

ORIGINAL AERICLE

Ocular Vestibular Evoked Myogenic Potentials to Air Conducted Tone Bursts in Patients with Unilateral Definite Ménière's Disease

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Purpose: The purposes of this study were to investigate the results of contra-lateral ocular vestibular evoked myogenic potentials (OVEMPs) elicited in patients with unilateral definite Ménière's disease (DMD) in response to monaural tone bursts acoustic stimulation and to compare them with that of the un-affected sides as well as normal subjects.

Materials and Method: This study consisted of 31 patients with DMD (13 males and 18 females) and thirty normal subjects (16 females and 14 males) as a control group. They were subjected to hearing assessment and OVEMPs measurements. The biphasic N1, P1 waveform was recorded with respect to latencies in ms and amplitude in μV . In this study OVEMPs differ in the affected than the un-affected side of Ménière's disease and normal subjects.

Results: The results revealed that the mean amplitudes of the contra-lateral OVEMPs in the affected ears were significantly lowers and the mean latencies were significantly longer than that of normal. The average asymmetry ratio was significantly greater in Ménière's disease patients in comparison to normal subjects.

Conclusion: These differences could be attributed to the patho-physiologic mechanism encountered in those patients. Hence, OVEMPs can be used as a part of the diagnostic work up of Ménière's disease to assess the crossed vestibular evoked potentials in those patients.

Submitted : 04 March 2013

Accepted : 28 April 2013

Introduction

Ménière's disease is a progressive idiopathic disorder that was first described by Prosper Ménière's^[1]. The cause of the disease has not yet been clarified and remains controversial. It is, however, hypothesized that an increased amount of endolymph (endolymphatic hydrops) which causes distension of the endolymphatic sac and the endolymphatic components of the vestibular and cochlear parts may be the underlying mechanism causing the symptoms^[2]. In a series of Ménière's patients in whom temporal bones were analyzed, all had evidence of cochlear hydrops^[3].

The age range of onset for the disease was found to be from 17 to 79 years. There is no gender difference as regards duration, intensity or frequency of the vertigo

attacks. The disease is dominantly unilateral with bilateral percentage of 16% and no predominance of one ear compared to the other^[4].

It is unclear, however, whether Ménière's disease is a consequence of endolymphatic hydrops or, alternatively, if endolymphatic hydrops builds up whenever Ménière's disease is clinically established. The Committee on Hearing and Equilibrium (1995) set a criterion for certain, definite, probable and possible Ménière's disease. The disease is characterized by fluctuating hearing loss, tinnitus, vertigo and aural fullness^[5].

Although, the vestibular afferents are primarily responsive to head acceleration, they can also be activated by non-physiologic techniques using loud sound, vibration, and electric stimulation applied over the mastoid processes^[6].

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Vestibular-dependant short latency electromyographic (EMG) responses to intense sound were initially recorded from the posterior neck muscles inserting at theinion^[7]. Sound induced vestibular evoked myogenic potentials (VEMPs) can be used to investigate the saccular function. They are typically measured from the tonically contracted sternocleidomastoid muscles^[8]. The VEMPs waveform recorded in these conditions is biphasic and consists of an initial positive (p13) followed by negative (n23) wave. They have become increasingly accepted as a reliable method of assessing otolith function^[9, 10].

VEMPs can also be recorded from extra-ocular muscle and termed ocular vestibular evoked myogenic potentials (OVEMPs)^[11]. OVEMPs is similar to the cervical VEMPs in that the vestibular system is also stimulated by a loud sound. The difference is that the response is measured on the inferior oblique muscle of the eye as opposed to the sternocleidomastoid muscle of the neck^[12]. Initially bone conduction stimuli were applied by Rosengren et al.^[11] to elicit the response. However, air conduction stimuli and head accelerations have also been effective in producing this evoked potential^[13, 14]. The test is reliable in investigating vestibular and probably otolithic function. It has been used for assessing crossed vestibulo-ocular reflex^[15].

The objectives of this study were to: investigate the results of OVEMPs to monaural air conducted tone bursts in patients with unilateral definite Ménière's disease; analyze and assess the results in the affected side for the right versus left and gender differences in both males and females; and to compare the responses of the affected side to the un-affected side and normal subjects.

Materials and Methods

Participants

This prospective study was conducted in the outpatient ENT and audiology clinics in our hospital from January to November 2012. It was approved by The Human Research Committee in the hospital. Pure tone audiometry and OVEMPs were performed for Ménière's disease patients and normal adult volunteers after their consent.

A total of 31 patients aged from 19 to 55 years (13 males and 18 females) were diagnosed as unilateral definite Ménière's disease according to the AAO-HNS 1995

criteria^[5]. They received the diagnosis when they had a history of at least two vertigo attacks, experienced or had experienced tinnitus, had a cochlear hearing loss of at least 20 dB at one of the frequencies of the standard audiogram at low frequencies and aural fullness. Complete history, ENT, medical and neurological examination was done for them to rule out any associated medical or neurological disorders.

The control group consisted of 30 subjects aged from 18 to 56 years (16 females and 14 males). They have no history of otologic or vestibular system affection with normal otoscopy and normal hearing sensitivity in the standard audiometric test measurement by conventional pure tone audiometry.

Apparatus

Pure tone audiometer (Interacoustic Clinical Audiometer AC 40) was used for testing both air conduction (from 250 to 8000 Hz) and bone conduction (from 500 to 4000 Hz) at octaves to obtain results from both ears of each participant. A tympanometry (Interacoustic Impedance Audiometer AZ 26) was used for testing the middle ear functional status for both the study and control groups. Auditory evoked potential unit was used to obtain and average OVEMPs activity for all participants in this study. OVEMPs were measured with ICS Medical version 3.00 CHARTR, USA, coupled with a preamplifier (ICS medical CHARTR preamplifier PA-800), an output amplifier, computer and insert earphones (ICS medical, IL, USA).

OVEMPs parameters

The following stimulating and recording parameters were used to obtain OVEMPs activity. A 500 Hz tone burst (two cycles plateau and one cycle rise and fall times) with rarefaction polarity was presented via CHARTR ICS standard foam insert earphones. The stimulus was presented at 95 dB nHL for all participants and was replicated to confirm the presence of the responses. 5 Hz stimulation rate was delivered.

Two hundred sweeps of electromyogenic (EMG) activity were recorded on the side contra-lateral to acoustic stimulation. The responses were collected, amplified (100,000×) and filtered between 5-1000 Hz. The analysis time was 50 milliseconds. The ground electrode was placed

on the high forehead, the active electrode was placed approximately one centimeter inferior to the contra-lateral lower eyelids and the reference electrode was placed immediately inferior to it. Impedances were maintained below 5k Ω .

Procedure

All participants in this study were subjected to OVEMPs recording. The skin of the face at the site of the surface electrodes placement was cleaned with abrasive to obtain acceptable electrode impedance. Contra-lateral OVEMPs was performed separately (monaurally) in the right and left ears. The test was recorded as the subject contracted the inferior oblique muscle by elevating the eye 30° (for optimal muscle tension) to maintain gaze fixation on the target that were premeasured for angle of the eye gaze. The waveform amplitude in μ V, latencies in ms and peak to peak amplitude asymmetry ratio (AR) were measured for all participants. The inter-aural amplitude difference ratio was measured as the difference of the amplitude N1-P1 on the right and left ears results divided by the sum of amplitude N1-P1 of both ears ($R - L/R + L$) according to that of Young et al., 2003^[16].

OVEMPs results were statistically analyzed and compared for Ménière's disease (affected and un-affected sides) and normal subjects. Descriptive statistics include

the mean; standard deviation (SD) and t test were used to both groups. A difference of $p < 0.05$ (5%) was considered significant. This analysis was carried out in relation to the latencies of N1, P1 and the amplitude values of N1-P1 for the contra-lateral OVEMPs waveforms.

Results

In this study, the mean age for Ménière's disease patients was 39.3 ± 8.1 years and it was 36.6 ± 7.8 years for the control group. The duration of the disease in the right affected side was 24.3 ± 7.3 months while it was 22.7 ± 5.7 months on the left side.

Figure 1 reveals, the mean pure-tone audiogram for Ménière's disease patients (affected and un-affected side) and normal subjects at frequencies 0.25, 0.5, 1, 2, 4, and 8 kHz as a function of hearing threshold level in dBHL.

OVEMPs began with initial negative then followed by positive wave. In this study, all normal subjects showed contra-lateral OVEMPs waveform in response to monaural air conducted tone bursts. Two patients with Ménière's disease showed absent OVEMPs on the un-affected side of lesion and absent in 15 out of 31 affected ears.

In the present study, the mean latencies for N1 and P1 of the affected side were significantly longer than the

Table 1. The mean latencies in ms \pm SD and amplitude in μ V \pm SD for OVEMPs evoked by 95-dBnHL tone bursts stimulation as measured in MD (affected and un-affected ears) and normal subjects.

	Latencies in ms		Amplitude in μ V
	N1	P1	N1-P1
Affected side	11.3 ± 0.7	15.7 ± 0.8	4.3 ± 1.0
Un-affected side	10.4 ± 0.6	14.9 ± 0.8	6.4 ± 1.4
Normal subjects	10.4 ± 0.7	14.8 ± 0.8	6.7 ± 1.5

ms = milliseconds μ V = micro volt SD= standard deviation MD = definite Ménière's disease

Table 2. T test of the affected versus un-affected, affected versus normal subjects, the un-affected versus normal and the affected side (right versus left and females versus males) as a function of monaural contra-lateral air conducted OVEMPs for N1, P1 latencies and N1-P1 amplitude.

	Latencies		Amplitude	T test
	N1	P1	N1-P1	P value
Affected versus un-affected side	0.0003	0.0007	0.0006	< 0.05
Affected side versus normal	0.0001	0.0003	0.0003	< 0.05
Un-affected side versus normal	0.6924	0.7688	0.8338	> 0.05
Right versus left (affected side)	0.2976	0.9585	0.5644	> 0.05
Females versus males (affected side)	0.9082	0.4531	0.5851	> 0.05

respective latencies for the un-affected side and normal subjects (Table 1). As regards the mean N1-P1 amplitude values, they were significantly lower than on the un-affected side and in normal subjects ($p < 0.05$). Also it was noticed that, the mean N1 and P1 latencies for the un-affected side were longer than normal subjects and the mean amplitude in μV of N1-P1 were less than that of the control group but it was statistically non significant ($p > 0.05$), table 2.

The amplitude of the OVEMPs varies among subjects. Hence, the IAD ratio was used to specify the side difference. The means IAD ratio was 0.25 ± 0.16 for normal subjects versus 0.46 ± 0.24 for Ménière's disease patients, demonstrating significant statistical difference ($p < 0.05$).

Figure 2 shows the mean latencies of N1 and P1 in ms as a function of monaural 500 Hz tone bursts of the right versus left and females versus males for the affected side with Ménière's disease. While, figure 3 demonstrates the mean amplitude in μV of the right versus left and females versus males affected side with Ménière's disease.

It was noticed in this study that no statistical significant differences found between the right and left affected side with Ménière's disease ($p > 0.05$) as regards both latencies and amplitude of N1 and P1 waveform. Furthermore, there were no statistical significant gender differences between (females and males) affected side ($p > 0.05$) table 2.

Discussion

In the present study, the female to male ratio was 1.38:1 with slight females prevalence than males and the mean age of Ménière's disease was 39.3 years. Previous studies have been reported that Ménière's disease has a slight female to male preponderance (1.3:1). Its peak incidence was in the 40 to 60 year age group^[17].

OVEMPs originates from the otolithic organs via the superior vestibular nerve to the undetermined vestibular nuclei, and then crosses to the opposite extra-ocular muscles, especially the inferior oblique and inferior rectus muscles^[15]. Murofushi et al. 2010^[18] suggest that OVEMPs in response to air-conducted sound reflect the functions of a population of the peripheral vestibular system different from those reflected by cVEMPs, perhaps predominantly

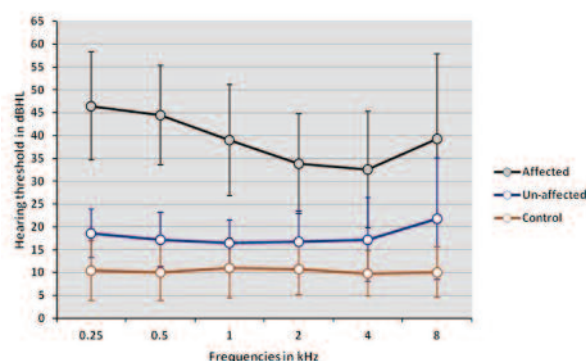


Figure 1. The mean pure tone audiogram in dBHL of MD patients (affected and un-affected ears) and normal subjects. Error bars represent 1 SD above and below the mean. SD = standard deviation MD = Ménière's disease

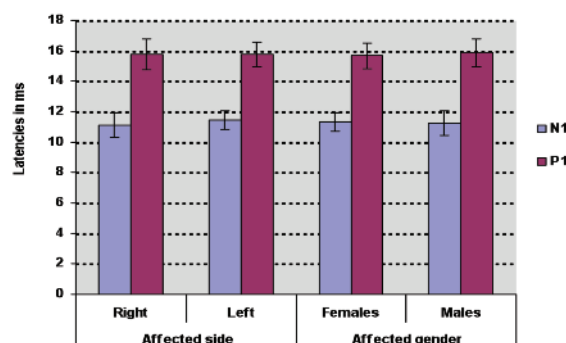


Figure 2. The mean latencies in ms for sides (right and left) and gender (females and males) affected side with MD. Error bars represent 1 SD above and below the mean. ms = milliseconds SD = standard deviation MD = definite Ménière's disease

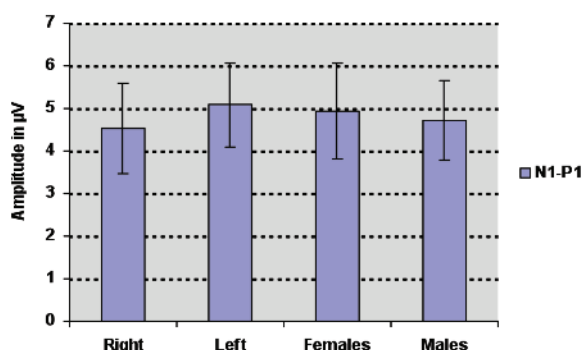


Figure 3. The mean amplitude in μV for sides (right and left) and gender (females and males) affected side with MD. Error bars represent 1 SD above and below the mean. μV = micro volt SD = standard deviation MD = definite Ménière's disease

utricular in origin. The procedure evaluates the ascending vestibular pathway as crossed VOR^[19].

In this study, a comparison between the results of OVEMPs in unilateral Ménière's disease and normal subjects were done. The air conducted tone bursts were used as a stimulus for eliciting the OVEMPs. The effectiveness of air-conducted OVEMPs can be attributed to that vestibular activation by air-conducted sound in normal adults is highly reproducible between experiments and more symmetrical than activation by head taps or bone conducted vibration^[20]. Furthermore, a conventional instrument for evoked potentials is generally equipped with a maximum level of 70 dBnHL for bone-conducted sound, which is lower than the normal threshold for eliciting OVEMPs^[21]. Consequently, air conducted acoustic stimulation is more specific, reliable and practicable than bone-conducted vibration in eliciting OVEMPs in subjects without conductive hearing loss.

Wang et al.^[22] found that the biphasic N1-P1 waveforms were recorded with maximal amplitudes from the electrodes located below the eyes contra-lateral to the side of acoustic stimulation while the subject was gazing upward. Therefore, the active and reference electrodes in this study were placed below the eye contra-lateral to the side of acoustic stimulation. It was noticed in this study that the amplitude of the OVEMPs varies among subjects. This finding was in agreement with that of Iwasaki et al.^[15].

Although the mean latencies in ms for the un-affected side were longer and the mean amplitude in μ V was less than that of the normal subjects, it was still statistically non-significant ($p > 0.05$). On the contrary, there were statistically significant differences between the affected side and normal subjects. Moreover, there were statistically significant differences between the un-affected and affected side with Ménière's disease. Also, it was found that OVEMPs were absent in 15 out of 31 affected ears with Ménière's disease.

Furthermore, the results were compared between sides (right or left) and gender (females or males) affected side to reveal whether OVEMPs would change as a function of side or gender differences. In the present study, there were no statistical significant differences in OVEMPs between

males and females affected sides. Moreover, there were no statistically significant differences between right and left affected side.

In this study, it was found that OVEMPs are reliable and repeatable procedure. Our results suggest that OVEMPs can be used as a part of a test battery for evaluation of patients with Ménière's disease to assess the crossed vestibular evoked potentials. It is a crossed excitatory vestibulo-ocular response and provides another diagnostic tool for assessing the integrity of VOR. However, further studies are needed to investigate OVEMPs results in different vestibular system disorders and to compare them with that of the norms.

Conclusion

OVEMPs in patients with Ménière's disease differ from those of the un-affected side and normal subjects. But, it was noticed that no significant sides (right or left) or gender (males or females) differences for the affected side responses. The latencies were longer than the un-affected side and normal subjects. Also, reduction in the amplitude in the affected ears was noticeable and significant in comparison with that of the un-affected side and normal subjects. These differences could be attributed to the patho-physiologic mechanism encountered in Ménière's disease. Hence, OVEMPs can be use as a complementary test that may contribute for the diagnosis of patients with Ménière's disease.

Conflict of interest There is no conflict of interest

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