



Original Article

Microvascular decompression for typical trigeminal neuralgia: Personal experience with intraoperative neuromonitoring with level-specific-CE-Chirp® brainstem auditory evoked potentials in preventing possible hearing loss

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ABSTRACT

Background: Permanent hearing loss after posterior fossa microvascular decompression (MVD) for typical trigeminal neuralgia (TTN) is one of the possible complications of this procedure. Intraoperative brainstem auditory evoked potentials (BAEPs) are used for monitoring the function of cochlear nerve during cerebellopontine angle (CPA) microsurgery. Level-specific (LS)-CE-Chirp® BAEPs are the most recent evolution of classical click BAEP, performed both in clinical studies and during intraoperative neuromonitoring (IONM) of acoustic pathways during several neurosurgical procedures.

Methods: Since February 2016, we routinely use LS-CE-Chirp® BAEPs for monitoring the function of cochlear nerve during CPA surgery, including MVD for trigeminal neuralgia. From September 2011 to December 2018, 71 MVDs for TTN were performed in our department, 47 without IONM of acoustic pathways (Group A), and, from February 2016, 24 with LS-CE-Chirp BAEP (Group B).

Results: Two patients of Group A developed a permanent ipsilateral anacusia after MVD. In Group B, we did not observe any permanent acoustic deficit after surgery. In one case of Group B, during arachnoid dissection, intraoperative LS-CE-Chirp BAEP showed a temporary lag of V wave, resolved in 5 min after application of intracisternal diluted papaverine (0.3% solution without excipients).

Conclusion: MVD is widely considered a definitive surgical procedure in the management of TTN. Even though posterior fossa MVD is a safe procedure, serious complications might occur. In particular, the use of IONM of acoustic pathways during MVD for TTN might contribute to prevention of postoperative hearing loss.

Keywords: Brainstem auditory evoked potentials, Hearing preservation, Level-specific-CE-Chirp stimuli, Microvascular decompression, Retrosigmoid approach, typical trigeminal neuralgia

INTRODUCTION

Typical trigeminal neuralgia (TTN) is characterized by severe temporary facial pain in the distribution of the trigeminal nerve that is unilateral, paroxysmal, provokable, and without

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sensory loss.^[2,5,9,25] The pain is triggered by sensory stimuli. The incidence of TTN is reported to be approximately 4/100,000 population and gradually increases with age; the condition is rare before 40 years of age and the average age of onset is 60 years.^[2,5,9,25]

Microvascular decompression (MVD) is the most effective treatment for patients with TTN. The success rate ranges from 80% to 90% and postoperative mortality is 0.1% (0.02–0.2).^[4,11,13,23,25] Complications included incisional infection, facial palsy, facial numbness, cerebrospinal fluid (CSF) leak, and hearing reduction or loss. In particular, hypo or anacusia is observed in 1–2% of cases.^[1,10,18,23,25,26]

Using of intraoperative neuromonitoring (IONM) with brainstem auditory evoked potentials (BAEP) and avoiding of impairment of the acoustic nerve might contribute to the prevention of the postoperative hearing impairment.^[7,22] In particular, LS-CE-Chirp® BAEPs seem to be the fastest noninvasive monitoring technique of cochlear nerve in cerebellopontine angle (CPA) and skull base surgery.^[7,15,16] Using LS-CE-Chirp® BAEP, neurosurgeon can be alerted in 10–15 s about variation of conduction parameters of acoustic pathways.^[7,15,16]

We report our preliminary experience with IONM of acoustic pathways with BAEP evoked with LS-CE-Chirp for minimizing hearing loss associated with MVD for TTN, comparing the results with those a previous series operated on without any cochlear nerve monitoring.

MATERIALS AND METHODS

From September 2011 to December 2018, 71 patients with TTN were operated on with MVD by retrosigmoid (RS) approach. The patients were divided into two groups: forty-seven patients operated on without IONM of acoustic pathways (Group A) and 24 patients intraoperatively monitored with LS-CE-Chirp BAEP (Group B).

Patients included in this study had socially useful hearing. In particular, selection criteria were pure tone audiogram better than 50 dB loss and speech discrimination score better than 50% (50/50 criterion; AAO-HNS Class A-B).^[6] In all cases of Group B, LS-CE-Chirp® BAEPs were performed preoperatively, to evaluate the best parameters (acoustic level and frequency of stimulation) for obtaining clear wave V (and sometimes wave III).

LS-CE-Chirp BAEPs are currently used by neuro-otological unit of our hospital and approved from Internal Ethics Committee for neurosurgical intraoperative monitoring too. For this reason, we did not request the approval for this retrospective observational study.

According to the International Headache Society,^[5] the diagnosis for typical TN was based on the following criteria:

1. Paroxysmal attacks lasting from few second to maximum 2 min
2. Distribution of severe intensity pain along one or more trigeminal divisions
3. Quality of pain: sudden, burning or stabbing, intense, sharp, and superficial
4. Precipitation from trigger points or by definite daily activities
5. No symptoms between the attacks
6. Absence of neurological deficits
7. Exclusion of other possible causes of facial pain
8. Positive response to carbamazepine.

Magnetic resonance imaging was performed in all cases for searching possible neurovascular conflict with the root entry zone (REZ) of trigeminal nerve. Patients who had previous MVD or who were classified as American Society of Anesthesiologists (ASA) Grade III or higher were excluded from the study.

The operative outcomes are subjectively considered to be: (a) excellent (complete relief), if patients became pain free; (b) good (partial relief), if patients tolerated the pain well with medications or referred mild pain not requiring medications; and (c) poor, if patients had minimal or no relief from TTN or presented neurological deficits (even if not severe).

Surgical procedure

Patients were operated on in lateral position, under general anesthesia. The RS craniectomy was approximately 3 squared-cm, with exposition of sigmoid and transverse sinuses. Dura mater was opened and CSF was slowly released from arachnoid upper part of CPA cistern, to obtain cerebellar decompression. Using microneurosurgical technique and instruments, the arachnoid surrounding the trigeminal nerve was opened sharply. The entire cisternal part of the nerve was exposed from the REZ. Conflicting vessels were gently dissected and moved away from the nerve; among them, small pieces of Teflon were inserted to prevent relapse of the compression. Small pieces of fibrillary surgical and gel foam were placed around and fibrin glue was applied for fixing the vessel in the new position. The superior petrosal vein (SPV) and its main branches were protected and spared. The dura was closed accurately and the bone reapplied with miniplates and miniscrews.

IONM of cochlear nerve in Group B

Since February 2016, we routinely use LS-CE-Chirp® BAEP (Nicolet Viking III, Viasys HealthCare, Madison USA/Hochberg, Germany) for monitoring the function of cochlear nerve during CPA surgery, including MVD for TTN. BAEPs evoked with LS-CE-Chirp® (Interacoustics Eclipse-EP15

ABR system) provide enhanced neural synchronicity and faster detection of larger amplitude wave V.^[7]

Each patient received a BAEP audiometry immediately before surgery. BAEPs were evoked with LS-CE-Chirp® stimuli by means subdermal needles or surface electrodes placed at the vertex (Cz) and on each earlobe (A1 and A2).

Sound pressure ranged between 60 dB and 100 dB HL. Contralateral ear was masked with noise at 50 dB HL. During arachnoidal dissection around 5th, 7th, and 8th nerves and vessels, on surgeon's request, one or more series of 400–1200 acoustic stimuli were performed.

RESULTS

General data

The mean age of the entire cohort was 59.8 ± 5.4 years (range, 40–84 years). There were 22 men and 49 women. There were not relevant differences in the mean age and sex distribution between Groups A and B. All patients were in ASA Grade I or II.

The second and third branches of trigeminal nerve were affected most frequently in both cohorts. The superior cerebellar artery (SCA), alone or in association with other vessels, was the dominant conflicting vessel in 62 cases (87.3%), without relevant differences between Groups A and B. Other vessels involved alone or coinvented were anterior-inferior cerebellar artery (AICA) in eight cases, the vertebral artery in three, and the petrosal vein in one patient.

Outcome: Pain control

At a mean follow-up 28.5 ± 5.3 months (range, 10 months–7 years), 63 patients (88.7%) had good pain outcome without necessity of any medication for pain. A total of 7 patients (9.9%) experienced recurrence of pain during the follow-up. An 84-year-old woman died 6 months after surgery for basal ganglia spontaneous cerebral hemorrhage.

Complications

Surgical mortality was zero in both cohorts. Headaches, nausea, and vomiting were minor and transient complications after surgery equally distributed in both groups, successfully treated with symptomatic medical therapy. One patient had CSF leak repaired with conservative treatment and one had small cerebellar hematoma gradually reabsorbed.

Hearing outcome

Two patients of Group A developed a permanent ipsilateral anacusia after MVD (AAO-HNS Class D).^[6] In both cases, a ventral loop of SCA was the offending vessel at the REZ

of trigeminal nerve; both patients had good pain outcome without necessity of any medication for pain, but judged the result as average/poor because of the hearing complication.

No one of the patients of Group B had a postoperative permanent reduction of hearing or anacusia. In a 62-year old man, intraoperative BAEP showed a lag of V wave of 1 ms during arachnoid dissection, likely due to vasospasm of internal auditory artery (IAA) probably caused by arachnoid tractions. Intracisternal injection of pure papaverine without excipients (60 mg/2 ml), diluted in 20 cc of 0.9% saline solution, was used as a direct treatment of vasospasm.^[20] The elongation of the V wave resolved 5 min after application of topical papaverine. At the end of surgery and at last follow-up, the patient did not have any hearing impairment.

DISCUSSION

According to Love and Coakham (2001), the segmental demyelination of trigeminal sensory nerve at the entry point in the brainstem is the cause of idiopathic TTN; the demyelination is usually related to chronic compression of the nerve root where it comes out from the pons.^[12] This chronic compression provokes a microinjury of the trigeminal nerve fibers compressed by a vessel, which may result in hyperexcitability of the trigeminal nucleus.^[4,21] Most theories, however, consider compression from an artery (usually the SCA) and/or a vein at the trigeminal nerve exit point as the main cause of typical TN.^[4,11,13,25]

The first line of treatment is medical therapy, usually carbamazepine or other similar antiepileptic drugs. In addition, ablative procedures are as glycerol injections, radiosurgery, and radiofrequency rhizotomy.^[11] According with the current international literature,^[11,23,25] MVD performed by RS approach is the most effective treatment for patients with TTN.^[4] Chen *et al.* (2014) demonstrated that compression of the trigeminal nerve by an artery or by arachnoid adhesions is most often the causes of TTN.^[4] An immediate postoperative pain-free condition is observed in the majority of patients operated on by expert neurosurgeons.^[4,23,25] In addition, age itself does not seem to represent a major contraindication of MVD for TN.^[14]

In their large systematic review on 6847 MVDs performed for TTN, Xia *et al.* (2014) reported a success rate of 83.5%, a surgical mortality of 0.1%, and some possible complications as facial numbness (9.1%), facial palsy (2.9%), CSF leak (1.6%), and incisional infection (1.3%). In particular, hearing deficits may occur in 1.9% (0.2–3.9%).^[25] To minimize possible side effects, including hearing impairment, Tomasello *et al.* (2016) suggested to open widely the arachnoid of the superior portion of CPA with enough CSF outflow, for obtaining exposure without retractors, to preserve the SPV, to handle gently the VIII cranial nerve (CN), and to preserve its vascularization.^[23]

As mentioned, one of the most relevant complications of MVD is hearing loss. In particular, conductive hearing loss (CHL) is usually transient and caused by middle ear impairment secondary to fluid entering the mastoid air cells during craniotomy. Sensorineural hearing loss (SNHL) is more likely permanent and can be potentially caused by stretching of CN VIII while retracting the cerebellum, direct trauma to CN VIII, manipulation of labyrinthine artery or of AICA, new compression of the nerve by the spacer material, and trauma from drill noise or warming.^[1,10,18,23,25,26] The distinction between CHL and SNHL is critical when the audiogram is performed during the 1st day after surgery.^[1] Therefore, timing of the audiogram becomes important because an observation period of 2–3 months will allow for middle ear and mastoid fluid to resolve and conductive hearing to normalize in most patients.

IONM is very useful for reducing the incidence of SNHL after MVD. In a retrospective study evaluating the length of cerebellar retraction and the changes of intraoperative BAEP during MVD, Lee *et al.*^[10] observed that the distance from the cerebellar surface of the petrous temporal bone to the neurovascular compression point is strongly correlated to hearing-loss. In particular, BAEP changed immediately after cerebellar retraction in 7 out of 12 postoperative deaf patients.^[10]

By means transcranial Doppler ultrasonography assistance, Qi *et al.* (2015)^[19] demonstrated that 53.8% of patients of their series of vestibular schwannomas experienced asymptomatic vasospasm. These data confirm that cerebral circulation shows a high reactivity to surgical trauma – like indirect arachnoid traction – of smaller arteries of CPA, with possible vasospasm and SNHL.

The treatment and prevention of vasospasm could minimize the possible vascular injuries of acoustic nerve. After inducing mechanically vasospasm of IAA in animal model, Morawski *et al.* demonstrated how topical diluted papaverine (PPV) influenced successfully the distortion of otoacoustic emissions.^[17] Proposed mechanism of the action of PPV includes direct vasodilation and cAMP-mediated effect.^[17] Vargas *et al.*^[24] published a systematic review of the literature of pharmacologic treatments of intraoperative vasospasm: they found that PPV ensures arterial microanastomosis patency, 116% increase of blood flow in comparison to control, and some degree of prevention of vasospasm.^[4,21] Time to effect after topical application ranges from 1 to 5 min.^[8] Several doubts persist about dose-related efficacy and complications of intracisternal PPV.^[27] Even if although definitive data are not available, according to Chadwick *et al.*,^[3] 0.3% solution without excipients represents an effective dose for vasospasm with lower risks of cranial neuropathies. Our surgical practice is in line with the literature:^[3] we use 60 mg of PPV diluted in 20 cc of 0.9%

saline solution at the end of any CPA surgical procedure for tumor or MVD, without any side effect.

Among several existing monitoring methods, intraoperative BAEP is useful and reliable for the preservation of hearing function in patients undergoing MVD, as suggested by many authors. The American Clinical Neurophysiology Society and American Society of Neurophysiological Monitoring recommend to alert the surgeon when significant changes in BAEP occur, especially when wave V latency increases ≥ 1.0 ms and/or amplitude decreases $\geq 50\%$.^[22]

Level-specific (LS) CE-Chirp® BAEPs are the most recent evolution of classical click BAEP, performed both in clinical studies and IONM of acoustic pathways during several neurosurgical procedures.^[7] LS-CE-Chirp® is a new group of acoustic stimuli, latter evolution of Broadband CE-Chirp®, providing faster recording of large amplitude BAEP V waves. While the original Broadband CE-Chirp® was conceived for optimal response amplitude of V wave at low and medium stimulation intensities, the LS-CE-Chirp® provides clearer I-III-V waves at high intensities.^[7] In our experience, LS-CE-Chirp® BAEPs represent a safe and effective method in IONM of cochlear nerve during CPA surgery.^[7,14,16,20] BAEP evoked by click stimulus needs a series of about 1000 stimuli to evoke a clear and monitorable V wave.^[7,22] For evoking a clear V wave with LS-CE-Chirp®, a series of about 600 stimuli are sufficient. This means that IONM is faster than classical BAEP, because they need a reduced numbers of stimulations at the double frequency. LS-CE-Chirp® BAEP V wave also showed a more clear morphology, without shoulders in IV-V waves complex, common finding in classical BAEP.^[7] This can allow an easiest detection of V wave in doubtful cases.

LS-CE-Chirp® BAEPs are currently in our department used since 2016, for IONM of cochlear nerve during CPA surgery, including MVD for TTN. On comparing 47 MVDs for TTN without IONM of acoustic pathways (Group A) and 24 with LS-CE-Chirp BAEP (Group B), we observed that two patients of Group A experienced a postoperative permanent ipsilateral anosmia, whereas in Group B, no one of the patients had a permanent acoustic impairment after MVD. In one case, during arachnoid dissection, intraoperative IONM showed a transient elongation of V wave, resolved 5 min after the application of intracisternal diluted PPV (0.3% solution without excipients).^[20]

CONCLUSION

MVD represents the definitive microsurgical procedure for curing TTN. Even though it is widely considered a safe procedure, SNHL and other complications might occur. The use of IONM of cochlear nerve might contribute to prevent postoperative hearing deficits.

Ethical approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee (name of institute/committee) and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Declaration of patient consent

Patient's consent not required as patients identity is not disclosed or compromised.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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