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Research Paper

Quantitative Measurements of Blood Flow Parameters in Normal Internal Carotid Arteries with Color Doppler Ultrasonography and Vascular Stenosis Index of Stenotic Vessels

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ABSTRACT: *The aim of this study was to determine the values of peak systolic velocity (PSV), end-diastolic velocity (EDV), resistive index (RI), pulsatility index (PI), and blood flow in normal internal carotid arteries (ICA) together with the percentage of stenosis (for diameter and area), and vascular stenosis index (VSI) in stenotic ICA. Fifteen male and 16 female adult patients aged between 50-71 with atherosclerotic plaques with different thicknesses in the internal carotid arteries, and together with 20 normal adult males and 20 females aged between 25 and 45 years were included in this work. The values of PSV, EDV, RI, PI, and blood flow volume of normal ICA were measured. Stenosis percentages and VSI values were obtained in the narrowed vessels due to atherosclerotic plaques. All parameters were shown as mean ± SD. For the statistical analysis, Statistical Package for Social Sciences Version 15.0 (SPSS Inc., Chicago, IL, USA) software was used. We have shown the data together in Table 2,3 without discriminating between gender and right left side. The normal lumen diameter of the ICA, the diameter of the stenotic lumen, the percentage of stenosis for diameter, normal lumen area, stenotic lumen area, the percentage of stenosis for the area, and VSI values were shown in Table 3. We believe that this data can be useful in evaluating cerebral hemodynamics in healthy and sick people because we cannot find any study on VSI in ICA stenosis in the literature.*
KEYWORDS: *Internal carotid artery, atherosclerosis, Doppler ultrasonography, vascular stenosis index, blood flow*

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I. INTRODUCTION

Carotid artery system is a very important vascular system that feeds all organs and tissues in the head, especially the brain, with the vertebral artery system (1).

Cerebrovascular accident is one of the leading causes of death and persistent disease in humans. 80% of the ischemic processes occur due to atherosclerosis. The most common location of these plaques is in the carotid bulb and carotid bifurcation segment (1-3).

Society of Radiologists in Ultrasound (SRU) consensus developed recommendations for the diagnosis and stratification of internal carotid artery (ICA) stenosis in Table 1 (4).

A large number of studies demonstrates previously the results of blood flow parameters for normal internal carotid artery (ICA) in the literature. While there are few studies on the vasospasm index (VI) in the ICA spasm, in the literature we did not find any study on vascular stenosis index (VSI) in cases of stenosis due to atherosclerosis.

The aim of this study was to determine the values of peak systolic velocity (PSV), end-diastolic velocity (EDV), resistive index (RI), pulsatility index (PI), and blood flow in normal ICA together with the percentage of stenosis (for diameter and area), and VSI in stenotic ICA.

II. MATERIALS AND METHODS

Fifteen male and 16 female adult patients aged between 50-71 with atherosclerotic plaques with different thicknesses in the internal carotid arteries, and together with 20 normal adult males and 20 females aged between 25 and 45 years were included in this work.

In our study which was approved by the ethics committee was performed by an only radiologist within 6 months.

We used a high resolution, an ultrasound probe of 7 MHz with a linear array. Doppler angle was adjusted between 30-60 degrees in parallel to the vessel wall.

The preferred patient position for carotid ultrasonography (US) examination is in the head hyperextension when the body is in the supine position. The neck is in the neutral position or rotated between 30-45 degrees in the opposite direction of the evaluated side.

We started imaging the carotid arteries with Doppler US immediately above the clavicle and continued until 4-6 cm above the carotid bifurcation.

The values of PSV, EDV, RI, PI, and blood flow volume of normal ICA were measured (Figure 1). Stenosis percentages and VSI values were obtained in the narrowed vessels due to atherosclerotic plaques (Figure 2).

All parameters were shown as mean ± SD. For the statistical analysis, Statistical Package for Social Sciences Version 15.0 (SPSS Inc., Chicago, IL, USA) software was used. ANOVA test, Mann-Whitney U tests, and paired samples t-test were used to determine if there was a difference between the right and left vessels and genders. The differences of VSI values of ICA were analyzed. P values less than or equal to 0.05 were considered as statistically significant.

III. RESULTS

Significant differences in blood velocity and other flow parameters were not observed between the right and left ICA in either sex ($p > 0.05$). For these reasons, we have shown the results together in Table 2,3 without discriminating between gender and right left side.

In our study we found the data, ICA diameter was 7.99 ± 0.64 mm; PSV in ICA was 89.4 ± 10.4 cm/sec; EDV was 31.1 ± 8.2 cm/sec; RI was 1.28 ± 0.11; PI was 4.29 ± 0.69; ICA blood flow volume was 273.4 ± 30.7 mL/min in normal adults (Table 2).

The normal lumen diameter of the ICA, the diameter of the stenotic lumen, the percentage of stenosis for diameter, normal lumen area, stenotic lumen area, the percentage of stenosis for the area, and VSI values were shown in Table 3.

IV. DISCUSSION

Carotid arteries can be displayed at the higher resolution than in other modalities by ultrasound due to their superficial location, course and appropriate placement for unobstructed access to the sound wave. Doppler ultrasonography is a reliable, noninvasive imaging method used for the examination of carotid and vertebral arteries. In addition to morphological information, colored and spectral Doppler US can show real-time flow changes caused by vascular lesions (5-8).

Society of Radiologists in Ultrasound (SRU) consensus developed recommendations for the diagnosis and stratification of internal carotid artery (ICA) stenosis in Table 1 (4).

The estimation method of VSI is seen by measuring diameters in stenotic ICA in Figure 2. The proportion of ICA wall surface values (wall ring) to lumen surface values was accepted as VSI. The VSI is the ratio of area 1 (A1) to area 2 (A2). Low luminal surface values and high VSI was accepted as prominent vascular stenosis (9-11). This index was calculated with the following formula:

$VSI=(\pi R^2-\pi r^2)/\pi r^2=(R^2-r^2)/r^2$

While there are few studies on the VI in the ICA spasm, in the literature we did not find any study on VSI in cases of stenosis due to atherosclerosis (9-11). Therefore, we aimed that determining the values of PSV, EDV, RI, PI, and blood flow in normal ICA together with the percentage of stenosis (for diameter and area), and VSI in stenotic ICA.

Measurement of carotid artery intima-media thickness and evaluation of plaque structure are an important step of the method. The carotid intima-media thickness should normally be less than 0.8 mm. The fact that intima-media thickness exceeds 1.0 mm is considered to be definitive pathological (12-15).

In addition to atherosclerosis, Takayasu's disease and fibromuscular dysplasia are also possible causes of vascular constriction. Takayasu disease is a chronic, inflammatory main artery disease involving the aorta and its main branches. It is observed more frequently in women. Fibromuscular dysplasia is a disease of unknown origin that occurs in young women and holds the internal carotid artery most frequently after renal arteries (16,17).

The rates of stricture in ICA determine the treatment approach. Medical treatment is applied in patients with stenosis less than 50% symptomatic. It is investigated whether there is a progression with Doppler US every 6 months in addition to medical treatment in 50-69% stenosis. Carotid endarterectomy is performed in patients with symptomatic symptoms in the group of a near occlusion and stenosis of more than 70%. In the case of complete occlusion, there is no surgical possibility (2,3,7,16).

Yazıcı et al. have reached the same conclusion with us about no significant differences were noted between the genders regarding ICA blood flow volume (3). Also, in some publications, carotid and vertebral artery

diameters significantly increased with increasing age. A significant decrease was detected in the ICA blood velocity and blood flow volume with respect to aging (2,7,16).

No significant differences were noted in ICA diameter in between genders ($p > 0.05$). Significant differences in blood velocity and other flow parameters were not observed between the right and left ICA in either sex ($p > 0.05$). For these reasons, we have shown the results together in Table 2,3 without discriminating between gender and right left side.

The normal lumen diameter of the ICA, the diameter of the stenotic lumen, the percentage of stenosis for diameter, normal lumen area, stenotic lumen area, the percentage of stenosis of the area, and VSI values in stenotic vessels were shown in Table 3. However, Table 4 demonstrates previously published blood flow results for normal ICA in the literature (3,17,18).

V. CONCLUSION

A large number of studies demonstrates previously the results of blood flow parameters for normal ICA in the literature. While there are few studies on the VI in the ICA spasm, in the literature we did not find any study on VSI in cases of stenosis due to atherosclerosis.

Therefore, we believe that these data could prove to be useful in the evaluation of cerebral hemodynamics in healthy and sick people.

REFERENCES

[1]. Moneta GL, Edwards JM, Papanicolaou G, et al. Screening for asymptomatic internal carotid artery stenosis: duplex criteria for discriminating 60% to 99% stenosis. J Vasc Surg 1995; 21:989–994.
[2]. Yurdakul S, Aytekin S. Doppler ultrasound imaging of the carotid and vertebral arteries. Arch Turk Soc Cardiol 2011; 39(6):508-517. doi: 10.5543/tkda.2011.01588
[3]. Yazıcı B, Erdoğmuş B, Tugay A. Cerebral blood flow measurements of the extracranial carotid and vertebral arteries with Doppler ultrasonography in healthy adults. Diagn Interv Radiol 2005; 11:195-198.
[4]. Grant EG, Benson CB, Moneta GL, Alexandrov AV, Baker JB, et al. Carotid Artery Stenosis: Gray-Scale and Doppler US Diagnosis—Society of Radiologists in Ultrasound Consensus Conference. Radiology 2003; 229(2):340–346.
[5]. Bendick PJ, Glover JL. Vertebrobasilar insufficiency: evaluation by quantitative duplex flow measurements. A preliminary report. J Vasc Surg 1987; 5:594-600.
[6]. Scheel P, Ruge C, Petruch UR, Schoning M. Color duplex measurement of cerebral blood flow volume in healthy adults. Stroke 2000; 31:147-150.
[7]. Beebe HG, Salles-Cunha SX, Scissons RP, et al. Carotid arterial ultrasound scan imaging: A direct approach to stenosis measurement. J Vasc Surg 1999; 29:838–844.
[8]. Marcus CD, Ladam-Marcus VJ, Bigot JL, Clement C, Baehrel B, Menanteau BP. Carotid arterial stenosis: evaluation at CT angiography with the volume-rendering technique. Radiology 1999; 211:775–780.
[9]. Ozdemir NG, Aydın MD, Yolaş C, Kanat A. Levent A. Gundogdu C, Aydın N. Predictive Role of External Carotid Artery Vasospasm on Cerebral Ischemia After Subarachnoid Hemorrhage: Experimental Study. Turk Neurosurg 2017 ;27(6):874-883. doi: 10.5137/1019-5149.JTN.17206-16.2
[10]. Atalay C, Gundogdu B, Aydın MD. Vagal Ischemia Induced Lung Immune Component Infarct Following Subarachnoid Hemorrhage: An Experimental Study. Turk Neurosurg 2017 ;27(4):509-515. doi: 10.5137/1019-5149.JTN.16940-16.3
[11]. Dabus G, Nogueira RG: Current options for the management of aneurysmal subarachnoid hemorrhage-induced cerebral vasospasm: A comprehensive review of the literature. Interv Neurol 2013; 2:30-51.
[12]. Donis J, Graf M, Sluga E. Flow measurements in extracranial carotid arteries by means of duplex sonography. Results in normal subjects. Ultraschall Med 1988; 9:216-222.
[13]. Kanters SD, Algra A, van Leeuwen MS, Banga JD. Reproducibility of in vivo carotid intima-media thickness measurements: a review. Stroke 1997; 28: 665-671.
[14]. Polak JF, Funk LC, O'Leary DH. Inter-reader differences in common carotid artery intima-media thickness: implications for cardiovascular risk assessment and vascular age determination. J Ultrasound Med 2011; 30: 915-920.
[15]. Inaba Yoichi, Chen JA, Bergmann SR. Carotid plaque, compared with carotid intima-media thickness, more accurately predicts coronary artery disease events: a metaanalysis. Atherosclerosis 2012; 220: 128-133.
[16]. Martínez JMP, Santos JMG, Martínez MLP, Pastor AM. Carotid intima-media thickness and hemodynamic parameters: reproducibility of manual measurements with Doppler ultrasound. Med Ultrason 2015; 17(2):167-174. Doi: 10.11152/mu.2013.2066.172.ci-m
[17]. Schoning M, Walter J, Scheel P. Estimation of cerebral blood flow through color duplex sonography of the carotid and vertebral arteries in healthy adults. Stroke 1994; 25:17-22.
[18]. Dorfler P, Puls I, Schliesser M, Maurer M, Becker G. Measurement of cerebral blood flow volume by extracranial sonography. J Cereb Blood Flow Metab 2000; 20:269-271.

Table-1: Society of Radiologists in Ultrasound (SRU) consensus developed recommendations for the diagnosis and stratification of ICA stenosis.

ICA stenosis	**PSV of ICA (cm/sec)**	**EDV of ICA (cm/sec)**	**ICA/CCA PSV ratio**
Normal	<125	<40	<2,0
<50 (plaque or intimal thickening is visible sonographically)	<125	<40	<2,0
50-69	125-230	40-100	2,0-4,0
≥70 (less than near occlusion)	>230	>100	>4,0
Near occlusion (velocities may be high, low, or undetectable)	variable	variable	variable
Complete occlusion	no flow	no flow	no flow

PSV: peak systolic velocity, EDV: end-diastolic velocity, ICA: internal carotid artery, CCA: common carotid artery

Table-2: Data for blood velocity (PSV, EDV), resistive index (RI), pulsatility index (PI), and blood flow of normal internal carotid artery (ICA) in normal adults.

FLOW PARAMETERS	**MEAN**	**± SD**
Peak Systolic Velocity (PSV): cm/sec	89,4	10,4
End-Diastolic Velocity (EDV): cm/sec	31,1	8,2
Resistive Index (RI)	1,28	,11
Pulsatility Index (PI)	4,29	,69
Blood Flow Volume (mL/min)	273,4	30,7

Table-3: The percentage of stenosis and vascular stenosis index (VSI) values of stenotic internal carotid artery (ICA).

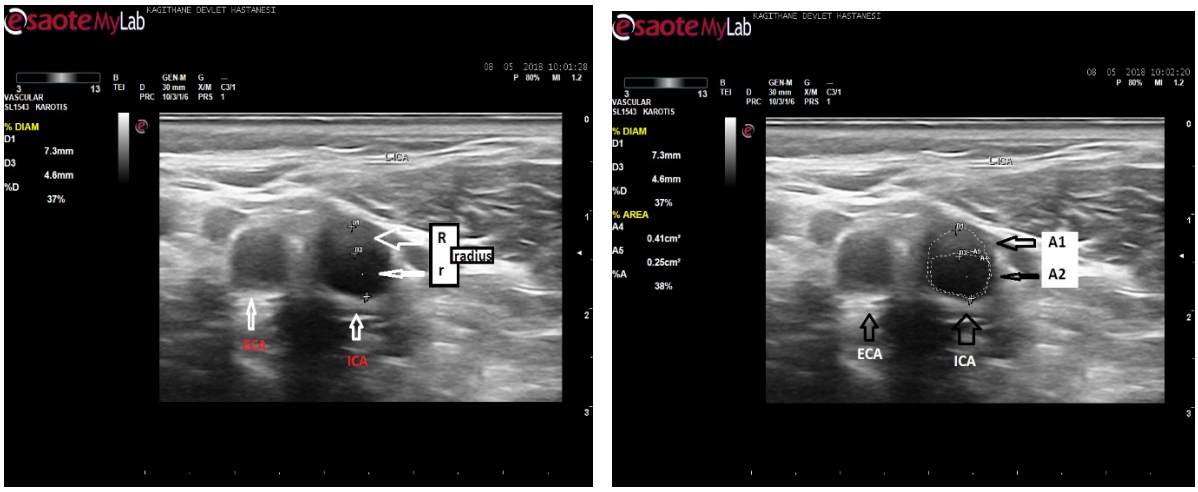
	MEAN	**± SD**
The normal lumen diameter of the internal carotid artery (ICA)	7,99	,64
Diameter of the stenotic lumen	5,06	,43
DIAMETER - The **percentage** of **stenosis**	37,00	3,01
Normal lumen area (cm^2)	,50	,086
Stenotic lumen area (cm^2)	,26	,01
AREA - The **percentage** of **stenosis**	47,71	9,09
VSI=$(R^2-r^2)/r^2$	1,50	,022

Table-4: It was demonstrated previously published blood flow results for normal internal carotid artery (ICA).

Authors	**MEAN**	**± SD**
Schoning et al.	265	26
Dorfler et al.	238	45
Yazıcı et al.	231	59
This study	273	31

a. b.

Figure-1: Doppler ultrasonography measurement of the vessel diameter, peak-systolic velocity (PSV), end-diastolic velocity (EDV), resistive index (RI), pulsatility index (PI) (a), and blood flow in the internal carotid artery (ICA) (b).



a. b.

Figure-2: The value estimation method of vascular stenosis index (VSI) is seen by measuring diameters in stenotic internal carotid artery (ICA) (a). The proportion of ICA wall surface values (wall ring) to lumen surface values was accepted as VSI. The VSI is the ratio of the Area 1 (A1) to Area 2 (A2) (b).

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