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Clinical Neurophysiology 116 (2005) 401–405

www.elsevier.com/locate/clinph

Sound-evoked neurogenic responses with short latency of vestibular origin

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Accepted 3 September 2004

Abstract

Objective: In ABR recording, a large negative deflection with a latency of 3 ms (N3) has been recorded in patients with peripheral profound deafness. It has been suggested that N3 might be of vestibular origin. So far, N3 has been recorded only in patients with peripheral profound deafness. If we can record N3 potentials in subjects with preserved hearing, recording N3 potentials might be a new clinical test of the vestibular system. To record neurogenic potentials (N3) of vestibular origin in healthy volunteers and patients with vestibular disorders.

Methods: Twelve healthy volunteers (10 men and two women, aged 23–37 years) and 12 patients with vestibular disorders (6 men and 6 women, aged 29–71 years) were enrolled in this study. To record responses, surface electrodes were placed on the ipsilateral mastoid and the vertex. An electrode on the nasion served as the ground. Recording was performed using an auditory evoked potential recording system with a mini-mixer and a stereo-amplifier. Signals at the vertex to the ispilateral mastoid were amplified and bandpass filtered (100–3000 Hz). One thousand-hertz short tone bursts (1 kHz STB; rise/fall time = 0.5 ms, plateau time = 1 ms) were presented to either ear through a headphone with or without white noise (WN) ipsilateral to the stimulated ear. The stimulation rate was 10 Hz, and the analysis time was 10 ms. The responses to 500 stimuli were averaged twice.

Results: When 1 kHz STB (95 dBnHL, equivalent to 130 dBSPL) were presented with 100 dBSPL WN (ipsilateral to the stimulated ear), a negative peak with 3–4 ms latency (N3) was observed in 23 of the 24 ears (95.8%) with reproducibility in healthy subjects. Without WN, N3 was observed in 17 of the 24 ears (70.8%). The threshold of N3 was 90.2 dBnHL on the average. The presence of N3 in the patients was in agreement with the presence of the VEMP, which were also recorded.

Conclusions: Using techniques of WN exposure ipsilateral to the stimulated ear, we recorded N3 in healthy subjects and in vestibular disorder patients with preserved hearing. This negative peak is likely to be of vestibular origin.

Significance: N3 may be measured from subjects who cannot contract neck muscles due to their ages, mental states, or consciousness disorders. In other words, N3 may be measured from subjects from whom VEMP cannot be recorded. In combination with VEMP, N3 may be useful for the detection of lesion sites.

Keywords: ABR; Vestibular; VEMP; Saccule; Otolith; Evoked potential; Tone burst

1. Introduction

The auditory brain-stem responses (ABR) have been widely used as a clinical test of the auditory pathway. The ABR consist of fast waves and slow waves within 10 ms after the onset of stimulation. Of the fast waves, five positive peaks (waves I–V) are well known. Apart from these positive waves, Kato et al. (1998) reported that a large negative deflection with a latency of 3 ms (N3) could be recorded in patients with peripheral profound deafness. Nong et al. (2002) and Ochi and Ohashi (2001) suggested that N3 might be of vestibular origin, saccular origin in particular as is the vestibular evoked myogenic potential (VEMP). They recorded N3 only in patients with peripheral profound deafness. If we can record N3 potentials in subjects with preserved hearing, recording N3 potentials could be a new clinical test of the vestibular system.

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1388-2457/$30.00
doi:10.1016/j.clinph.2004.09.005

It would be applicable to subjects with consciousness disorders or infants. We tried to record N3 potentials in subjects with preserved hearing.

2. Materials and methods

2.1. Subjects

Twelve healthy volunteers (10 men and two women, aged 23–37 years) and 12 patients with vestibular disorders (6 men and 6 women, aged 29–71 years) were enrolled in this study. The clinical diagnoses of the patients were Meniere disease in 6 patients, acoustic neuroma in 4, vestibular neuritis in one, and sudden deafness with vertigo in one. Informed consent was obtained from all of the subjects.

2.2. Methods

To record responses, surface electrodes were placed on the ipsilateral mastoid and the vertex. An electrode on the nasion served as the ground. Recording was performed using an auditory evoked potential recording system (Neuropack Sigma, Nihon Kohden Co., Ltd, Tokyo, Japan) with a mini-mixer (MN04, Fostex) and a stereo-amplifier (NS901, Maruei Electric Co., Ltd, Tokyo, Japan) (Takegoshi and Murofushi, 2003). Signals at the vertex to the ipsilateral mastoid were amplified and bandpass filtered (100–3000 Hz). One thousand-hertz short tone bursts (1 kHz STB; rise/fall time = 0.5 ms, plateau time = 1 ms, fixed polarity) were presented to either ear through a headphone (Type DR-531, Elga Acous Co., Ltd, Tokyo, Japan) with or without white noise (WN) ipsilateral to the stimulated ear. The intensity of the STB was from 95 dBnHL (equivalent to 130 dBSPL) to 65 dBnHL. The stimulation rate was 10 Hz, and the analysis time was 10 ms. The responses to 500 stimuli were averaged twice. In figures of this paper, a negative wave recorded at the vertex was displayed upwards.

Based on a preliminary study, we regarded the peak as N3 when the following conditions were fulfilled. Firstly, the negative peak at the vertex to the ipsilateral mastoid should be reproducible. Secondly, the negative peak should appear 3–5 ms after the onset of the stimulation. Thirdly, the onset to peak amplitude, with onset defined as the starting point of the deflection toward the negative peak, should be more than 0.05 μV. If there are two or more candidates of N3, we regarded the largest peak as N3.

The patients also underwent vestibular evoked myogenic potential (VEMP) testing (Colebatch et al., 1994; Murofushi et al., 1996, 1999), caloric testing, and pure tone audiometry. The tests were performed at random.

VEMP was recorded between an electrode on the middle of the SCM (sternocleidomastoid muscle) with respect to an electrode on the lateral end of the upper sternum. The ground electrode was on the nasion. As acoustic stimuli, 95 dBnHL clicks (0.1 ms) were used. Electromyographic activities were amplified and bandpass-filtered (20–2000 Hz). The stimulation rate was 5 Hz, and the analysis time was 50 ms. Responses to 100 stimuli during SCM contraction for acoustic stimulation were averaged twice. To contract the SCM, the subjects were asked to raise their heads from the pillow.

To record caloric nystagmus, electronystagmography (ENG) was used. To calculate the canal paresis (CP), we used the maximum slow phase eye velocity (Murofushi et al., 2002).

This study was approved by the local ethics committee.

3. Results

3.1. Healthy volunteers

3.1.1. Negative potentials with short latency

When 1 kHz STB (95 dBnHL, equivalent to 130 dBSPL) were presented with 100 dBSPL WN (ipsilateral to the

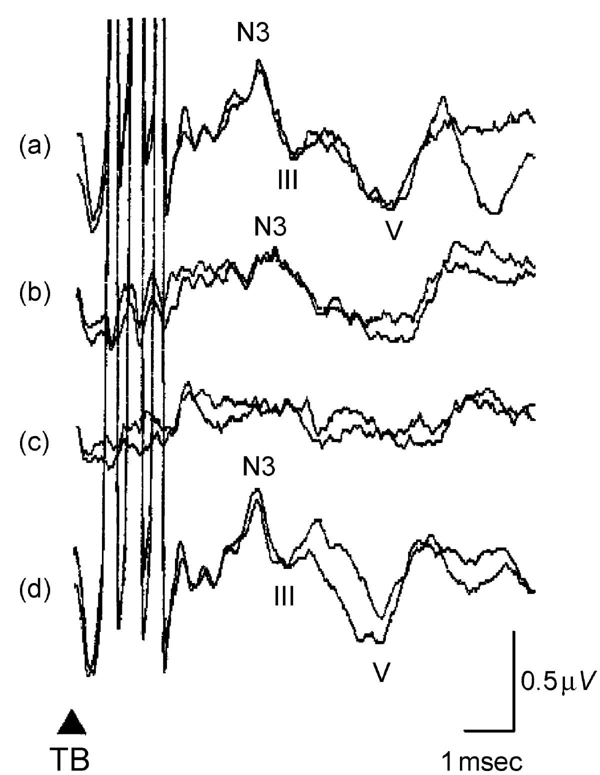

Fig. 1. N3 of a 35-year-old healthy man. (a) Responses to 95 dBnHL (equivalent to 130 dBSPL) 1 kHz STB with ipsilateral 100 dBSPL WN. (b) Responses to 85 dBnHL 1 kHz STB with ipsilateral 100 dBSPL WN. (c) Responses to 75 dBnHL 1 kHz STB with ipsilateral 100 dBSPL WN. (d) Responses to 95 dBnHL 1 kHz STB without WN. He showed N3 to 95 dBnHL and 85 dBnHL 1 kHz STB with ipsilateral 100 dBSPL white noise (WN). However, he did not show N3 to 75 dBnHL 1 kHz STB with ipsilateral 100 dBSPL WN. In all of the figures, negativity at the vertex electrode is displayed upwards. III and V show waves III and V of auditory brain-stem responses (ABR).