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Is there a relationship between vascular flow parameters of carotid arterial system and trigeminal neuralgia?

Karotis arteryel sistem vasküler akım parametreleri ile trigeminal nevralji arasında ilişki var mıdır?

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Abstract

Aim: To investigate the flow velocity values and resistance parameters determined by carotid artery doppler ultrasonography (DUS) examination in patients with trigeminal neuralgia (TN).

Materials and Methods: 79 patients diagnosed with TN and who underwent carotid DUS were included in the study. Spectral examination results were recorded for the TN side and the healthy side.

Results: Peak systolic velocity (PSV) internal carotid artery (ICA), resistive index (RI) (ICA) and PSV (ICA)/PSV external carotid (ECA) values in patients were relatively higher in arterial structures on the TN clinical side compared to the healthy side. RI (ICA)/RI common carotid artery (CCA) value was also high in arterial structures on the TN diagnosed side.

Conclusion: It was shown that especially ICA flow velocity and vascular resistance parameters increased in the carotid arterial system on the TN side. These findings indicate that flow parameters in the carotid artery system may also be effective in TN pathophysiology.

Keywords: Trigeminal neuralgia; Carotid artery; Doppler ultrasound imaging.

Öz

Amaç: Trigeminal nevralji (TN) hastalarında karotis arter doppler ultrasonografi (DUS) incelemesi ile saptanan akım hızı değerleri ve direnç parametrelerini araştırmak.

Gereç ve Yöntem: TN tanısı almış 79 hastaya karotis DUS yapıldı. Spektral inceleme sonuçları TN'li bölge ve sağlam bölge için kaydedildi.

Bulgular: Hastalarda peak sistolik hız (PSV) internal karotis arter (ICA), rezitif indeks (RI) (ICA) ve PSV (ICA)/PSV eksternal karotis (ECA) değerleri TN kliniği olan taraftaki arteriyel yapılarda sağlıklı tarafa göre nispeten yüksekti. RI (ICA)/RI common carotis arter (CCA) değeri de TN tanısı olan taraftaki arteriyel yapılarda yüksekti.

Sonuç: Özellikle ICA akım hızı ve vasküler direnç parametrelerinin TN tarafında karotis arteriyel sistemde arttığı gösterildi. Bu bulgular karotid arter sistemindeki akış parametrelerinin TN patofizyolojisinde etkili olabileceğini göstermektedir.

Anahtar Kelimeler: Trigeminal nevralji; Karotis arteri; Doppler ultrason görüntüleme.

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Introduction

Trigeminal neuralgia (TN) is a unilateral facial pain originating from one or more divisions of the trigeminal nerve (fifth cranial nerve-CN V).[1] The pain is unilateral, severe, brief, paroxysmal, typically described as electrical or sharp, and is "triggered" by touching the face, talking, eating, and drinking.[2] Trigeminal neuralgia affects 4-13/100000 people every year.

Women are more affected than men; presenting a 3:2 ratio of female-to-male. TN is commonly diagnosed in the elderly population, mostly occurring after age 50.[1]

The International Headache Society divides TN into three subtypes in the third edition of the International Classification of Headache Disorders; classical, secondary, and idiopathic.[3] The diagnosis of TN is made clinically according to the diagnostic criteria, but imaging is required to identify its subtypes.[4] Classical trigeminal neuralgia is proceed from neurovascular compression that causes morphological changes in the trigeminal nerve root demonstrated by imaging or surgery. Secondary trigeminal neuralgia is associated with demyelination of the trigeminal nerve root. Idiopathic trigeminal neuralgia is defined as TN with neither electrophysiological tests nor magnetic resonance imaging (MRI) showing significant abnormalities.[3] Its pathologies think about from neuronal voltage-gated ion channel gain-of-function mutations and non-specific brainstem lesions.[5]

TN is a unilateral facial pain, bilateral cases are rare.[6] The case series show that right side pain is more frequent.[7] Pain is described according to the three branches of the trigeminal nerve: the ophthalmic (V1), maxillary (V2), and mandibular (V3) nerves[2]. V2 and V3 are the most commonly affected together, V1 branch affected solely is rarest.[6] Treatment alternatives include some medications, surgery, and complementary therapies.[2]

The most common diagnostic tool used in the evaluation of patients with trigeminal neuralgia is MRI.[7,8] MRI is particularly useful in the detection of TN secondary to neurological pathologies such as multiple sclerosis. In addition, imaging of the nerve root level detects neurovascular pathologies at this level and findings such as compression of the nerve root by vascular structures. In this way, long-term results can be obtained with simple neurovascular compression surgery.[9] MRI imaging provides information not only in the detection of etiological problems but also about morphological changes in the trigeminal nerve root. It helps in the detection of features such as increased signal in T2A series in the nerve root, hypertrophy in the nerve root/atrophy findings in long-term cases.[9] It can also provide information about the success of treatment in these patients. It has been stated in various publications that the success rate is low in patients with atrophic and deformed nerve structures.[10,11]

The carotid arterial system consists of the main vascular structures that provide vascularization of the central nervous system. Pathologies that may develop in these vascular structures, such as possible stenosis, aneurysm or steal phenomenon, cause pathologies in a spectrum ranging from simple headache and dizziness symptoms to ischemic cerebrovascular events. Carotid ultrasonographic imaging is a non-invasive, cheap and easily applicable examination used to examine atherosclerotic changes in the carotid arteries and to evaluate the flow velocity patterns of these vascular structures. The data obtained are quantitative and the results are mostly consistent with the examination findings of the patients.[12,13] The presence of findings such as gliotic changes in the brain caused by changes in the flow patterns in the carotid artery system and associated symptoms such as headache and dizziness have revealed the necessity of investigating whether the flow parameters in the carotid arterial system play a role in the pathophysiology of TN originating from the cranial nerve roots. Considering that TN can develop secondary to possible vascular compression in the vicinity of the nerve root, it is thought that it may be affected by arterial flow and pressure changes in the carotid arterial system. The aim of this study is to investigate the flow velocity values and

resistance parameters detected by carotid arterial doppler ultrasonography (DUS) examination in patients with trigeminal neuralgia (TN).

Materials and Methods

Type of the study

This is a cross-sectional study.

The sample size of the study

The study was conducted using the anamnesis and imaging results of 79 patients diagnosed with TN registered in our hospital's database who applied to our radiology outpatient clinic affiliated with a tertiary center between 2019-2022. Ethics committee approval for this study was obtained from the regional hospital ethics committee Medicine Non-invasive Clinical Research Ethics Committee (Date: 16/02/2022, Decision No: 2022/2-4). All procedures were utilized in accordance with the Declaration of Helsinki. Informed consent form was obtained from all patients.

In patients diagnosed with TN, carotid DUS and brain MRI are routinely requested by neurology during the diagnosis phase to rule out possible vascular causes and space-occupying lesions or vascular compression in the brain. Carotid vertebral doppler ultrasonographic examination was performed with using a Samsung RS85 Prestige ultrasonography device (Figure 1). Among these patients in our system, patients with vascular compression findings in MRI and patients with atherosclerotic changes leading to stenosis in carotid DUS imaging findings, plaque formations, and hypoplasia in the vertebral arteries (vertebral artery diameter < 2 mm) were excluded from the study. In the patient diagnosed with trigeminal neuralgia, measurements were made separately for the right and left carotid arterial systems and noted.

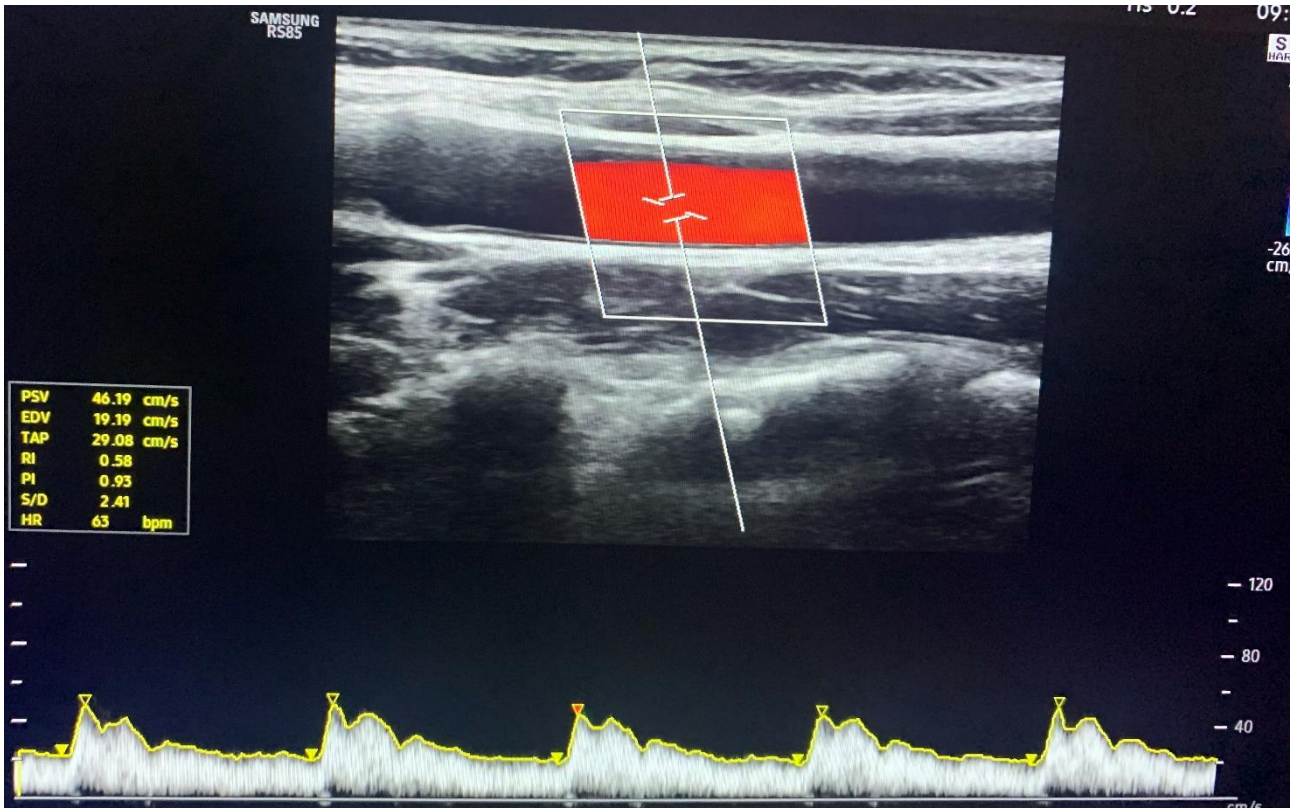

Figure 1. Internal carotid artery power doppler ultrasonography examination and spectral imaging

Carotid DUS was performed as standard with a 12 MHz probe using B-mode grayscale imaging, color flow doppler in transverse and longitudinal planes, and spectral doppler to evaluate flow parameters. First, the intimal level and possible plaque presence were excluded by evaluating from the visible segment of the common carotid artery (CCA) to the level of the internal carotid artery (ICA) and external carotid artery (ECA) bifurcation and to the furthest point that could be examined. Flow directions were examined

with color doppler. Flow patterns were evaluated with spectral examination by placing the spectrum at an angle of 30-60 degrees. When the images were completely filled with color, Peak Systolic Velocity (PSV), End Diastolic Velocity (EDV), Resitive Index (RI), Pulsatility Index (PI) values were measured by the automatic software of the device and noted for both sides. PSV (ICA)/PSV (CCA) value was obtained by dividing the ICA PSV value to the CCA PSV value for both sides. Again, ICA RI value was dividing the CCA RI value to obtain ICA (RI)/CCA (RI) values. These values were included in the patient group for the side with trigeminal neuralgia and in the control group for the healthy side without trigeminal neuralgia.

Data collection tools

The demographic data of all patients were recorded in the hospital database. The patient's age, clinical and anamnesis information, and imaging features of the ultrasonography reports were noted from this database.

Data analysis

Statistical analysis was performed using the SPSS 2.2 (IBM, Armonk, NY, USA) program. The Mann-Whitney U test was used for independent binary groups that did not fit the normal distribution. Categorical variables presented as ratio, continuous variables were presented as median (min-max) value and standart deviation (SD). A $p<0.05$ value was considered significant.

Ethics committee approval

Ethics committee approval for this study was obtained from the regional hospital ethics committee Medicine Non-invasive Clinical Research Ethics Committee (Date: 16/02/2022, Decision No: 2022/2-4). All procedures were utilized in accordance with the Declaration of Helsinki.

Results

The mean age of the patients was 48.05±10.43 (min: 21 max: 73). Fifty one (64.6%) of the patients had right-sided pathology, 28 (35.4%) had left-sided pathology. While 25 (31.7%) of the patients were within the first year of the disease, 34 (43%) had been diagnosed for periods ranging from 1 to 3 years. 20 (25.3%) patients had been suffering from the disease for more than 3 years (Table 1).

Table 1. Demographic characteristics of trigeminal neuralgia patients

	n/%
Age	48.05±10.43 (Min: 27- Max: 63)
Gender (W/M)	45/34 (%57/%43)
Half of the face with TN findings (R/L)	51/28 (%64.6/%35.4)
Disease history	
<1 year	25 (%31.7)
1-3 year	34 (%43)
>3 year	20 (%25.3)

n: number min: minimum, max: maximum

PSV (ICA), RI (ICA) and PSV (ICA)/PSV (ECA) values in the patients were relatively higher in the arterial structures on the side with TN clinic compared to the healthy side. In addition, RI (ICA)/RI (CCA) value was also high in the arterial structures on the side with TN diagnosis. There is no significant difference between the RI (CCA) and PSV (CCA) values. (Table 2).

Table 2. Parameters of carotid doppler ultrasonography imaging of the patient and healthy side in patients with trigeminal neuralgia

	Trigeminal Neuralgia (+)	**Trigeminal Neuralgia (-)**	***p* value**
PSV (ICA)	61.49±14.2	53.39±21.62	**0.004**
PSV(CCA)	54.26±17.05	51.07±23.41	**0.41**
PSV (ICA/CCA)	1.23±0.07	1.02±0.03	**0.001**
RI(ICA)	0.51±0.07	0.44±0.02	**0.049**
RI(CCA)	0.62±0.13	0.63±0.17	**0.81**
RI(ICA/CCA)	0.81±0.09	0.76±0.11	**0.031**

Peak Sistolik Velocity (PSV), End Diastolic Velocity (EDV), Resitive Index (RI)

Discussion

According to the results of this study examining the changes in carotid DUS examination parameters on the diseased side in patients with TN, a significant increase was observed in the resistance parameters and flow velocities of the CCA and ICA, the main vascular structures of the carotid artery system.

In previous studies, vascular structures are evaluated with T2-weighted sequences using MRI-specific imaging methods in the detection of findings secondary to compression in neurovascular structures. Possible aberrant vascular structures in the trigeminal nerve tract, compressions secondary to aneurysms or ectasia in vascular structures can be easily visualized with three-dimensional angiography images created.[14-16] At these levels, T2-weighted signal increase due to nerve edema secondary to compression in the trigeminal nerve root and nerve root diameter increase can be evaluated. Moreover, changes secondary to atrophy in nerve roots secondary to long-term compression symptoms at this level can also be evaluated. It has been stated in some studies that microdamage can be visualized with new methods such as diffusion tensor imaging (DTI).[14,17]. However, MRI is an expensive and difficult to access imaging method and DTI imaging is not performed in most centers. In addition, there are many patients diagnosed with TN who have normal MRI imaging findings. In such patients, the pathophysiology of TN cannot be understood and the patient tries to benefit from symptomatic treatments. The carotid arterial system is a vascular structure located in the proximal and it is known that the flow patterns at this level change before intracranial pathologies develop and cause gliotic changes in microdamages in the brain.

The vascular structures examined in MRI are ICA segments and branches from the main carotid arterial system. It has been stated that the presence of ectasias, aneurysms or rotations in the traces of these vascular structures may lead to TN. It is known that stenoses at the CCA and ICA levels cause significant differences in flow and pressure values, and the risk of ischemic stroke increases in patients with increased intimal media thickness and stenotic findings in the carotid artery.[18,19] This was the reason why patients with stenosis in the carotid artery system were excluded from the study in our study. Although plaque formations and stenosis develop in the carotid artery system and the plaque diameter and vascular diameter are measured and evaluated, the most important point determining the degree of stenosis is the changes in flow velocity parameters. The increase in flow velocity causes an increase in vascular pressure, turbulent flow at this level and changes in blood fluidity. It first causes changes in the microvascular level and then in the macrovascular structures, causing brain ischemia. At this point, we thought that carotid DUS results could be effective in determining whether the increase and/or decrease in carotid flow parameters would have an effect at the microvascular level, even though there was no vascular compression finding in TN patients.

Parameters obtained with carotid artery DUS such as maximum systolic velocity (Vmax), minimum diastolic velocity (Vmin), mean velocity and pulsatility index (PI) are used to measure hemodynamic parameters.[20] No previous study has investigated the values of carotid artery doppler parameters in TN patients. The aim of this study is to determine whether carotid doppler hemodynamic parameters will differ on the TN side compared to the healthy side. In our study, the significant increase in the flow velocity values and RI values in arterial structures on the TN clinical side may suggest that the increase in the flow pattern may be effective in the etiology of TN.

Limitations

This study has some limitations. First and foremost, ultrasonographic examination can be affected by factors such as the experience of the radiologist and the imaging features of the device. Therefore, there may be bias in the study results. Secondly, in this study, data were obtained with the results recorded in the system in a limited number of patients and no control examination was performed on the patients. Finally, diabetes mellitus, coronary artery changes in flow parameters in patients with diseases such as may have affected the study results. Patients with stenosis findings on carotid artery DUS were excluded from the study to prevent this situation.

Conclusion

TN etiology and treatment methods are still being investigated and are an important pathology affecting the quality of life of patients. Although there are studies

investigating the effects of vascular compression on trigeminal neuralgia, there is no study in the literature investigating its relationship with vascular nutrition. The fact that the change in carotid DUS flow parameters was significant in TN patients suggests that vascular nutrition may also play a role in the pathophysiology of this disease. In this study, it was shown that especially the ICA flow velocity and vascular resistance parameters increased in the carotid arterial system on the TN side. These findings indicate that the flow parameters in the carotid arterial system may also be effective in pathophysiology of TN. Evaluation of carotid arterial system flow patterns in patients suffering from TN may be a new method for measures to be taken against possible pressure and flow rate increases in patients, in attack treatments or in reducing the frequency of attacks. However, comprehensive studies are required in larger patient populations.

Ethics Committee Approval

Ethics committee approval for this study was obtained from the regional hospital ethics committee Medicine Non-invasive Clinical Research Ethics Committee (Date: 16/02/2022, Decision No: 2022/2-4). All procedures were utilized in accordance with the Declaration of Helsinki.

Informed Consent

Informed consent form was obtained from all patients.

Author Contributions

E.K: Data collection and processing, analysis, materials, writing and literature review. M.K. Design, data collection, literature review and writing.

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Conflict of Interest

There is no conflict of interest to declare.

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Peer-review

Externally peer-reviewed.

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