JOURNAL OF PURE AND APPLIED MICROBIOLOGY, March 2013. Vol. 7(1), p. 195-199

Vestibular Evoked Myogenic Potential in Profoundly Hearing Impaired Adults

Seyedeh Nazanin Hajjari[1], Maryam Ramezani[1]* and Amir Arash Motahari[2]

[1]Department of Audiology, Faculty of Rehabilitation,
Tehran University of Medical Sciences, Tehran, Iran.
[2]MD, Neuroscience Research Center, Baghiatallah University of Medical Sciences, Tehran, Iran.

(Received: 21 July 2012; accepted: 18 September 2012)

Vestibular evoked myogenic potential (VEMP) is used as a test for investigating the performance of atrium, especially saccule. The present study aimed at comparing the results of VEMP test in adults with normal hearing and profound hearing impairment and investigating the incidence of this response in profoundly hearing impaired adults. In this cross-sectional investigation, VEMP was recorded through presenting the 500 Hertz tone-burst stimulus with the intensity of 97db nHL in 20 profoundly hearing impaired adults who did not have any vestibular disorders and 20 adults with normal hearing in the age range of 18-40 years old. VEMP waves were observed in 34 profoundly hearing impaired ears (87.17%). Average latency time of p13 and n23 was obtained as 15.73±0.25 ms and 24.35±0.26 ms, respectively, and p13-n23 range was 125.30±13.16 micro-v. There was no statistically significant difference between the values of average latency time of p13 and n23 and range of p13-n23 in the two groups (P>0.05). Considering the incidence of 87.17%, it seems that VEMP is evoked by the stimulation of profoundly hearing impaired ears and can be helpful in evaluating the balance performance of deaf and hard-of-hearing patients.

Key words: Vestibular evoked myogenic potential, profound hearing loss, Tone-burst.

Vestibular stimulation with acoustic stimulus leads to the vestibular evoked myogenic potential (VEMP) which is widely used for evaluating the vestibular performance[1]. Colebatch reported the surface potential in sternocleidomastoid muscle (SCM) in response to the click stimulus with high intensity in 1992 [2]. Probably otolithic, and mainly saccular, afferents are responsible for response production. Saccular afferents inhibit lateral cervical motor neurons through inhibitory neurons in vestibular nuclei. This inhibition produces positive inhibitory muscle potential (p13) with short latency time from sternocleidomastoid muscle which is followed by the emergence of a negative wave (n23) [3]. Cochlear dysfunction, which causes sensorineural hearing loss, can be accompanied by atrial defect because both vestibule and cochlea share membranous labyrinth of the inner ear [4].

Nevertheless, hearing loss is independent from VEMP, that is, as long as saccule and inferior vestibular branch of VIII paired nerves are healthy, VEMP will be recorded. Although loud acoustic signals are used for response production, the signal produces a compression wave which starts the hydrodynamic stimulation of vestibular hair cells[5].

* To whom all correspondence should be addressed.
Tel.: +98-912 7233584
E-mail: m.ramezani2074@yahoo.com

Colebatch and Halmagi and Colebatch et al. stated that these potentials disappear after cutting vestibular verves; however, they can be still observed in the patients suffering from bilateral profound hearing loss. Accordingly, they were named vestibular evoked myogenic potentials[6].

Zhou *et al.*[4] investigated all the response parameters of VEMP (threshold, range, latency time of p13 and n23 waves) in the children suffering from severe to profound sensorineural hearing loss; but, they found no evident relationship between the level of hearing loss and intensity of saccule disorder. They reported that latency time of p13 and n23 had no significant difference in the children with normal hearing and hearing loss[4]. Considering the response range, Zhou et al. declared that most of these hearing impaired children had reduced saccule-dependent performance[4]. In general, clinical application of VEMP demonstrated that this test was helpful in evaluating the balance performance of deaf and hard hearing patients[5]. Some studies have also shown that VEMP response has been evoked via the stimulation of ears with profound hearing loss[4, 7, 8, 9].

To this end, the aim of the present study was to compare the results of VEMP test in adults with normal hearing and profound hearing loss and investigate the occurrence rate of this response in profoundly hearing impaired adults.

Methodology

This cross-sectional and analytical research was performed on 20 adults with normal hearing and 20 adults with profoundly impaired hearing in the age range of 18 to 40 years old using a non-probability sampling method. VEMP test was implemented for all the volunteers in the Audiology Clinic, Faculty of Rehabilitation, Shahid Beheshti University of Medical Sciences. The inclusion criteria were having more than 90 dBHL airway hearing thresholds in the octave frequencies of 250-8000 Hertz (for people with profoundly impaired hearing), having no history of balance disorder, having no history in suffering from cervical problems such as arthritis, having no history of head trauma and no history of taking ototoxic drugs.

Those who voluntarily participated in the study were first introduced with the research methodology; then, their history was taken after signing the consent form. To investigate the health of outer and middle ears, otoscopy, pure tone audiometry and acoustic immittance test were taken. To record VEMP (ICS Charter system made in the USA), invert and non-invert electrodes were placed on the upper end of the sternum and the upper one-third of SCM muscle, respectively[10]. After connecting the electrodes, their impedance was investigated to be constantly less than 5 kilo ohm. In this test, the muscle needs to be activated; thus, the person was asked to sit on a chair and spin his head 30 degrees forward and 30 degrees to the opposite side of the target muscle. In order to equally control the muscles during the test, the feedback method was used[11], in which the cuff of a sphygmomanometer was blown up to 20 mm Hg and the participant placed the cuff between his chin and opposite hand to keep the pressure constant at 40 mm Hg. 500 Hertz tone-burst stimulus at the intensity level of 97 db nHL, which was presented using insert earphones, was used for VEMP recording. In this study, the number of stimulus presentation per second, band-pass filter and time window were considered as 5.1 Hertz, 10-2000 Hertz and 50 ms, respectively. Finally, the test was repeated twice for each ear in order to assure the reproducibility of the response. In addition, to remove fatigue effects on the results of VEMP test, the participants rested for 2 or more min after recording each wave. The investigated indicators included p13 and n23 latency time and p13-n23 range.

To investigate the results of this research, Kolmogorov-Smirnov test and paired t-test were used for examining the normality of distribution and comparing the variables, respectively. The analysis of data was done using SPSS17 at the $P<0.05$ significance level.

Findings

P13 and n23 waves were observed in all forty ears with normal hearing; from among 39 ears with profoundly impaired hearing (due to the lack of cooperation of one ear), VEMP response was observed in 34 ears (87.71%). Average latency time of p13 and n23 in the profound hearing loss group was 15.73 ± 0.25 ms and 24.35 ± 0.26 ms and the p13-n23 response range was 125.30 ± 13.16 micro v. In the normal group, average latency time of p13 and n23 was 15.56 ± 1.22 and 24.59 ± 1.89 ms and p13-n23 response range was 140.77 ± 46.10 micro v (Figure 1). There was no statistically significant difference between the amount of average latency time of p13 and n23 and response range of p13-n23 in the two groups (P>0.05). The results obtained in both groups are briefly presented in table 1.

Table 1. Mean and standard deviation of latency time of p13 and n23 peaks and p13-n23 range in two groups with normal and profound hearing loss

VEMP parameters	Profound hearing loss	Normal	p-value*
Latency time (ms)			
P13	15.73±0.25	15.56±1.22	0.534
N23	24.35±0.26	24.59±1.89	0.973
Amplitude (µv)			
N23-p13	125.30±13.16	140.77±46.10	0.337

* significance level of P<0.05

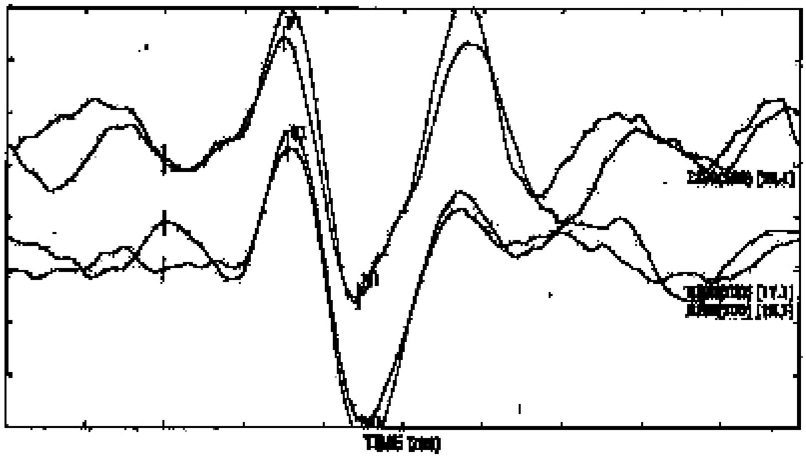

Fig. 1. A sample of VEMP waves recorded in a person with normal hearing

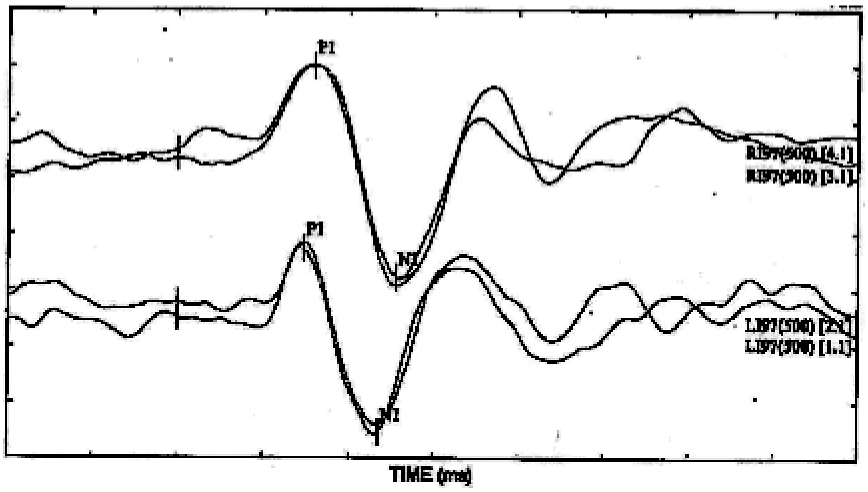

Fig. 2. A sample of VEMP waves recorded in a person with profound hearing loss

DISCUSSION

From among 39 ears with profoundly impaired hearing, 34 ears (87.17%) recorded VEMP normal response. There was no statistically significant difference between the amount of average latency time of p13 and n23 and response range of p13-n23 in the two groups (P>0.05).

Rosengren and Colebatch[8] used 0.2 ms click stimulus for evaluating 15 patients (26 to 82 years old) who were suffering from severe to profound hearing loss due to different reasons like meniere, rubella and mumps. Five of these patients also received cochlear implantation. Among 25 evaluated ears, normal VEMP response was recorded in 12 ears (48%), which was less than the amount of 87.17% obtained in this research. The first reason for this difference was the studied population in Rosengren and Colebatch study. Their patients were suffering from severe to profound hearing loss due to the reasons which damaged inner ear, like saccule. Furthermore, cochlear implantation can be a damaging factor for saccule, as well[12]. Moreover, when age is above 60, VEMP response may not be recorded even in people with normal hearing[13]. The second reason is the difference in the applied stimulus type (click versus tone-burst). The occurrence possibility of VEMP response with 500 Hertz tone-burst stimulus is higher since saccular afferents have the highest sensitivity to the low frequency stimuli[14,15] while click contains high frequencies. The amount of range and VEMP latency time was not mentioned in that study.

In the present study, adults with profoundly impaired hearing who had no history of suffering from damaging factors to the inner ear and vestibular disorders were studied. Thus, the findings were not in line with those of Zagolski[16] because he obtained VEMP response (with the 500 Hertz tone-burst stimulus) in 35.30% of 17 three-month children with profound hearing loss. Fifteen children were subject to the damage to inner ear due to different reasons like taking antibiotic amikacin[16]. Anatomic proximity of saccule to the acoustic energy receiving system, high similarity of the hair cell structures of cochlear and vestibule and profusion to the end organs of cochlear and vestibule through similar end artery indicated that deterioration and destruction of atrium are related to the cochlear damaging factors[17]. Therefore, the possibility of recording VEMP response decreases in such a situation. Zagolski[16] reported the latency time for p13 and n23 waves as 8.3 with the standard deviation of 1.7 ms and 13.5 with the standard deviation of 1.8 ms, respectively, which was in line with the amount obtained from the control group in his study. Emara[18] examined VEMP response with click stimulus in 23 children with severe to profound hearing loss and reported that 31 out of 46 ears (67.39%) had normal VEMP response[18]. Due to the difference in the type of applied stimulus (click versus tone-burst) and difference in the studied population (children versus adults), his results were not in line with the amount of 87.17% found in this study.

Since VEMP is independent of hearing, as long as saccule and inferior vestibular branches of the eighth pair of cranial nerve (VIII) are healthy, VEMP will be recorded[5]. This issue was supported by the results of the study by Jin *et al.* [19] who studied 16 Olympic athletes suffering from profound hearing loss using VEMP test with 500 Hertz tone-burst and click stimuli; they reported that 75% of athletes with profound sensorineural hearing loss recorded normal response for VEMP clicks. Furthermore, in 28 out of 32 ears (87.5%), VEMP response with normal 500 Hertz tone-burst was obtained[19]. This finding was in agreement with the obtained VEMP response in the present study using 500 Hertz tone-burst stimulus since VEMP response was recorded using the tone-burst stimulus in the 18-40 adult population with no history of vestibular disorders.

According to the above mentioned points, VEMP response can be recorded in people with severe to profound hearing loss and profound low hearing. Contradiction in the percentage level of cases with recordable VEMP responses is caused by the difference in the causes for sensorineural hearing loss, their probable effect on saccule and stimulus types.

CONCLUSION

Considering the results of this study, it can be concluded that VEMP response is independent from cochlear performance, is evoked by stimulating ears with profound hearing loss and can be considered in evaluating the balance performance of deaf and hard-of-hearing patients.

ACKNOWLEDGMENTS

Authors would like to appreciate Abdoreza Sheibanizadeh, and Akram Pourbakht, the academia of Rehabilitation Faculty of Tehran University of Medical Sciences, and Homa Zarrinkoub from Rehabilitation Faculty of Shahid Beheshti University of Medical Sciences for their contribution in this study.

REFERENCES

1. Colebatch JG, Halmagyi GM, Skuse NF. Myogenic potentials generated by a click-evoked vestibulocollic reflex. *J Neurosurg Psychiatry.* 1994; **57**:190-7.
2. Rosengren SM, Todd NPM, Colebatch JG. Vestibular-evoked extraocular potentials produced by stimulation with bone conducted sound. *Clin Neurophysiol* 2005; **116**: 1938-48.
3. Iwasaki Sh. Ocular vestibular-evoked myogenic potentials to bone conduction vibration in vestibular schwannomas. *Otology& neurotology*. 2009; **31**: 147-52.
4. Zhou G, Kenna MA, Stevens k, Licameli G. Assessment of saccular function in children with sensorineural hearing loss. *Arch Otolaryngol Head Neck Surg*. 2009; **135**(1): 40-44.
5. Ackley S. Contributions of hearing loss to the VEMP measurement. 2006. Audiology Online. Available at:http://www.audiologyonline.com/ askexpert /display_question.asp? question_ id=443. Accessed March 23, 2011.
6. Ozeki H, Matsuzaki M, Murofushi T. Vestibular evoked myogenic potentials in patients with bilateral profound hearing loss. *J Otorhinolaryngol.* 1999; **61**(2): 80-3.
7. Hullar TE, Page NC, Minor LB. Vestibular physiology disorder of the labyrinth. In: Gulay AJ, minor LB, Poe DS, editors. Surgery of the ear. 6th ed. USA: PMPH-USA; 2010. P. 113.
8. Rosengren SM, Colebatch JG. Vestibular evoked potentials (VsEPs) in patients with severe to profound bilateral hearing loss. *Clin Neurophysiol*. 2006; **117**: 1145-53.
9. Carey JP, Minor LB. Disorder that affect central and peripheral vestibular function. In: Goebel JA, editor. Practical management of the dizzy patient. philadelphia: Lippincott Williams & Wilkins; 2008. p. 458.
10. -Wang SJ,Jaw FS, Young YH .Ocular vestibular-evoked myogenic potentials elicited from monaural versus binaural acoustic stimulations. *Clin Neurophysiol*.2009;**120**:420-423.
11. Cheng PW ,Chen Ch, Wang Sh, Young Y. Acoustic, mechanical and galvanic stimulation modes elicit ocular vestibular-evoked myogenic potentials. *Clin Neurophysiol*.2009; **120**:1841-44.
12. Sazgar A, Akrami K , Akrami S, Karimi Yazdi A. Recording of vestibular evoked myogenic potentials. *Acta Medica Iranica.* 2006; **44**: 13-16.
13. Colebatch JG, Halmagyi GM. Vestibular evoked potentials in human neck muscles before and after unilateral vestibular deafferentation. *Neurology.* 1992; **42**: 1635-6.
14. Akin FW, Murnane OD. Vestibular evoked myogenic potentials: Preliminary report. *J Am Acad Audiol.* 2001;**12**: 445–52.
15. Welgampola MS, Colebatch JG. Vestibulocollic reflexes: normal values and the effect of age. *Clin Neurophysiol.* 2001;**112**:1971–9.
16. Zagolski O. An acoustically evoked short latency negative response in profound hearing loss infant. *Auris Nasus Larynx.* 2008; **35**(3): 328-32.
17. Sazgar A, Dortaj V, Akrami K, Akrami S, Karimi Yazdi AR. Saccular damage in patients with high-frequency sensorineural hearing loss. *Eur Arch Otorhinolaryngol*. 2006; **263**: 608-13.
18. Emara A. Acoustically evoked short latency negative response (ASNR) in children with hearing loss. *J Laryngol Otol.* 2009; **124**(2): 141-6.
19. Jin Y, Munetaka U, Hayasi A, Takegoshi H, Nakajima Y, Kaga K. Vestibular myogenic potentials of athletes for the Deaf Olympic Games with congenital profound hearing loss. *Acta Otolaryngol*. 2010; **130**(8): 935-41.