Available online at www.sciencedirect.com

ScienceDirect

Journal of Otology 11 (2016) 192−197

www.journals.elsevier.com/journal-of-otology/

Evaluation of ocular and cervical vestibular evoked myogenic potentials in a conductive hearing loss model

Peng Han [a], Rui Zhang [a,b], Zichen Chen [a], Ying Gao [a], Ying Cheng [a], Qing Zhang [a,*], Min Xu [a,**]

[a] Department of Otorhinolaryngology-Head and Neck Surgery, Ear Institute, Second Affiliated Hospital, Xi'an Jiaotong University College of Medicine, Xi'an, 710004 China

[b] Department of Otorhinolaryngology-Head and Neck Surgery, Xi'an Children's Hospital, Xi'an, 710004 China

Received 22 October 2016; revised 20 December 2016; accepted 20 December 2016

Abstract

Objective: To investigate the effects of conductive hearing loss (CHL) on vestibular evoked myogenic potentials (VEMPs) using a simulated CHL model, and to provide the basis for future studies.

Methods: Twenty-one healthy subjects were recruited in this study. We measured ocular VEMPs (oVEMPs) and cervical VEMPs (cVEMPs) in these subjects by air-conduction sound (ACS) stimulation. CHL was simulated later by blocking the right external auditory canal with a soundproof earplug to evaluate its impacts on VEMPs. Subjects' responses before simulated CHL served as the control, and were compared to their responses following simulated CHL.

Results: oVEMPs following simulated CHL showed decreased response rate, elevated thresholds, attenuated amplitudes and prolonged N1 latencies compared with those before simulated CHL, and the differences were statistically significant. Similarly, cVEMPs following simulated CHL also showed decreased response rate, elevated thresholds and attenuated amplitudes, with prolonged P1 latencies compared with those before simulated CHL, although only differences in response rate, threshold and amplitude were significant.

Conclusions: Conductive hearing loss affects the response rate and other response parameters in oVEMPs and cVEMPs.

Keywords: Conductive hearing loss; Ocular vestibular evoked myogenic potentials (oVEMPs); Cervical vestibular evoked myogenic potentials (cVEMPs); Model; Vestibular function

1. Introduction

Vestibular evoked myogenic potentials (VEMPs) are neurophysiological assessment techniques to evaluate the patient's vestibular functions (Colebatch and Halmagyi, 1992; Halmagyi et al., 1994). Based on the location of recording electrodes as well as the response origin, VEMPs can be chiefly categorized into ocular VEMPs (oVEMPs) and cervical VEMPs (cVEMPs) (Zhang et al., 2014a). The cVEMPs can be recorded from the sternocleidomastoid muscle, and is considered to be generated via the inferior vestibular nerve (Papathanasiou et al., 2014). The oVEMPs can be recorded from the contralateral inferior oblique muscle and is elicited mainly through the superior vestibular nerve (Curthoys, 2010; Curthoys et al., 2011). Several stimuli are used to elicit VEMPs, such as air-conducted sound (ACS), bone-conducted sound (BCV), and galvanic vestibular stimulation (GVS), among which ACS is the major and widely-used stimulus (Miyamoto et al., 2006; Curthoys et al., 2011). Because waves of ACS-VEMPs require loud sound stimulation to be evoked,

* Corresponding author. Fax: +86 29 87275892.
** Corresponding author. Fax: +86 29 87275892.
E-mail addresses: zhqent@163.com (Q. Zhang), ent551205@163.com (M. Xu).

Peer review under responsibility of PLA General Hospital Department of Otolaryngology Head and Neck Surgery.

http://dx.doi.org/10.1016/j.joto.2016.12.002

1672-2930/

impairment of sound transmission by ear diseases may affect VEMPs measurement. These ear diseases may include chronic otitis media (Lee et al., 2014), otosclerosis (Zhou et al., 2012), sudden sensorineural hearing loss (Niu et al., 2015) and Meniere's disease (Sandhu et al., 2012).

Conductive hearing loss (CHL) is a common presentation in patients visiting ENT clinics, and typically includes abnormalities of the outer and middle ear. Primary causes of CHL include cerumen, infection, perforation of tympanic membrane, fluid in the middle ear and ossicular chain disarticulations (Yueh et al., 2003). Impaired sound transmission in CHL may affect VEMPs measurement in vestibular function assessment. For example, Halmagyi et al. reported that cVEMPs were absent when air-bone gap was greater than 20 dB (Halmagyi et al., 1994). In addition, Bath et al. showed that cVEMPs were successfully elicited in only two of the 23 tested ears in the presence of CHL (Bath et al., 1999). However, CHL's impacts on VEMPs response rate and other measured parameters, especially for oVEMPs, remain largely unknown. Therefore, it is crucial to determine specific impacts on VEMPs parameters by CHL. In this study, using a simulated CHL model with soundproof earplugs, we tested CHL's impacts on VEMPs responses rate, threshold, amplitude, as well as P1 and N1 latencies.

2. Materials and methods

2.1. Subjects

Twenty-one healthy subjects (mean age = 24.52 ± 3.33 years; range 19−35 years, 13 males and eight females) were recruited by the following criteria: no history of any ear disorders; no history of any vestibular disorders; passed otoscopy, acoustical impedance, and pure tone audiometry tests. This study was approved by the Institutional Review Board of the Second Affiliated Hospital of Xi'an Jiaotong University School of Medicine, and each subject signed an informed consent.

2.2. CHL simulation

The right external auditory canal in the 21 subjects was blocked using a plastic soundproof earplug of appropriate sizes (Fig. 1). Following the blockage, pure tone audiogram (PTA) showed an average hearing threshold across 500, 1000, 2000 and 4000 Hz in the blocked ear at 30.24 ± 5.53 dB HL, and an average air-bone gap (ABG) of 22.66 ± 4.28 dB (range 16.67−28.33 dB).

2.3. oVEMPs and cVEMPs recording

All tests were performed in a sound-proofed examination room. For VEMPs testing. ACS (500 Hz tone bursts) was presented through a calibrated headphone. oVEMPs and cVEMPs recording techniques have been described previously (Sheykholeslami et al., 2001; Zhang et al., 2014b). Namely, for oVEMPs testing, two active electrodes were placed below the lower margin of each eyelid, while the reference electrodes were placed 1−2 cm below each active electrode. A ground electrode was placed on the median line of the forehead. The subject lay down in a supine position and was asked to look upwards when hearing the sound. For cVEMPs testing, an active electrode was placed at the mid point of each sternocleidomastoid muscle, the reference electrode was placed on the surface of sternoclavicular joint on each side, and a ground electrode on the median line of the forehead. The subject was asked to raise his/her head to increase tension of the SCM muscle.

2.4. oVEMPs and cVEMPs measurement

Both oVEMPs and cVEMPs were recorded before and after the simulated CHL. The response rate, threshold (dB nHL), P1 and N1 latencies (ms), interpeak intervals (ms), and amplitudes (μV) were measured. Repeatable biphasic waveforms were regarded as a positive response, whereas unrepeatable or unrecognizable waveforms were regarded as non-responses. The positive (P1) and negative (N1) peaks in the recorded biphasic waveform were marked for both cVEMPs and oVEMPs. The threshold was the lowest stimulus intensity to elicit a recognizable and repeatable biphasic waveform. The length of time between 0 ms and the peak of P1 or N1 was recorded as P1 or N1 latency, respectively, and the period between the peaks of P1 and N1 was determined as the interpeak interval. Amplitude was determined as the vertical distance of voltage between the peaks of P1 and N1.

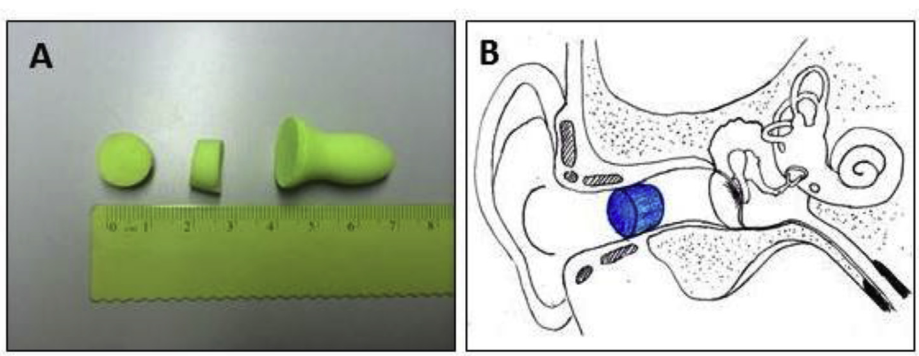

Fig. 1. (A) Plastic soundproof earplugs (B) Sketches showing right external auditory canal blockage.