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# The critical warning sign of real-time brainstem auditory evoked potentials during microvascular decompression for hemifacial spasm

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HIGHLIGHTS

- Critical warning sign of real-time BAEP during MVD for hemifacial spasm have been studied.
- Loss of wave V and the significant change of both latency and amplitude are the critical signs.
- Isolated wave V latency prolongation of >1 ms without amplitude loss >50% is not saaociated with postoperative hearing loss.

ABSTRACT

*Objective:* The aim of this study was to define the critical warning sign of real-time brainstem auditory evoked potential (BAEP) for predicting hearing loss (HL) after microvascular decompression (MVD) for hemifacial spasm (HFS).

*Methods:* Nine hundred and thirty-two patients with HFS who underwent MVD with intraoperative monitoring (IOM) of BAEP were analyzed. We used a 43.9 Hz/s stimulation rate and 400 averaging trials to obtain BAEP. To evaluate HL, pure-tone audiometry and speech discrimination scoring were performed before and one week after surgery. We analyzed the incidence for postoperative HL according to BAEP changes and calculated the diagnostic accuracy of significant warning criteria.

*Results:* Only 11 (1.2%) patients experienced postoperative HL. The group showing permanent loss of wave V showed the largest percentage of postoperative HL ($p < 0.001$). No patient who experienced only latency prolongation (≥1 ms) had postoperative HL. Loss of wave V and latency prolongation (≥1 ms) with amplitude decrement (≥50%) were highly associated with postoperative HL.

*Conclusions:* Loss of wave V and latency prolongation of 1 ms with amplitude decrement ≥50% were the critical warning signs of BAEP for predicting postoperative HL.

*Significance:* These findings elucidate the critical warning sign of real-time BAEP.



## 1. Introduction

Hemifacial spasm (HFS) presents as involuntary, intermittent spasm and is caused by facial nerve compression, secondary to arterial or venous compression at the root exit zone (REZ) (Barker et al., 1995; McLaughlin et al., 1999). Microvascular decompression (MVD) surgery, which involves relieving neurovascular compression, is a widely popular treatment for HFS (Jannetta, 1975; Barker et al., 1995). Since the vestibulocochlear nerve is

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directly adjacent to the facial nerve, the vestibulocochlear nerve can be damaged during MVD surgery, which could lead to hearing loss (HL) (Barker et al., 1995; Park et al., 2009). Brainstem auditory evoked potential (BAEP) is a tool that can monitor the functional integrity of the auditory pathway (1995), and postoperative HL is being significantly reduced through intraoperative monitoring (IOM) of BAEP during MVD surgery for over 30 years (Radtke et al., 1989; Acevedo et al., 1997; Polo et al., 2004; Sindou, 2005).

To prevent postoperative HL during MVD surgery effectively, the IOM of BAEP must meet two important conditions. First, as nerve injury can occur within a very short time, it is important to obtain reliable BAEP waves in as short a time as possible. Second, the warning criteria to predict postoperative HL must be reliable. The American Clinical Neurophysiology Society recommended a stimulus rate of 5–12 Hz/s and an averaging time of 1000–4000 for IOM of BAEP (American Clinical Neurophysiology, 2006). However, this protocol is limited in its ability to prevent postoperative HL since a relatively long time is required to obtain the BAEP. Therefore, many physicians have already used a protocol for obtaining a reliable BAEP in a short time using a faster frequency and shorter averaging times (Thirumala et al., 2014). We also developed a protocol to obtain real-time BAEP within about 9 s using a 43.9-Hz/s stimulation rate and an averaging time of 400 trials, which allowed us to significantly reduce postoperative HL during MVD surgery (Joo et al., 2016). Although there have been many advances in protocols for obtaining BAEP in a shorter time frame, there is still no consensus for the reliable warning criteria for predicting postoperative HL. A latency prolongation of 1 ms or an amplitude decrement of at least 50% on two successive trials has empirically been thought to be associated with postoperative HL, and these warning criteria are still used arbitrarily (James and Husain, 2005; Loiselle and Nuwer, 2005).

To better prevent postoperative HL in patients with HFS, identifying the reliable warning sign of BAEP is very important when using a protocol to obtain a reliable BAEP in a short time. Therefore, we tried to define the critical warning signs associated with postoperative HL when using our new protocol for real-time BAEP.

## 2. Methods

### 2.1. Subjects

We enrolled 952 patients with primary HFS who underwent MVD surgery with IOM of BAEP from January 2014 to December 2016 at Samsung Medical Center (SMC). This study was approved by the Regional Committee for Ethics in Medical Research at Samsung Medical Center (IRB No. 2015-08-040). The inclusion criteria for primary HFS were unilateral facial spasm demonstrated by synkinetic activities and an abnormal lateral spread evoked motor response on electromyography. Using brain magnetic resonance imaging, patients with secondary HFS were excluded. The clinical severity of HFS was evaluated using the SMC novel grading system (Lee et al., 2012).

### 2.2. Surgical technique

MVD was performed under general anesthesia using total intravenous anesthesia. With the patients placed in the lateral decubitus position, the surgeon performed a small retromastoid craniectomy. After confirming facial nerve compression by a specific blood vessel, the surgeon moved the vessel by dissecting the arachnoid bands that tethered it, and a Teflon pledget was placed between the vessel and the nerve to attain adequate decompression. All MVD surgeries were performed by a single neurosurgeon (K.P.).

### 2.3. Audiologic evaluation and hearing loss criteria

To define HL more accurately, we conducted pure tone audiometry (PTA) scores and speech discrimination scoring (SDS) (Polo et al., 2004; Sindou, 2005). PTA and SDS were performed on all patients prior to surgery, and those tests were conducted repeatedly at 7 days after surgery. The average PTA thresholds for 500, 1000, 2000, and 3000 Hz were calculated. We determined postoperative HL status based on the Association of Otolaryngology-Head and Neck Society (AAO-HNS) classification system (1995)Postoperative HL (class C/D) was defined as PTA > 50 dB and/or SDS < 50% within the speech frequency range. During preoperative hearing evaluations, the patients with preoperative HL (classes C and D) were excluded from the analysis.

### 2.4. Intraoperative monitoring of BAEP

All MVD surgeries for HFS were conducted under continuous IOM of BAEP. Our technique for IOM of BAEP was described previously (Joo et al., 2016). BAEP stimuli were delivered through transducers that connected to plastic tubing with a sponge collar at the end. As a stimulus mode, alternating polarity clicks were used, and stimulus intensity was set to 120 dB (SPL = Sound Pressure Level). White noise at 80 dB was also applied to the contralateral ear. We used subdermal needle electrodes for recording, and the electrodes were inserted at the vertex (Cz) and over the ipsilateral and contralateral earlobes. The amplifier bandpass was set to 150–3000 Hz for all channels. To obtain the BAEP, we used a 43.9 Hz/s stimulation rate and 400 averaged trials, and we were able to obtain the BAEP within about 9.1 s (Joo et al., 2016). By placing the monitoring equipment in the operating room, the neurophysiologist could immediately alert the surgeon when latency prolongation of 1 ms or amplitude decrement of at least 50% of wave V occurred, and the surgeon immediately performed surgical corrective maneuvers only when an amplitude decrement of at least 50% of wave V occurred.

### 2.5. Analysis of BAEP parameters

The absolute latencies and amplitudes of waves I, III, and V of the BAEPs were identified. As wave V of BAEP was the most robust, we also used wave V for our analyses, consistent with previous studies (James and Husain, 2005; American Clinical Neurophysiology, 2006, Martin and Stecker, 2008). The amplitude and the latency of wave V were continuously monitored and compared to the baseline during the MVD surgery.

To define the critical warning signs of BAEP for predicting postoperative HL, the patients were classified into six groups based on the greatest change of wave V compared to the baseline during IOM of BAEP: Group A: no significant changes, Group B: greatest latency prolongation greater than 1 ms without amplitude reduction greater than 50%, Group C: amplitude reduction greater than 50% without greatest latency prolongation greater than 1 ms, Group D: greatest latency prolongation greater than 1.0 ms and amplitude reduction greater than 50%; Group E: transient loss of wave V; and Group F: Permanent loss of wave V. Transient loss was considered as wave-V peaks that recovered to baseline in amplitude and latency before surgery completion and the patient was considered to have persistent BAEP loss when the waves did not recover before the end of surgery.

### 2.6. Statistical analysis

Fisher's exact test was used to define the significant difference of the incidence for postoperative HL among the groups. A $p$ value

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