

Case Report

Hints to localization; the usefulness of brainstem auditory evoked potential monitoring in ependymoma removal surgery

Jongmok Ha^{1,2}, Dong Jun Kim^{1,2}, Yeon Hak Chung^{1,2}, Jae Rim Kim^{1,2}, Suk Geun Han³, Dae-Won Seo^{1,2*}

¹Department of Neurology, Samsung Medical Center, Sungkyunkwan University School of Medicine, Seoul, Korea

²Neuroscience Center, Samsung Medical Center, Seoul, Korea

³Department of Neurology, Samsung Changwon Hospital, Sungkyunkwan University School of Medicine, Changwon, Korea

ABSTRACT

Brainstem auditory evoked potential (BAEP) is an effective neurophysiologic assessment tool for intraoperative monitoring during the surgery of posterior fossa tumors. A 12-month-old male presented with posterior fossa ependymoma. BAEP monitoring was performed during tumor removal surgery. During manipulation of the tumor around right cerebellopontine angle, ipsilesional ipsilateral BAEP wave I, III, and V amplitudes were abruptly decreased to less than 50% from the baseline data. However, the contralesional, contralateral BAEPs were stable. This finding suggests that peripheral lesion sparing the brainstem can be the main cause of wave changes because the contralesional, contralateral BAEP reflects the functional integrity of ipsilesional brainstem auditory pathway. In BAEP monitoring, contralesional contralateral BAEP may not only be helpful in localizing the lesion itself, but also in ensuring the brainstem integrity during surgical manipulation.

Keywords: evoked potentials; auditory; brain stem; neuroanatomy; cranial fossa, posterior

Introduction

Brainstem auditory evoked potentials (BAEPs) are widely used in monitoring the integrity of longitudinal network from the acoustic nerve to the auditory cortex [1]. Posterior fossa surgery, such as cerebellopontine angle (CPA) tumor removal is where BAEP monitoring has the most value. Tracking changes in amplitudes of wave I, III, V and interpeak intervals of I-III, III-V, and I-V in close temporal relationship to surgical maneuver is imperative throughout the surgery, since it may influence the surgical outcome [2-5]. As a normative rule, the ipsilesional ipsilateral channel wherein stimulation is occurring has the most direct value during monitoring, and the contralateral channel will be used only as a control; the same is true for the contralesional channel. Nevertheless, we herein present a case describing the role of contralesional, contralateral channel in BAEP monitoring during surgical removal of infratentorial extramedullary ependymoma.

Case

A 12-month old male with no prior medical history presented to the hospital with symptoms of neck hyperextension, difficulty in sitting down, standing up, walking, and crying when laid down in supine position that started five days ago. Brain MRI revealed a 3 × 5 cm cerebellar mass occupying both (more predominantly in the right) CPA and 4th ventricle, which resulted in hydrocephalus (Fig. 1-A, Fig. 1-B). An alleged diagnosis of ependymoma was made and extraventricular drainage (EVD) for obstructive hydrocephalus was performed prior to tumor removal operation to relieve intracranial pressure. Three days after EVD insertion, suboccipital craniotomy and tumor removal operation were done under general anesthesia, with intraoperative neurophysiological monitoring of somatosensory evoked potential (SEP), motor evoked potential (MEP), free-running electromyography (EMG) and BAEP.

Total intravenous anesthesia with midazolam 3 mg,

Received August 5, 2019; Revised September 5, 2019; Accepted September 13, 2019

*Corresponding author: Dae-Won Seo, Department of Neurology, Samsung Medical Center, Sungkyunkwan University School of Medicine, Seoul 06351, Korea
Tel: +82-2-3410-3595, Fax: +82-2-3410-0052, E-mail: daewon@skku.edu

© 2019 Korean Society of Intraoperative Neurophysiological monitoring (KSION)

This is an Open Access article distributed under the terms of the Creative Commons Attribution Non-Commercial License (<http://creativecommons.org/licenses/by-nc/4.0/>) which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

2% propofol 1,000 mg, and remifentanyl 0.5mg were used. Neuromuscular blockade was performed just before intubation with rocuronium 6.4 mg. During the whole operation, train-of-four ratio was kept above 2.

BAEP was obtained by monitoring the two-channels placed in bilateral mastoid processes (A1 and A2, left and right respectively), referenced to Cz when 43.9 Hz auditory stimuli was given by 1.5 msec/div using an in-ear microphone. Bilateral latencies and amplitudes from waves I-V were recorded at baseline.

SEP was obtained from median nerve and posterior tibial nerve. For median nerve SEP, square-wave pulses were administered for 0.2 ms at 15 mA, at frequency of 5.1 Hz. For posterior tibial nerve SEP, square-wave pulses were administered for 0.2 ms at 20 mA, at frequency of 5.1 Hz. Four-channel recording electrodes were placed at C3', Cz', C4', and Fpz. Bilateral N20

latencies were recorded at baseline.

MEP was evoked by delivering train-of-five square-wave transcranial electrical stimuli, each lasting 0.2 ms with an intensity of 400 volts and inter-stimulus interval of 2 ms. The output was recorded in abductor pollicis brevis and abductor digiti quinti muscles for upper extremities and tibialis anterior and abductor hallucis muscles in lower extremities. The baseline MEP threshold was 300 volts.

Free-running EMG was performed in bilateral orbicularis oculi, orbicularis oris, and trapezius muscles.

During surgery, ipsilesional ipsilateral channel in right BAEP already had decreased amplitude from the baseline, but as surgical removal in the right CPA proceeded, wave I, III, and V amplitudes decreased more severely, down to less than 50%. However, the contralesional, contralateral channel demonstrated

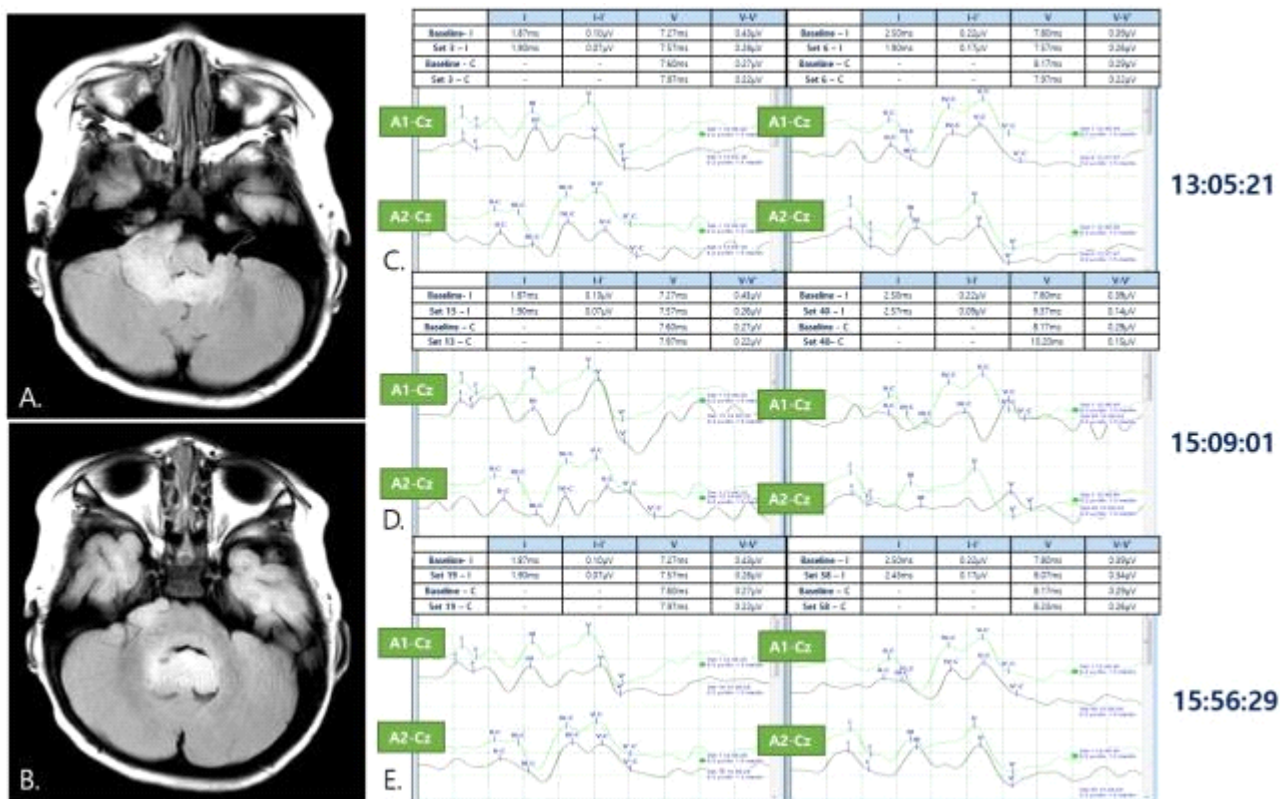


Fig. 1. Brain MR imaging and BAEP monitoring during ependymoma surgery. (A, B) The axial Brain MRI FLAIR images, taken 5 days after initial symptom onset, show ependymoma in the fourth ventricle and at cerebellopontine angles. (C-E) The results of BAEP monitoring are archived as baseline (13:05:21), changed (15:09:01) and closing (15:56:29) data. The baseline data showed clear, stable peaks (I, III, and V) at left and right BAEP (C). The changed data reveals reduced peak amplitude in waves I, III, V, and increased I-III, I-V, III-V inter-peak latencies at right BAEP, but stable waves at A2-Cz in left BAEP during detachment and suctioning-out of right lateral recess tumor (D). The closing data shows recovered BAEP near the end of the surgery (E). BAEP: brainstem auditory evoked potential; MRI: magnetic resonance imaging; FLAIR: fluid attenuated inversion recovery.

stable BAEP throughout the surgery (Fig. 1-C, Fig. 1-D, Fig. 1-E). No subsequent intervention other than close observation was performed in response to this change. The tumor was grayish, suitable for suction, and was completely removed from both lateral recesses. Restoration of ipsilesional ipsilateral BAEP was observed after successful removal of ependymoma in the right CPA, 4 minutes after first detection of decreased wave I amplitude. SEP remained stable throughout the surgery. No abnormal neurotonic discharges were observed in free-running EMG.

Discussion

The present case illustrates a promising role of monitoring contralateral channel during BAEP monitoring. In cases where ipsilesional ipsilateral BAEP is already attenuated from or after wave I, brainstem pathways are prone to underestimation. The contralesional contralateral BAEP however, has strength in that the brainstem pathways are relatively free of tumor-laden bias of the periphery from acoustic nerve to superior olive. Therefore, in our case, although ipsilesional ipsilateral channel amplitudes were decreased, stable contralesional contralateral BAEP suggested that the brainstem auditory pathway was relatively intact, suggesting that the BAEP fluctuation was probably caused by transient compression and traction of BAEP pathways during surgical manipulation than direct damage to the brainstem.

Functional assessment of brainstem pathway is important because it represents the invasiveness of the tumor. Ependymomas are generally not invasive, but aggressive anaplastic ependymomas can infiltrate the brainstem [6]. Compressive effect by large-growing ependymomas are possible, and obstructive hydrocephalus can cause compression in the longitudinal pathways linking brainstem nuclei to the auditory cortex [7,8]. Contralesional contralateral BAEP monitoring, along with ipsilesional ipsilateral BAEP, remains a useful adjunctive tool in assessing the functional integrity of brainstem through the auditory pathways.

Furthermore, BAEP monitoring can aid in localization of tumor inside the longitudinal axis: intrame-

dullary vs. extramedullary. Imaging is a guiding tool to differentiate the degree of involvement, but form does not always reflect function, and cases with micro-invasion to the brainstem had been reported [6]. This information not only can facilitate the quality of surgical performance but also guide to understanding the surgical outcome of the patient.

BAEP is an accurate and reliable indicator of auditory pathway, which can be used in non-invasive fashion, regardless of state of consciousness [9]. BAEP is commonly used for localization of lesion along the auditory pathway by measuring latencies and amplitudes in the stimulation-sided channel (ipsilateral A-Cz). Usually, intraoperative BAEP monitoring adopts the same method of routine BAEP tests, so the waves on the nonstimulation-sided channel may not be of interest practically. However, our case demonstrates that the nonstimulation-sided channel (contralateral A-Cz) at contralesional ear could give some useful information on interpreting the wave changes. Our example emphasizes that a broader interpretation of auditory pathway is possible, using contralesional contralateral channel in BAEP monitoring during posterior fossa tumor surgery.

Ethical approval

This article does not require IRB/IACUC approval because there are no human and animal participants.

Conflicts of interests

No potential conflict of interest relevant to this article was reported.

ORCID

Jongmok Ha, <https://orcid.org/0000-0003-4886-7650>
Dong Jun Kim, <https://orcid.org/0000-0002-2306-0757>
Yeon Hak Chung, <https://orcid.org/0000-0002-7052-2432>
Jae Rim Kim, <https://orcid.org/0000-0002-3404-199X>
Suk Geun Han, <https://orcid.org/0000-0002-4299-2015>
Dae-Won Seo, <https://orcid.org/0000-0002-9266-9355>

References

1. Legatt AD. Mechanisms of intraoperative brainstem auditory evoked potential changes. *J Clin Neurophysiol.* 2002;19(5):396-408.
2. Radtke RA, Erwin CW, Wilkins RH. Intraoperative brainstem auditory evoked potentials: significant decrease in postoperative morbidity. *Neurology.* 1989; 39(2 Pt 1):187-91.
3. Thirumala PD, Krishnaiah B, Habeych ME, Balzer JR, Crammond DJ. Hearing outcomes after loss of brainstem auditory evoked potentials during microvascular decompression. *J Clin Neurosci.* 2015;22(4):659-63.
4. Polo G, Fischer C, Sindou MP, Marneffe V. Brainstem auditory evoked potential monitoring during microvascular decompression for hemifacial spasm: intraoperative brainstem auditory evoked potential changes and warning values to prevent hearing loss-prospective study in a consecutive series of 84 patients. *Neurosurgery.* 2004;54(1):97-104.
5. Moller MB, Moller AR. Loss of auditory function in microvascular decompression for hemifacial spasm. Results in 143 consecutive cases. *J Neurosurg.* 1985; 63(1):17-20.
6. Snuderl M, Chi SN, De Santis SM, Stemmer-Rachamimov AO, Betensky RA, De Girolami U, et al. Prognostic value of tumor microinvasion and metalloproteinases expression in intracranial pediatric ependymomas. *J Neuropathol Exp Neurol.* 2008;67(9):911-20.
7. Prasad KSV, Ravi D, Pallikonda V, Raman BVS. Clinico-pathological study of pediatric posterior fossa tumors. *J Pediatr Neurosci.* 2017;12(3):245-50.
8. Cachia D, Johnson DR, Kaufmann TJ, Lowe S, Andersen S, Olar A, et al. Case-based review: ependymomas in adults. *Neurooncol Pract.* 2018;5(3):142-53.
9. Nodar RH, Hahn J, Levine HL. Brain stem auditory evoked potentials in determining site of lesion of brain stem gliomas in children. *Laryngoscope.* 1980; 90(2):258-66.