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Original Article

Assessment of Compatibility Between Cardiologists and Radiologists for Interpreting and Reporting Carotid Duplex Ultrasound Images

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ABSTRACT

Objective: This study aimed to evaluate the degree of agreement between cardiologists and radiologists for interpreting and reporting carotid duplex ultrasound images.

Methods: This prospective observational study was conducted in a cardiology outpatient clinic. For the sample size calculation, according to the kappa (2 raters) hypothesis testing method, assuming minimum acceptable kappa of 0.6, expected kappa of 0.8, a significance level of 0.05, power of 90%, and considering the expected dropout rate of 10% in the study, 116 patients were enrolled in the study. Demographic findings, personal histories, and laboratory test results were recorded. Carotid artery duplex ultrasonography was performed simultaneously and recorded by cardiologists and radiologists.

Results: This study included 116 patients who were treated in cardiology outpatient clinics for ischemic stroke, trans-ischemic attack, amaurosis fugax, dizziness, and severe headache complaints. While 50.9% of them are female, 49.1% were male. The age range of patients included in the study was a minimum of 32 years and a maximum of 71 years. Their mean age and deviation were 58.6 ± 10.1. Examination of their distribution according to chronic disease states revealed that 44.8% had hypertension, 58.6% were smokers, 36.2% had diabetes mellitus, 22.4% had dyslipidemia, 13.8% had ischemic heart disease, 29.3% had chronic obstructive pulmonary disease, and 16.4% had congestive heart failure. According to the criteria for carotid stenosis measurement of ≤50% and >50%, a significant and almost perfect agreement was found between the measurements by cardiologists and radiologists (Cohen's kappa coefficient $\kappa = 0.811$; $P < .0001$).

Conclusion: Diagnostic compatibility with radiologists was found to be near-perfect for carotid ultrasound evaluation.

Keywords: Carotid ultrasound, dizziness, handheld ultrasound, POCUS, stroke

INTRODUCTION

Carotid artery disease is observed in less than 3% of the general population.[1] It has a wide range of clinical presentations. It is considered one of the causes of the transient ischemic attack, ischemic stroke, sudden vision loss, dizziness, and severe headaches. It is common in patients with coronary and peripheral artery diseases.[2]

Cerebrovascular events due to carotid artery diseases are common in developed countries.[3] In clinical practice, imaging obtained using carotid duplex ultrasound (USG) is important in both the management of patients with acute stroke and the risk assessment of coronary artery disease or stroke.[4]

Treatment approaches are generally determined by cardiologists based on carotid ultrasonography results. The increase in the number of patients, together with the increasing elderly population, has further increased the workload of radiologists and sonographers.

The carotid arteries can be evaluated if the vascular imaging application is selected in echocardiography devices and a linear probe is used. If short-term training is provided to cardiologists who know the features of ultrasound devices, carotid ultrasound can be performed simultaneously by cardiologists along with echocardiography. Thus, patients are evaluated in a short time.

Our study aimed to determine whether the reports of carotid duplex USG performed and interpreted by cardiologists who have attended an accredited USG course are compatible with reports interpreted by radiologists.

METHODS

Study Design and Settings

This prospective observational study was conducted in 2022. The Ethics Commission of Gazi Yaşargil Training and Research Hospital authorized the study and waived the need for informed consent (Date: March 11, 2022, Decision no: 2022-45). This study was conducted as per the Declaration of Helsinki (2013).

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Selection of Participants

Patients over the age of 18 who provided written informed consent and were admitted to the cardiology outpatient clinics with ischemic stroke, trans-ischemic attack, amaurosis fugax, dizziness, and severe headache were included in the study. First, unstable patients were excluded. Patients with neck tumors, masses, diffuse goiters, recent neck trauma, or neck surgery were excluded from the study.

Study Protocol

This study included only patients who met the inclusion criteria. Demographic findings, history, and laboratory test results were recorded. Carotid duplex USG imaging was interpreted by cardiologists with at least 5 years of experience, attended an accredited ultrasound course, and achieved success. Before the study, the cardiologists received 2 hours of didactic and 2 hours of practical training. In a preliminary study, accurate measurements were obtained at least 30 times. Ultrasound images were transferred to a computer and interpreted by an experienced and independent radiologist. Figure 1 shows the flow diagram of the patients enrolled in the study. Images with poor quality were excluded from further analyses.

Imaging

The carotid artery imaging procedure was performed according to the recommendations of the American Society of Echocardiography and the European Society of Radiology.[5] The carotid arteries were evaluated in the transverse and sagittal planes (Figure 2). Intima-media thickness and arterial flow velocity were measured from the transverse plane following the recommendations of the American Society of Echocardiography.[6] The examinations were performed with a linear probe (L 12-3) using a Philips brand ultrasonography device (Model HD7 XE).

Pre-Study Power Analysis

For the sample size calculation, according to kappa (2 raters) hypothesis testing method, assuming minimum acceptable kappa of 0.6, expected kappa of 0.8, a significance level of 0.05, power of 90%, and considering the expected dropout rate of 10% in the study, 116 patients were enrolled in the study.

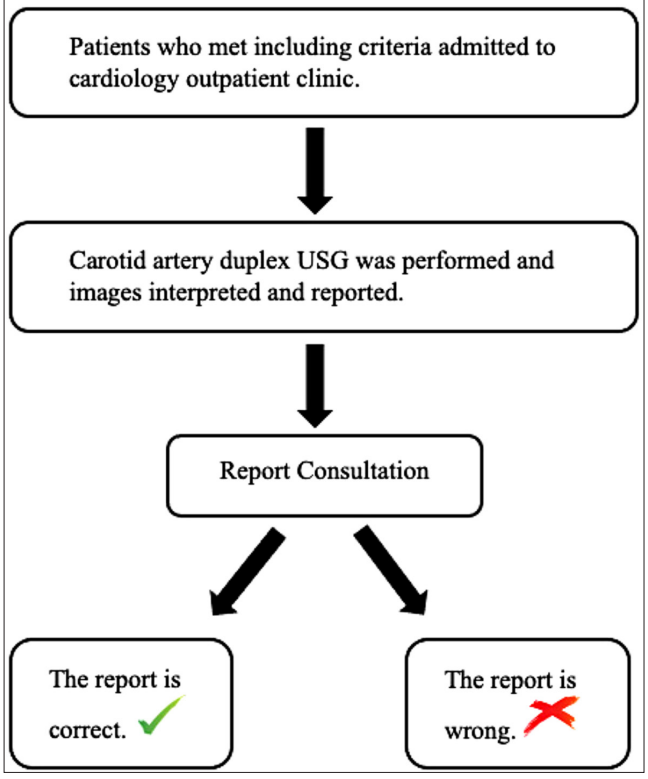
Statistical Analysis

The Statistical Package for the Social Sciences program was used to conduct all analyses (version 24.0, Chicago, Ill, USA). The mean and standard deviation and the minimum and maximum values of the features were used to establish categorical variables, such as frequency and percentage values. The compatibility of different doctors' nominal-level measurement results was evaluated using Cohen's kappa. The statistical significance level was set at $P < .05$.

Main Points

- Cardiologists can perform carotid duplex ultrasounds as part of the exam and speculate about the severity of coronary artery disease.
- Cardiologists can easily detect non-stroke subclinical carotid artery stenosis using carotid duplex ultrasound.
- Interventional cardiologists who perform carotid artery stenting can follow up the patients before and after the procedure with carotid ultrasound.

Figure 1. Study flow diagram.



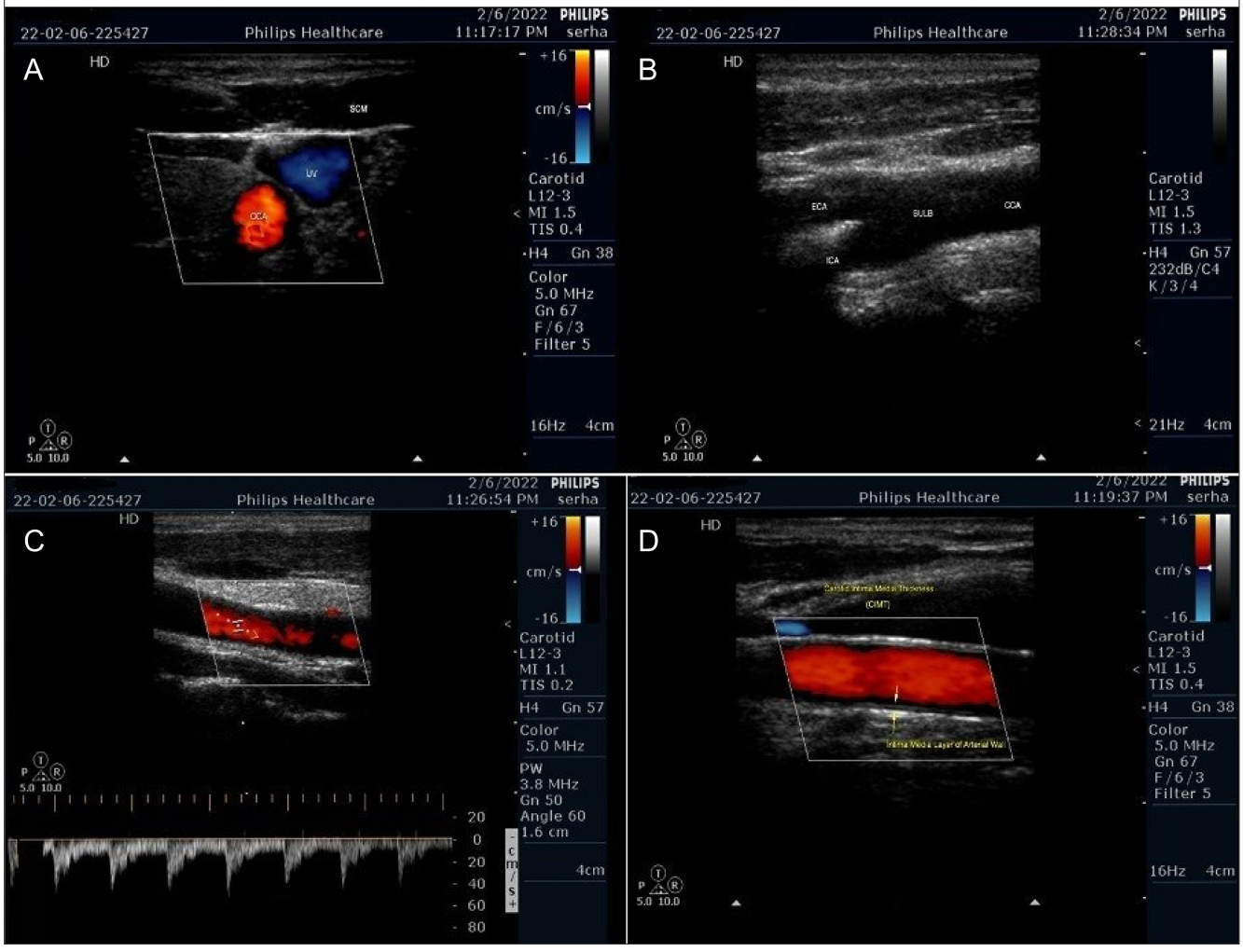
RESULTS

The socio-demographic and clinical history of the patients are shown in Table 1. While 50.8% of them were female, 49.2% were male. The age range of the patients included in the study was a minimum of 32 years and a maximum of 71. Their mean age and deviation were 58.6 ± 10.1. When their distribution according to chronic disease states was examined, 44.8% had hypertension (HT), 58.6% were smokers, 36.2% had diabetes mellitus (DM), 22.4% had dyslipidemia, 13.8% had ischemic heart disease (IHD), 29.3% had chronic obstructive pulmonary disease (COPD), and 16.4% had congestive heart failure (CHF) (Table 1). The mean and min-max measurements of vital signs and laboratory parameters of the patients are shown in Table 2. Table 3 shows physician compliance statistics between radiologists and cardiologists according to carotid artery stenosis measurements. As seen in Table 3, according to the criteria for carotid stenosis measurement of ≤50% and >50%, a significant and almost perfect agreement was found between the measurements of cardiologists and radiologists (Cohen's kappa coefficient (κ) = 0.811; $P < .0001$) (Table 3).

DISCUSSION

This study suggests that cardiologists who attended accredited carotid USG training can successfully interpret and report carotid artery USG images with short-term training (κ = 0.811; $P < .001$).

Figure 2. (A) Transverse Doppler image of common carotid artery (CCA) and internal jugular vein (İJV); (B) sagittal B-mode view of CCA, BULB, internal carotid artery (ICA), and external carotid artery (ECA); (C) normal carotid artery duplex; (D) image of carotid intima-media thickness (CIMT).



Carotid atherosclerosis is observed in 25% of men and women worldwide. While it is 1% between the ages of 50 and 60, this rate can reach 80% between the ages of 70 and 90. A recent study observed a higher rate of carotid atherosclerosis in women in Chinese society.[7,8] Smoking, high LDL levels, obesity, hypertension, diabetes, COPD, advanced age, and family history were identified as risk factors.[9-11] In our study, the average age of the patients was 58.6 ± 10.1 years, and the incidence in females was 50.8%. Smoking was observed in 58.6%, dyslipidemia in 22.4%, overweight in 19%, hypertension in 44.8%, diabetes in 36.2%, COPD in 29.3%, CHF in 16.4%, and CVD in 20.7% rates. Mean SBP was measured at 137.0 ± 6.75 mmHg, DBP was 87.9 ± 2.91 mmHG, heart rate was 91.3 ± 20.82 beats/min, and glucose was 158.2 ± 74.37 mg/dL. Other laboratory findings were normal.

Coronary heart disease, ischemic stroke, and peripheral vascular disease are caused by atherosclerosis. Cardiovascular diseases are closely related to each other.[12] Echocardiography is usually performed in patients who visit a cardiology outpatient clinic. A certain majority of the patients had HT, diabetes, and ischemic stroke. Carotid duplex ultrasound is sometimes required for optimal treatment of these patients. Atherosclerotic plaques in the carotid artery cause a significant part of ischemic strokes and are easily assessed using duplex ultrasonography.[13] Assessment of arterial stiffness and atherosclerotic load in the carotid arteries can provide crucial prognostic information regarding the risk of future cardiovascular events.[14] Carotis intima-media thickness (CIMT) is a biomarker used in the diagnosis of atherosclerosis.[15] It is an independent risk factor for stroke and myocardial infarction.[16,17] Therefore, it has been the focus of attention of both cardiologists and neurologists. Cardiologists with the skill of using an ultrasound device can determine the severity of cardiovascular disease by calculating the CIMT or by directly assessing the volume and morphology of the plaque.

Continuous advances in ultrasound technology have led to an era of widespread access to these devices. Point-of-care

Table 1. Socio–Demographical and Disease History Distribution

N = 116		$\bar{x} \pm SD$	Min–Max
Age		58.6 ± 10.1	32–71
N = 116		**n**	**%**
Gender	Female	59	50.9
	Male	57	49.1
Smoker	No	48	41.4
	Yes	68	58.6
HT	No	64	55.2
	Yes	52	44.8
DM	No	74	63.8
	Yes	42	36.2
IHD	No	100	86.2
	Yes	16	13.8
CVD	No	92	79.3
	Yes	24	20.7
COPD	No	82	70.7
	Yes	34	29.3
CHF	No	97	83.6
	Yes	19	16.4
DL	No	90	77.6
	Yes	26	22.4
BMI	Underweight	7	6
	Normal weight	87	75
	Overweight	22	19

Values are reported as n (%) for categorical variables. HT, hypertension; DM, diabetes mellitus; CVD, cerebrovascular disease; CHD, coronary heart disease; COPD, chronic obstructive pulmonary disease; CHF, congestive heart failure; BMI, body mass index; SD, standard deviation.

ultrasound and handheld ultrasound devices with dual probes, which are considered stethoscopes of the 21st century, have been adopted by many experts for diagnosis and treatment. It has been applied in areas such as the gastrointestinal, musculoskeletal, obstetric, respiratory, vascular, and cardiovascular systems.[18] Its use in intensive care units and emergency departments is becoming increasingly common.[19,20] Oluku et al.[21] achieved excellent results in bone fracture diagnostics. In comparison with radiologists, diagnostic compatibility with high sensitivity and specificity was observed. Ultrasound training has been integrated into the education of emergency physicians. Thus, the need for radiologists has gradually decreased.[22] Simultaneously, the workload of the radiologists was alleviated by decreasing the ultrasound orders.[23]

The performance of carotid ultrasonography and interpretation of the exam are delayed because of the heavy workload of the sonographers and radiologists. Cardiologists can evaluate the carotid arteries simultaneously with echocardiography instead of waiting for USG reports from radiologists to organize optimal

Table 2. Distribution of Vital Findings and Laboratory Measurements

N = 116	$\bar{x} \pm SD$	Min–Max
Systolic blood pressure (mmHg)	137.0 ± 6.75	130–159
Diastolic blood pressure (mmHg)	87.9 ± 2.91	85–98
Pulse (beat/min)	91.3 ± 20.82	60–170
Glucose (mg/dL)	158.2 ± 74.37	72–421
Creatinine (mg/dL)	1.04 ± 0.54	0.41–3.75
Na (mmol/L)	139.3 ± 3.32	128–147
K (mmol/L)	4.0 ± 0.46	3.0–5.19
HBG (g/dL)	13.4 ± 1.86	9.0–17.1
HCT (%)	40.5 ± 4.93	27.1– 50.2
AST (U/L)	28.2 ± 17.51	10–99
ALT (U/L)	18.6 ± 10.42	4–56
WBC ($10^3/mm^3$)	11.5 ± 3.15	6.09–18.34
PLT ($10^3/mm^3$)	268.8 ± 70.45	67–633

Values are reported as mean ± SD for continuous variables. Na, sodium; K, potassium; HBG, hemoglobin; HTC, hematocrit; ALT, alanine aminotransferase; AST, aspartate aminotransferase; WBC, white blood cells; PLT, platelets; INR, international normalized ratio; SD, standard deviation.

treatment. Thus, they can notice subclinical carotid artery stenosis without developing a stroke or having an idea of the severity of the concomitant coronary artery disease.[24,25] In addition, interventional cardiologists who perform carotid artery stenting will more easily perform pre- and post-procedure follow-ups of patients with carotid artery USG without the need for radiologists.[26,27]

Performing carotid ultrasonography and echocardiography will increase time and labor intensity. The lack of reimbursement for carotid ultrasonography may not convince cardiologists. Carotid artery duplex USG by cardiologists will bring a big change in favor of patients if suitable conditions are provided.[28] Stroke and coronary artery events can be reduced through early diagnosis and treatment.

The prominent limitation of this study was its single-center prospective nature with a small patient cohort. During the procedure, calcification obscuring a large-vessel segment in some patients requires another imaging modality. Carotid USG could

Table 3. Evaluation of Inter–Physician Compliance

N = 116		Cardiology		Cohen's Kappa	*P*
Carotis Artery Stenosis		**≤50%**	**>50%**		
Radiology	**≤50%**	78	6	***0.811****	***<.001****
	>50%	3	29		
	Total	81	35		

*Cohen's kappa coefficient is accepted at the $\kappa > 0.6$.
**$P < .05$.

not be performed in patients suspected or diagnosed with COVID-19 during the COVID-19 pandemic.

CONCLUSION

We found almost perfect compatibility between cardiologists and radiologists in interpreting and reporting of carotid duplex USG findings. We believe that this will be beneficial in decision-making for patients who present to the cardiology outpatient clinic with complaints of sudden numbness or weakness of the unilateral arm and leg, sudden loss of vision, dizziness, and severe headache. Cardiologists should have vascular ultrasound training as part of their education.

Ethics Committee Approval: Ethical committee approval was received from the Ethics Committee of Gazi Yaşargil Training and Research Hospital (Date: March 11, 2022, Decision no: 2022-45).

Informed Consent: Written informed consent was obtained from all participants who participated in this study.

Peer-review: Externally peer-reviewed.

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