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Correlation between auditory brainstem response and hearing prognosis in idiopathic sudden sensorineural hearing loss patients

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ABSTRACT

Objective: To investigate the latency and amplitude of auditory brainstem response (ABR) and hearing prognosis in patients with idiopathic sudden sensorineural hearing loss (ISSNHL).
Methods: Patients with ISSNHL were classified into four different recovery groups. All patients' clinical and demographic features were analyzed. Two-channel ABRs were collected in response to click stimuli at 90 dB nHL. ABR amplitudes for wave I and ABR latency for waves I, III, and V were analyzed.
Results: One hundred and two patients (54 men and 48 women) were included in the study. Hearing recovery was observed in 72 cases (70.6%). Waves I, III, and V latencies were significantly prolonged in the affected ears compared with the unaffected ears. A smaller wave I amplitude was found in the affected ear compared with the unaffected ear in the three recovery groups. There was a significant association between wave I latency and hearing outcome ($p = 0.009$) with a prolonged trend from complete to slight hearing recovery group.
Conclusions: There was a significant correlation between wave I latency and hearing outcome in patients with ISSNHL. The finding may provide diagnostic information and serve as a potential prognostic indicator in patients with ISSNHL.

1. Introduction

Idiopathic sudden sensorineural hearing loss (ISSNHL) has an annual incidence of approximately 20/100,000 people; it is a medical emergency and remains a challenge for the clinician [1,2]. The definition of ISSNHL refers to have a hearing loss of at least 30 dB in 3 consecutive frequencies in 72 h [3]. The etiology of ISSNHL is still controversial and is reported to result from vascular diseases, viral infection, inner ear immune diseases, and cochlear membrane rupture [3]. In view of these, the prognosis of the final hearing after treatment is variable. Physicians have explored several prognostic factors, such as age, presence or absence of vertigo, type and severity of hearing loss, shape of the audiogram, and timeliness of treatment initiation to predict hearing prognosis for patients with ISSNHL [4,5].

Some auditory electrophysiological studies also have been reported as prognostic factors, including auditory brainstem response (ABR) [4,6,7], electrocochleography [1], distortion product of otoacoustic emission [8], and vestibular function tests [7,9]. ABR is an electrophysiological response primarily to

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the onset of a sound and is used for detecting the auditory pathway integrity and identifying retrocochlear lesion. It consists of up to seven waveform peaks occurring within a 10 ms window after sound stimulation [10]. Waves I and II arise in the distal and proximal auditory nerves, respectively, whereas wave III is generated from within the cochlear nucleus. Wave V arises from the end of the lateral lemniscal tract within the inferior colliculus [11]. The detection of these wave amplitudes and latencies may help differentiate lesions in the cochlear auditory pathways from those in the central auditory pathways [12].

Reports about the evaluation and prognostic prediction of ISSNHL by recording ABR metrics (wave I amplitude and wave I, III, and V latencies) are sparse [1,4]. Moreover, recent data from animal studies showed that wave I amplitude could be an indicator of the degree in auditory nerve fibers deafferentation even after full recovery from temporary noise-induced hearing loss [13,14]. It is unknown whether a similar condition exists in recovered patients with ISSNHL. The aim of the present study was to assess the findings of ABR metrics and their relationship with final hearing outcome in patients with ISSNHL.

2. Materials and methods

2.1. Participants

From January 2011 to December 2013, 102 patients with ISSNHL were treated at the Department of Otolaryngology–Head and Neck Surgery, Tri-Service General Hospital, Taipei, Taiwan. Those having a previous history of otologic surgery in the affected ear, fluctuating or relapsing hearing loss, or nasopharyngeal carcinoma were excluded from the study. The medical history with diabetes mellitus and hypertension were reviewed as comorbidities. An Ethical Committee approval was obtained and the study was conducted in accordance with the Helsinki Declaration. Before analysis, the patients' data and personal information were anonymized and de-identified.

The following data was collected from medical records: gender, age, affected side, symptom of vertigo, time from onset to treatment, initial hearing level (presenting as the worst during admission), and hearing gain (3 months' follow-up after treatment). The patients who were compatible with ISSNHL criteria were included and were admitted to our hospital when the hearing loss onset within 2 weeks. The treatment and follow-up protocols were specified with our previous paper [3]. Briefly, the medication included systemic intravenous high-dose betamethasone following tapered dose within 6 days and intravenous low molecular dextran 500 ml administration every day. We followed the hearing level by pure tone audiogram (PTA) at an interval of 2 days during admission and monitored at 1, 4, 8, and 12 weeks after discharge.

2.2. ABR measurement

ABR was measured in all patients during hospitalization. ABR testing was performed using a Biologic Navigator-Pro Evoked Potential System (Bio-logic Systems Corp., Mundelein, Illinois). The electrode montage is arranged with noninverting electrode placed at the vertex and the inverting electrode placed on the ipsilateral earlobe with a common electrode located on forehead. The stimuli were presented at 90 dB nHL through ER-3 insert earphones. The clicks were presented at rarefaction polarity stimuli with a stimulation rate of 11.7/s in each ear monaurally. Using a filter setting of 100–3000 Hz, responses to 1024 click stimuli were averaged for each run and digitized in a 15-ms time window. Replication across at least two samples of 1024 runs was used to determine the reliability of a waveform. Positive peak latencies for waves I, III, and V, and peak-to-trough wave I amplitude were identified using visual overlay cursors on a computer screen. We used contralateral masking noise with a level 65 dB SPL to mask the unaffected ear.

2.3. Criteria for hearing recovery classifications

We adopted the Sudden Deafness Research Group (SDRG) criteria reported by the Japanese Ministry of Welfare for analyzing the hearing recovery based on the 5-frequency average of thresholds at 250, 500, 1000, 2000, and 4000 Hz [15]. The worst PTA during admission was defined as the initial hearing loss, and the recovery PTA was monitored on the day after 3-month follow-up. Hearing gain indicates the difference of the hearing level between initial hearing loss and after 3-month follow-up. The degree of hearing recovery was calculated according to the SDRG criteria (Table 1). We also categorized the patients into five groups of hearing impairment on the basis of the initial hearing levels (calculated as decibels hearing level [dBHL]): $<$40 dBHL indicated mild impairment; 41–55 dBHL indicated moderate impairment; 56–70 dBHL indicated moderately severe impairment; 71–90 dBHL indicated severe impairment; and $\geq$91 dBHL indicated profound impairment.

2.4. Statistics

The Statistical Package of Social Science (SPSS Inc., Chicago,IL) for Windows version 21.0 was used to analyze the data. Demographic and clinical characteristics were analyzed using means and standard deviations for continuous variables. Recovery group differences were determined using the paired t test and one-way analysis of variance (ANOVA), followed by Scheffe's post hoc test. All statistical tests were two-tailed, and values of $p < 0.05$ were considered statistically significant.

Table 1
Degree of hearing recovery from sudden hearing loss according to the Sudden Deafness Research Group of the Japanese Ministry of Welfare.

Hearing recovery	Degree
Complete recovery	Patients in whom all the thresholds of 250, 500, 1000, 2000, and 4000 Hz recover within 20 dB or recover to the same threshold level of the other ear
Partial recovery	Patients whose arithmetic hearing gain average of the 5 frequencies is not less than 30 dB
Slight recovery	Patients whose arithmetic hearing gain average of the 5 frequencies is 10–30 dB
No recovery	Patients whose arithmetic hearing gain average of the 5 frequencies is less than 10 dB