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Original article

Comparing Vestibular Evoked Myogenic Potentials and Caloric Test in Patients with Vestibular Schwannoma

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Abstract

Objective: Vestibular Schwannoma (VS) influences the function of the vestibular nerve system. The present study compared the results of three clinical tests: ocular vestibular evoked myogenic potentials (oVEMP), cervical vestibular evoked myogenic potentials with air conducted sound (cVEMP) and caloric test that evaluated vestibular function in the patients with VS.

Materials and Methods: The present analytical, cross-sectional study was carried out on 5 patients with unilateral VS in the age range of 33-62 years old and 15 normal adults in the age range of 20-27 years old with normal hearing sensitivity) the patients were selected using simple sampling method from among those admitted to Amiralam Hospital in Tehran). The investigated indexes included latency time, amplitude and asymmetry ratio of amplitude in oVEMP and Cvemp and canal paresis of the caloric. The applied statistical methods were paired and independent t-tests, Mann-Whitney parametric test and Kolmogorov-Smirnov test.

Results: From among five patients with VS, four showed a reduction or absence of oVEMP amplitude. Three patients demonstrated abnormal results in cVEMP test and 3 others showed abnormal caloric responses.

Conclusion: Vestibular-evoked myogenic potentials, especially oVEMP, are useful tools for assessing vestibular nerve function in VS patients. It seems that they may be useful for assessing preoperative vestibular function or monitoring vestibular function in the patients with tumors for whom the wait-and watch method was selected.

Keywords: *Ocular vestibular evoked myogenic potentials, Cervical vestibular evoked myogenic potentials, Caloric test, Vestibular schwannoma*

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Introduction

Vestibular stimulation by acoustic stimulus leads to the generation of vestibular evoked myogenic potentials which are widely used for evaluating vestibular function today [1]. Colebatch (1992) reported surface potentials from sternocleidomastoid Muscle (SCM) in response to the click stimulus with high intensity [2]. This response which is recorded from tense cervical muscles using acoustic stimulus with high intensity is called cervical vestibular evoked myogenic potential (cVEMP) [3]. Since the saccule, the inferior vestibular nerve and lateral vestibulo-collic reflex are the pathways related to cVEMP, this test is widely used for evaluating these parts [4].

Recent studies have shown that myogenic potential which has short latency time can be recorded from the area under the eyes in response to the air conducted sound (ACS) and bone conducted vibration (BCV), which is called ocular vestibular evoked myogenic potentials [5]. It seems that oVEMP indicates vestibular function generated by crossed vestibular-ocular pathways.

oVEMP was first reported by Rosenberg (2005); it probably shows the electrical muscle activity of extra-ocular muscles, especially inferior oblique (IO) muscle.

The advantage of oVEMP over cVEMP is that it does not require any SCM muscle contraction during recording [6].

Therefore, this response can be easily recorded in the elderly, children and patients with cervical spondylosis [7]. When strong bone conducted vibration such as short tone-burst of 500 Hertz (4 ms rise and fall time and 1 ms plateau time) is presented in the middle of forehead on the hairline, the negative component with short latency time of 10 ms is detected from both eyes in normal people and it is known as n10 [8]. Because n10 potential is absent in patients with a bilateral vestibular loss but normal hearing, and people with the hearing disorder and remained vestibular function demonstrate a normal response, it is proved that n10 has a vestibular origin [6].

Also, n10 response is not caused by blinking or facial nerve activity [9] since oVEMP is absent in people with unilateral vestibular lesion and preserved bilateral facial nerve; however, people with unilateral facial nerve palsy and without vestibular disorder demonstrate bilateral oVEMP response [6]. Moreover, n10 is not caused by blinking since the initial component of blinking response (R1) at the beginning of response has a latency time of 12.5-14.5 which has more delay as compared to the starting time of n10 response. Additionally, R1 does not have an amplitude increase in upward gazing [9].

Vestibular schwannoma (VS) is a benign tumor originating from the inferior or superior vestibular nerve. Audiologic and neurotologic tests including pure tone audiometry, auditory brainstem response, vestibular evoked myogenic potential test and caloric test along with neural imaging studies are required for detecting this lesion. cVEMP and caloric tests are the physiological tests for investigating inferior and superior vestibular nerves, respectively [10]. Also, oVEMP tests are used as a new tool for evaluating vestibular system. Some reports have shown that the patients with VS show wide disorders in caloric and cVEMP tests with AC stimulation [6] .

This study aimed to examine the results of oVEMP, caloric and cVEMP tests in patients with vestibular schwannoma. It can be expected that the results of these examinations would determine the location of the lesion.

Materials and Methods

Subjects

This cross-sectional study was performed on 15 normal subjects with the age range 20-27 years, and 5 patients age range 33-62 years with vestibular schwannoma After final diagnosis by MRI. We used a simple sampling method among the patients admitted to Amir-Aalam hospital to choose the subjects. Those who were interested to participate in our study were completely familiarized with the implementation method of the project. After then, all participants gave informed consent and signed a deceleration form. None of them were undergone surgery. The exclusion criteria were any cervical disease, any active pathology in the middle or external ear or any kind of balance, neurological or visual disorders. The study was approved by the ethics committee of Tehran University of Medical Sciences. To be sure about the aforementioned exclusion criteria, otoscopy, pure tone audiometry (PTA) and acoustic immittance test were done. Also, a complete physical examination and history taking were done. All 5 patients with vestibular schwannoma had had sensory neural hearing loss. oVEMP and cVEMP test with AC stimulation and bilateral caloric tests were done on the subjects who were qualified entering the study.

VEMP recordings

The cVEMP was recorded using aICS chartr system (made in USA). The invented electrode was placed on the superior end of the sternum and the non-inverted electrode on the superior one-third of right and left SCM muscles symmetrically. The ground electrode was placed on the frontal bone. In this method, the sphygmomanometer cuff was inflated up to 20mmHg and was placed between participants' chin and opposite shoulder and they were asked to compress the cuff up to 40mmHg.

To record cVEMP, a 500Hz tone burst stimuli at the level of 95dBnHL were used through interested earphones. The number of stimulus presentations per second, bound-pass filter and time window were 5.1 Hz, 10-2000 Hz and 50 ms, respectively.

Each ear was tested twice to make sure about the reproducibility of responses. Moreover, to remove muscle fatigue effects on test responses the participants were asked to rest almost two minutes between each test.

oVEMP test was also done using a ICS chartr system (made in USA) and there was no need for muscle contraction. We asked the participants to sit on a chair while the non-inverted electrode placed under the contralateral eye 1cm away from the lower eyelid and inverted electrode 1-2cm below the non-inverted electrode. The ground electrode was located under the superior end of the sternum. Then he was asked to look at the object which was placed one meter away from each eye with 30-degree angle. The parameters were similar to the cVEMP, except for the bandpass filter and the number of stimulations which were 5-1000Hz and 3.1 Hz respectively.

If n10 wave was observed in repetitions, it was considered as no response and if it was reproducible but Asymmetry Ratio (AR) was higher than the normal limit, the response was reduced. Both aforementioned conditions are abnormal. The ARs were calculated by the electrophysiological instrument [11].

Caloric test

Caloric test was done by using ICS chartr system (made by USA). Before starting, spontaneous nystagmus was ruled out in order not to interfere caloric test results also bilateral air stimulated caloric test was conducted bilaterally. First, 52°C air stimulation for 60 seconds and then 23°C air stimulation for 60 seconds was performed for both ears.

Between each test, the patients were asked to rest for a few minutes to remove dizziness, nausea or any other related symptoms. Moreover, we asked the patients to count or review the alphabets to maintain their level of consciousness. The unilateral weakness percentage as the aimed index was calculated by the electrophysiological instrument [12].

All the stages of the present research were done in the Audiology Clinic, Faculty of Rehabilitation, ShahidBeheshti University of Medical Sciences.

To analyze the results of this study, Kolmogorov-Smirnov statistical test, paired and independent t-tests, and Mann-Whitney parametric test was used for examining the normal distribution of data, comparing normally distributed variables and comparing the data with non-normal distribution, respectively. Data analysis was done using SPSS16 at the significance level of P<0.05.

Results

In this study, the responses were obtained from three tests in normal adults (mean age of 22.18±2.19 years) and those with vestibular schwannoma (mean age of 47.2±12.13 years). Latency time, amplitude, asymmetry ratio of bilateral amplitude in evoked myogenic potentials and lateral weakness of caloric test were calculated. The table 1 gives the results obtained from patients with VS.

As far as negative initial potentials which were recorded in almost 10 ms were concerned, on the opposite side of the lesion, no response was recorded in 1 out of 5 patients with VS and considerable reduction of amplitude was observed in three (figure 1 and 2). One had no response on both sides. Therefore, the abnormal response was recorded in four people on the opposite side-eye of the lesion. In the present work, a significant increase in latency time was observed in three people who had a reduction in amplitude (P<0.042). Also, a significant difference was observed in the asymmetry ratio of bilateral amplitude (P=0.000).

In cVEMP test, three people showed absent response on the same side of the lesion and two others showed natural responses on both sides; all three people had an absent response on the lesion side.

In the caloric test, one person and two people demonstrated absent response and decrease on one side, respectively, while two people showed a natural response on both sides. Then, in this test, three people had an abnormal response on the side of the lesion and two others had a natural response on both sides.

Two people showed abnormal results on the side of the lesion in three tests. Abnormal results were obtained in only one person in oVEMP test and one person in caloric and oVEMP tests. Thus, three people had abnormal results in both caloric and oVEMP tests on the lesion side.

The size of measured tumor in MRI ranged from 7 mm to 22 mm (mean and standard deviation of 15.6± 6.1). There was no significant difference between tumor size and test results.

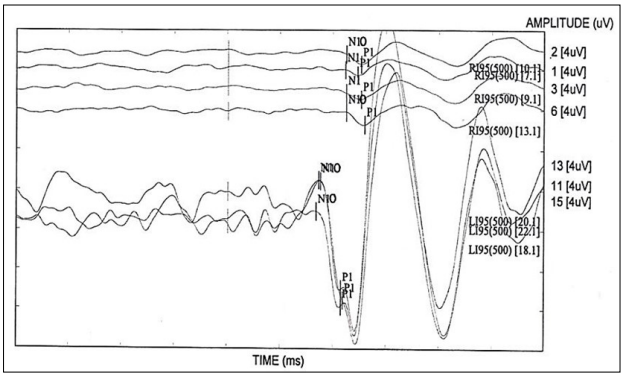

Figure 1. Decrease in the oVEMP amplitude on the lesion side

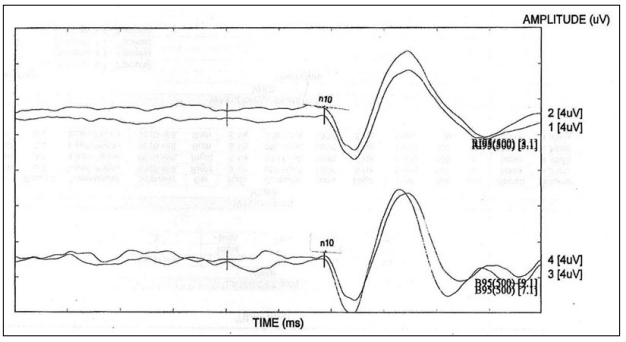

Figure 2. oVEMP amplitude in normal people

Discussion

In this study, results of oVEMP with air conducted stimulation, cVEMP, and caloric tests were compared in the patients with vestibular schwannoma and normal adults. Among five patients with a vestibular schwannoma, four showed reduced or absent oVEMP amplitude; three people showed abnormal results in cVEMP test and three had abnormal caloric responses. In sum, two people showed abnormal results in three tests.

oVEMP with larger amplitude was observed in the middle and high lines while gazing since, in this situation, the inferior oblique muscle was closer to the recorded electrodes [5] .

In contrast to cervical vestibular evoked myogenic potential, ocular vestibular evoked myogenic potential depends on the function of crossed neural pathway; meaning that, if people suffer from unilateral vestibular disorder, reduction or absence of n10 potential of oVEMP will be observed in contralateral eye [3] while, in the cVEMP test, response reduction is observed on

Table 1: Results of patients with vestibular schwannoma

Patient number	age	sex	Affected side	oVEMP AR%	cVEMP AR%	Caloric CP%	Tumor size (mm)
1	57	F*	Left	Response removal in two ears	Normal (5)	abnormal (100)	7
2	33	M*	Left	abnormal(56)	Normal (22)	normal(2.5)	20
3	62	F	Right	abnormal (100)	abnormal (100)	abnormal (100)	12
4	39	M	Right	abnormal (83)	abnormal (44)	abnormal (100)	17
5	45	M	Right	abnormal (62)	abnormal (52)	normal(7.2)	22

F: Female , M :Male

the same side of lesion since the pathway related to this response is on the same side with cervical vestibular pathway.

In this study, no response of oVEMP test was observed in one patient, which was probably due to the application of air conducted stimulation since n10 potential of oVEMP cannot be recorded in normal people with air conducted stimulation. In this study, the occurrence rate of n10 response of oVEMP in patients with VS was obtained as 90%. In a study by Cheng et al. (2009), the occurrence rate of n10 response in oVEMP test with air conducted stimulation was about 80% [13]and, in another study by Chihara et al. (2007), this response rate was reported as 90% [14] . The findings of these studies were similar to those of the present work In a study by Ralli et al.(2018), a 65-year-old man presented with progressive right-sided sensorineural hearing loss, dizziness, and tinnitus and fullness in his right ear. Audiovestibular examination and MRI detected an intravestibular schwannomas on the right. That they found that oVEMPs were absent on the contralateral side, which contributed to the diagnostic process [15].

Furthermore, in this study, abnormal oVEMP amplitude was observed in four out of five people (80%), which was also reported by Iwazaki et al. (2009) (80%).In all the cases, the response was absent on the affected side and the response with very small amplitude was observed; this could be due to the point that ocular otolithic pathway is not 100% crossed and the ipsilateral pathway has a small role in the production of this response [1].

Due to the high interpersonal variability of indicator amplitude, asymmetry ratio (AR) of bilateral amplitude is a more appropriate indicator for the comparison. In this study, there was a significant difference between the results of the bilateral latency time of n10 ($P<0.42$); it seemed to be because of tumor pressure on brainstem which affected neural transmission.

Abnormal results of caloric test (lateral weakness on the lesion side) and cVEMP (response absence) were observed in three people. In the study by Iwazaki3 et al., these results were reported as 86b and 78%, respectively. This difference in observation probably depended on the small population of the studied group in this investigation. Finally, this study demonstrated that most patients with VS had abnormal responses in oVEMP test. This finding was in line with that of Iwazaki et al. (2009). Iwazaki used bone conducted stimulation in oVEMP test; accordingly, physiological studies stated that bone-conducted stimulation selectively activates primary nerves of the irregular otolith, most of which are placed in the superior part of the vestibular nerve and originate from macula of the utricle. Since this tumor mostly originates from the superior part of vestibular nerves, abnormal oVEMP results are observed in most patients [1]. Rosengren and Curthoys (2010) conducted more studies and indicated that some irregular primary utricular afferents which respond to the bone-conducted simulation of 500 hertz were activated in air conducted stimulation of 500 hertz. It seemed that air conducted stimulation was not a selective stimulation for saccular macula receptors and activates some irregular utricular afferents [16,17]

Moreover, they stated that cVEMP with AC stimulation showed saccular function not only because saccular afferents were activated by air conducted stimuli, but also because SCM response was mostly determined by saccular activities. Also, oVEMP with BC stimulation demonstrated utricular function not only because utricular afferents were activated by bone-conducted vibration but also because the response of eye movements was mostly determined by utricular function [18].

Therefore, it seems that oVEMP with air conducted stimulation was also caused by the utricular activity of the superior vestibular nerve. The vestibular test can be used to investigate the function of the superior vestibular nerve and the inferior vestibular nerve [19].

In this study, there was no significant relationship between tumor size and obtained results, which was in line with the finding of Suzuki's study.

Since the growth of vestibular schwannoma is both inward and outward of the nerve; therefore, abnormal responses and function disorders are observed in the parts other than the affected nerves. In fact, in most cases, tumor affects other parts of the nerve with its growth; thus, VS can influence all the nerves of the internal auditory canal and have an impact on the results of all tests. This issue prevented us from deciding the tumor origin in the eighth cranial nerve based on the results obtained from these tests.

Conclusion

In this study, abnormal results for vestibular myogenic potentials in patients with VS included absence of response, reduction of amplitude, increase of asymmetry ratio of bilateral amplitude and increase of latency time; for caloric test, lateral weakness percentage increased, too. According to these findings, it seems that, for recording vestibular myogenic potentials, the asymmetry ratio of bilateral amplitude was more appropriate for identifying the function disorder of vestibular nerves compared with other parameters.

Vestibular-evoked myogenic potentials, especially oVEMP, is a valuable tool for studying the function of the vestibular nerve in patients with VS. Moreover, these tests require much shorter periods for implementation. Seemingly, these tests are useful for assessing preoperative vestibular function or monitoring vestibular function in patients with tumors, for whom the wait-and-watch method was selected.

It is recommended for future works to conduct similar studies with a larger sample size to precisely use these results for clinical interpretations.

Conflicts of Interest

None

Funding source

None

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