSV than Doppler-US by EDV, but with higher specificity of Doppler-US by EDV in diagnosis of carotid artery stenosis as compared to CTA.[27]

CONCLUSION

In conclusion, the Doppler ultrasound examination is a valid non-invasive diagnostic tool of carotid artery stenosis. The peak systolic velocity measurement of Doppler ultrasonography is highly sensitive tool in diagnosis of carotid artery stenosis, while the end-diastolic velocity measurement of Doppler ultrasonography is highly specific tool in diagnosis of carotid artery stenosis. This study recommended the use of Doppler ultrasonography in screening and diagnosis of carotid artery stenosis.

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CONFLICT OF INTEREST
Authors declare no conflict of interest.
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AUTHORS' CONTRIBUTION

The following authors have made substantial contributions to the manuscript as under:

Conception or Design:	CNA, SAR
Acquisition, Analysis or Interpretation of Data:	CNA, SAR
Manuscript Writing & Approval:	CNA, SAR

All the authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.