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Doppler ultrasonography can be useful to determine the etiology of idiopathic sudden sensorineural hearing loss

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ABSTRACT

Objective: This study aims to evaluate clinical features of both carotid and vertebral arteries in the idiopathic sudden sensorineural hearing loss (ISSNHL) patients and healthy individuals to contribute additional knowledge on vascular compromise theory.

Methods: This study was designed as a retrospective case control study in a tertiary referral center. 55 patients for ISSNHL and 35 healthy participants (70 ears) are involved to the study. All of the patients were evaluated for the systemic disorders and excluded other possible causes (autoimmune diseases, acoustic schwannoma, drug toxicity, etc) of ISSNHL. The carotid and vertebral arteries were assessed with Doppler USG; in fact, the vascular diameter (VD), intima media thickness (IMT), peak systolic velocity (PSV), blood flow (BF) and resistive index (RI) were evaluated. Related parameters were compared with the control groups.

Results: In carotid artery system; common carotid artery intima-media thickness (CC-IMT) ($p < 0.001$), and internal carotid artery intima-media thickness (IC-IMT) ($p < 0.001$) were found significantly increased. Otherwise; PSV, VD and BF were not differed significantly. In vertebral artery system; VD (<0.001), PSV (<0.002) and BF (<0.001) were decreased significantly but vertebral artery RI was statistically increased (<0.001).

Conclusion: In our study, we found the carotid artery thickening on vascular wall. We also demonstrate the vascular compromise on vertebral arteries. The Doppler USG may lead to determine the etiology of ISSNHL and further investigations are needed to define the exact results.

Level of evidence: III b

1. Introduction

Idiopathic sudden sensorineural hearing loss (ISSNHL) is sensorineural hearing loss of more than 30 dB in 3 adjacent pure tone frequencies in less than 3 days and reported incidence is from 5 to 20 per 100,000 individuals [1]. Various etiologies (viral infection, immune mediated mechanisms, intracochlear membrane rupture, vascular compromise, perilymph fistula etc) are suspended for this dilemma; however, none of the existing theories clarify the exact reason [2].

The vascular stenosis is suspected as the one of the main causes in the etiology. Inner-ear structures require high energy for their metabolism and constant blood flow is vital to maintain the metabolism. The inner ear structures are supplied by internal auditory artery, which is terminal branch of anterior inferior cerebellar artery (AICA) and proximal basilar artery. In fact;

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these terminal branches have poor collateral circulation and inner ear is vulnerable to ischemia because of the vascular anatomy.

Compromised vascular flow may result ISSNHL and various mechanisms were discussed in the literature. Aimoni et al. reported the association of atherosclerosis risks (diabetes mellitus, hypercholesterolemia) in the patients of ISSNHL [3]. Pirodda et al. suspected hypotension and this blood tension decrease the blood flow and cause ISSNHL [4]. Mösges et al. related the hyper viscosity syndromes and offers the rheopheresis as an alternative treatment [5]. Palma et al. speculated the carotid artery pseudoaneurysm as a reason for the ISSNHL [6] and Kim et al. associated the basilar artery curvature [7] for the vascular occlusion theory in the literature of ISSNHL.

The ultrasonography (USG) evaluations may provide precious knowledge on the vascular conditions (diameters, vascular thickness, occlusions or stenosis) and blood flow velocity in the vessels. Many studies have defined several vascular parameters including carotid artery intima media thickness (C-IMT), which is strongly correlated with cardiac events and stroke, is one of the most focused parameter [8]. The Doppler USG examination of the vertebral artery (VA) and carotid (CA) artery is simple and non-invasive method on providing additional information to detect reason of the ischemia or stroke [9]. San et al. presented the use of transcranial Doppler ultrasonography in ISSNHL patients [10].

In this study, we aimed to investigate the Doppler USG features of both carotid and vertebral arteries in the ISSNHL patients and healthy individuals to contribute additional knowledge on vascular compromise theory.

2. Material and methods

2.1. Patient selection

This study was designed as a retrospective case control study and the data was collected from files of the patients who were applied for the sudden sensorineural hearing loss to Kocaeli University Medical Faculty otorhinolaryngology department between 2011 and 2015. All of the patients were evaluated with standard audiometry (AC 40 Interacoustics®, Assens, Denmark) for detecting the pure tone average of 0.25, 0.5, 1, 2, 4 and 8 kHz frequencies in a quiet test room and the test were repeated for every 48 h until hospital discharge. The arithmetical average of the 0.5, 1, 2 and 4 kHz frequencies was accepted as the pure tone average (PTA). Before the treatment, all of the patients were systematically assessed for blood count, biochemistry (included inflammatory markers, cholesterol levels, autoimmune markers, thyroid hormones, vitamin levels, blood coagulation parameters) and received a temporal bone magnetic resonance scan. The patients, who were suspected for vestibulocochlear nerve lesion or inner ear malformation, were excluded from the study. While the exact reason of the SSNHL was not identified from the systemic evaluations, it was called idiopathic. The carotid and vertebral artery systems were also analyzed with Doppler USG for the study before the medical treatment.

The control group was constituted from the healthy volunteers who declared of no history of an ear disease or a systemic disorder. All of the participants were evaluated for the PTA and normal hearing thresholds were detected. All of the participants were underwent the same blood tests with patients and volunteers, who have inappropriate results, were excluded from the study.

Patients who have bilateral hearing loss, stroke or cerebrovascular disease past, ear or neck surgery history, smoking habit, systemic disorders (diabetes mellitus, hypertension, hypercholesterolemia, autoimmune) were excluded from the study. Patients with positional disorders, who cannot lay in supine position and have limited head positioning, were not included to the study, as well.

2.2. Doppler USG measurements

All Doppler measurements were performed blindly for clinical status by the same radiologist in Kocaeli University Medical Faculty Radiology Department and performed via an ultrasound machine (HD 15 Philips®, Bothell, WA, USA) with a 5–12 MHz linear transducer. Subjects were positioned in supine position, with the head turned away from the side is scanned and the neck is extended.

The Doppler USG measurements were separated into two different vasculature systems, as carotid and vertebral artery. The vascular diameter (VD), intima media thickness (IMT), peak systolic velocity (PSV) and blood flow (BF) were evaluated for both carotid and vertebral systems, additionally resistive index (RI) were to be assessed for the vertebral system. All of the measurements were performed in two different planes (axial and longitudinal) and represented with the average of five heartbeats on both sides.

Common carotid artery (CCA) (from the most proximal portion in neck to carotid bifurcation) and internal carotid artery (ICA) (from bifurcation to skull base) were evaluated in the carotid system. VD was assessed as the distance between the vessel lumens of superficial and deep walls on longitudinal plane [11,12]. The CCA diameter was measured at 4 cm (approximately middle of CCA) below the carotid bifurcation. ICA was evaluated from the 1 cm above the carotid bulb [13]. The distance between the leading edges of first (vessel lumen) and second bright lines (media-adventitia interface) was measured as intima-media thickness (IMT). The intima media thickness measurements were performed on a plaque-free portion of vasculature at 1–2 cm proximal to the carotid bulb [11,12]. For the blood velocity recordings, the sample volume was kept at 1 mm and the corrected angle of insonation was arranged as $\leq 60^{\circ}$ with the cursor parallel to the vessel lumen [14]. Velocity recordings were taken from the mid-portion of the CCA. Blood flow, the blood volume which goes through the vessel in a minute, was measured at the same part of the vessel where the IMT measured.

Vertebral arteries were assessed from the transverse process at the C4–5 or C5–6 levels of the cervical spine. VD, PSV, BF and resistive index (RI) were the parameters which are evaluated in the study in the VA. RI is an another sonographic parameter which is calculated with a specific formula and recent studies were represented the association with the vessel stenosis [15].

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