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Original Research

The value of abnormal muscle response monitoring during microvascular decompression surgery for hemifacial spasm

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ABSTRACT

Background and objectives: Abnormal muscle response (AMR) to the electrical stimulation of a branch of facial nerve is a specific electrophysiological feature of primary hemifacial spasm (HFS). The aim of this study was to evaluate the value of AMR monitoring during microvascular decompression surgery (MVD), and the correlation between the AMR changes and the clinical outcomes.

Methods: This study included 241 cases of MVDs. Intraoperative AMR monitoring was performed for each subject. The patients were divided into two groups based on whether the AMR-disappeared or not following decompression of the facial nerve.

Results: Postoperatively, 229 (95.0%) patients were relieved from the spasm, 215 (93.9%) occurred in the AMR-disappeared group, 14 (6.1%) in the non-AMR-disappeared group. The correlation between intraoperative AMR abolition and HFS relief was statistically significant.

Conclusions: Intraoperative AMR monitoring was an effective assistant for a successful MVD for the patient with HFS. It is worth being routinely employed during the operation.

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1. Introduction

Hemifacial spasm (HFS), a syndrome of unilateral facial nerve hyperactive dysfunction, is a benign, chronic, involuntary movement of one side of the face. It is a severe and disabling condition that causes impairments in patients' daily life.¹ The etiology has been generally agreed to be the result of vascular compression of the facial nerve.^{2–4} Over the past three decades, microvascular decompression (MVD) surgery has been exhibited as an effective treatment of this condition.^{5,6} Nevertheless, spasm remained following MVDs have still been reported around 10%–30%,^{7,8} even if it was carried out by an experienced neurosurgeon. Therefore, a real time monitoring which can be employed to objectively predict the efficacy of MVD seems to be required.

For patients with HFS, an abnormal muscle response (AMR) can be elicited by electrical stimulation of a branch of the facial nerve and recorded from muscles innervated by other branches of the facial nerve. It can be recorded pre-operatively and intraoperatively in most patients. This response is useful for electrophysiological

diagnosis of HFS.^{7,9–11} It is especially notable that the AMR observed in other muscles disappears immediately after the offending vessel is moved off the facial nerve.^{11–13} So, it is supposed to be a useful indicator in identifying the offending vessels and in confirming complete decompression of the facial nerve intraoperatively. Accordingly, we conducted a retrospective study in order to evaluate the role of AMR monitoring during the surgery and the relation with the outcome.

2. Patients and methods

2.1. Patient population

From March to June 2010, 241 consecutive patients with typical HFS undergoing MVDs at Xinhua Hospital were included in this study. They were 58 males and 183 females, with a mean age of 53.3 years (ranging from 19 to 84 years). The right side was affected in 122 patients and the left in 119. The length between onset and surgery ranged from 0.5 to 28 years (mean 6.5 years). The diagnosis of HFS was based on the clinical history of typical symptom and physical examination. All patients underwent pre-operative 3D-TOF magnetic resonance image (MRI) scan to rule out other disease.

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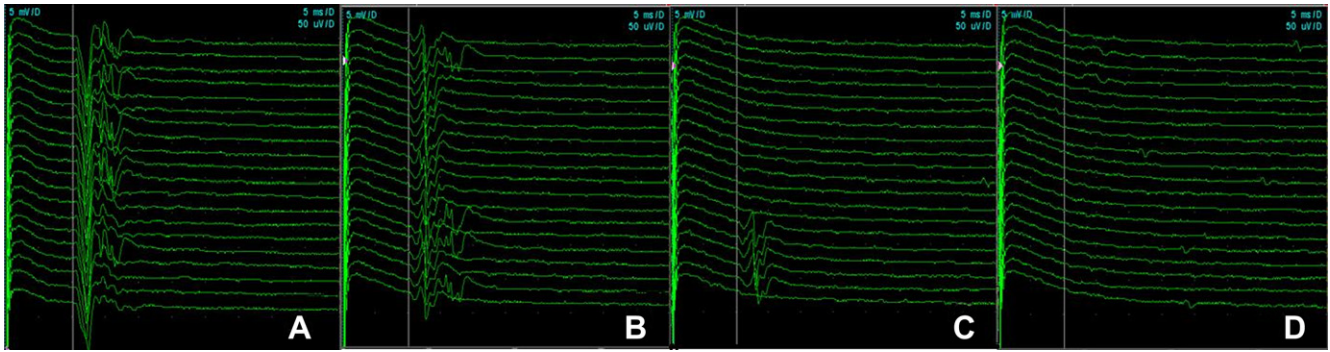


Fig. 1. Typical changes of AMR during MVD. Intraoperative AMR monitoring depicting a gradual disappearance of AMRs during craniotomy (A), dura opening (B), decompression of facial nerve (C) and closure (D), respectively.

2.2. Intraoperative monitoring

With the methods proposed by Møller,¹¹ AMR recordings were achieved from the mentalis muscle by electrical stimulation of the temporal branch of the facial nerve and from the orbicularis oculi muscles by stimulation of the marginal mandibular branch, with an evoked potential system (Medtronic Keypoint 4, Dantec, Denmark).

After induction of anesthesia using a short-duration muscle relaxant, bipolar subdermal needle electrodes were inserted 0.5–1 cm apart subcutaneously on the affected side. Electrical stimulation, consisted of square-wave pulses (duration: 0.2 ms) was adjusted to supramaximal strength, and the frequency is 0.5 Hz. Electrical stimulation and electromyographic recordings were filtered through a 5 Hz to 3 kHz band pass (gain: 500 mV/division; analysis time: 50 ms). Usually, a stable AMR was recorded at a stimulation intensity level of 5–15 mA. To avoid nerve fatigue, the AMR was evoked with a 5-min interval before dura opening. Once the dura was opened, the AMR was recorded continuously until the end of the operation. During the decompression of culprit vessels, the AMR may decrease in amplitude or frequency. At that moment, we would increase the stimulation intensity to the maximal value of 100 mA. If this still did not induce the AMR, we would consider the facial nerve to be completely decompressed.

2.3. Operative procedure

The surgery was performed with a standardized procedure as described previously.^{6,14–18} The retro-mastoid microsurgical approach was performed while the patient was in the lateral decubitus position. After the edge of the sigmoid sinus was identified, the dura mater was opened. The VIIth and VIIIth cranial nerves were approached inferolaterally. With the arachnoids being opened, gentle retraction of the cerebellum was used to expose the

entire intracranial facial nerve. The offending vessel was moved away from the nerve and a soft shredded Teflon was put between them. At the time when the AMR-disappeared, we believed a satisfactory decompression was obtained and the operation was over by then. When the AMR was found to be persistent despite decompression had been done, we kept looking for any other suspected underlying causes such as possible compression by another vessel until we confirmed that there was no further neurovascular confliction in the entire nerve root course.

2.4. Outcome evaluation

All patients were evaluated at day 1, day 90, day 180 post-operatively. The postoperative result was considered ‘relief’ when the spasm disappeared or the symptom (frequency and degree) improved more than 75%, ‘no relief’ when decrease in spasms was less than 25% or unchanged.

2.5. Statistical analysis

Data processing was performed using commercial available software (SAS, version V8). Chi-square test and grouped t test were used to assess the correlation between the intraoperative AMR and the clinical outcome. The level for statistical significance was a probability value of less than 0.05.

3. Results

3.1. AMR findings

With intraoperative facial EMG monitoring, an AMR wave with a latency of around 10 ms after stimulation was observed before the decompression in all the 241 cases. Except for 21 patients (8.7%), an apparent disappearance of AMR was observed in most of the patients (91.3%) at the end of the surgery. (Fig. 1). It occurred on dura opening in 47, and after the decompression in 173. However,

Table 1
Time course of postoperative outcomes with association of intraoperative AMR recordings.

Group	No. of cases	Day 1		Day 90		Day 180	
		HFS (-)	HFS (+)	HFS (-)	HFS (+)	HFS (-)	HFS (+)
AMR-disappeared	220	205	15	214	6	215	5
Non-AMR-disappeared	21	12	9	14	7	14	7
Total	241	217	24	228	13	229	12
P value		<0.01		<0.01		<0.01	

HFS (-): the spasm disappeared or the symptom (frequency and degree) improved more than 75%; HFS (+): the spasm decreased less than 25% or unchanged.

Table 2
Demographic data of patients.

Items	Group		P value
	Non-AMR-disappeared (n = 66)	AMR-disappeared (n = 175)	
Age (yrs)	53 ± 2.3	53 ± 2.7	0.07
Duration of symptom (yrs)	6 ± 0.5	6 ± 0.5	0.09
Sex (M/F)	10/56	45/130	0.08
Side (rt/lt)	42/24	93/82	0.14

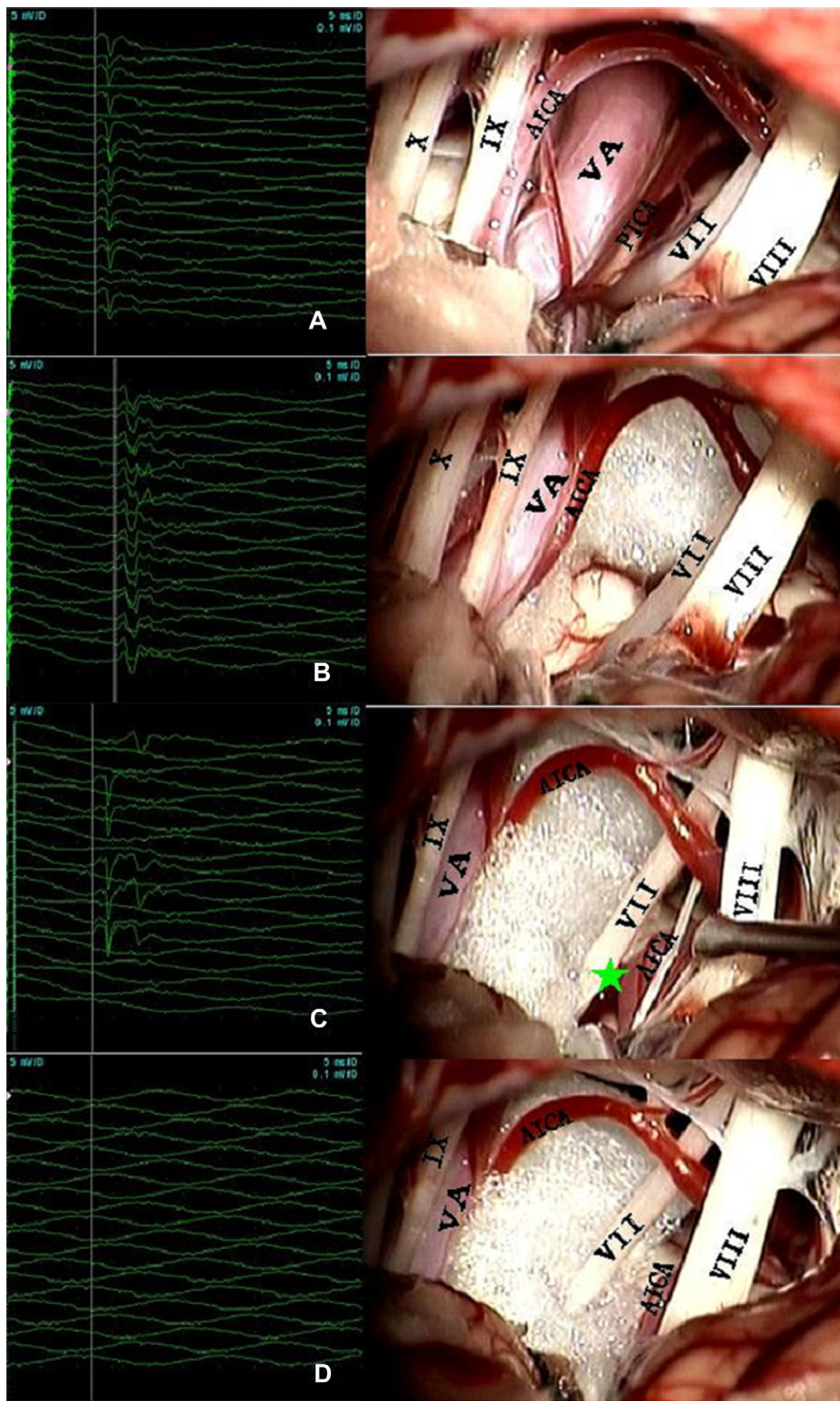


Fig. 2. AMR guiding the MVD process. In this case, the posterior inferior cerebellar artery (PICA), raised from a tortuous vertebral artery (VA) and contacted the facial nerve, might thought to be the offending vessel without AMR monitoring (A). However after decompression of the artery, the AMR didn't disappeared (B), which drove the surgeon to search the real confliction continually. After the acoustic nerve was retracted off, an anterior inferior cerebellar artery (AICA) contacted the nerve rostrally was realized. The AMR was finally disappeared following the AICA was mobilized away from the nerve. (C, D). * The real conflict site.



Fig. 3. Apparent changes of AMR in some postoperative improved patients. The amplitude of AMR decreased >80%.

10 of them, the AMR reappeared upon the accomplishment of the operation. With reviewing the video recordings attentively, the dura was opened again in 5, whom were suspected of an unsatisfied decompression or the real offending artery being missed. A thorough exploration of entire VII cranial nerve course was then resumed till the AMR was eventually vanished. Postoperatively, all those patients with double check experienced spasm resolution. Meanwhile, among the other 5, whom were believed a satisfied MVD had been done, 4 still had HFS.

3.2. Correlation between AMR and outcomes

Day 1 postoperatively, the spasm had completely stopped in 217 of the 241 patients (90.0%). 24 patients still had spasm; they were 15 in AMR-disappeared group and 9 in non-AMR-disappeared group.

Day 90 postoperatively, 11 patients improved and the residual 13 still had spasm. They were 6 in AMR-disappeared group and 7 in non-AMR-disappeared group.

Day 180 postoperatively, another 2 patients improved and the remained 11 patients still had spasm. They were 4 in AMR-disappeared group and 7 in non-AMR-disappeared group.

Finally, 229 patients relieved. Among them, 215 were in AMR-disappeared group and 14 in non-AMR-disappeared group. The correlation between AMR abolition and symptom disappearance was significant ($p < 0.01$). (Table 1). Yet, the demographic data were not significantly different between groups (Table 2), which indicated that the disappearance of the AMR has no relation with the age, duration of symptom, sex or suffered side.

The sensitivity was 94.5%, 93.9%, 93.9% at day 1, day 90 and day 180 postoperatively. The specificity was 37.5%, 53.8%, 58.3%, and the accuracy was 88.8%, 91.7%, 92.1%, respectively.

3.3. Complications

There was no mortality or severe complication occurred postoperatively with the exception of transient conductive-type hearing impairment and ear fullness in 7 (2.9%), immediate facial weakness in 5 (2.1%), delayed facial weakness in 11 (4.6%), cerebrospinal fluid leak in 3 (1.2%).

4. Discussion

Several studies have suggested that intraoperative monitoring of the AMR is useful for identifying the offending vessels and for confirming a successful decompression of the facial nerve.^{14,19–22} The phenomenon of AMR-disappeared after decompression may attribute to elimination of the spontaneous or ectopic excitation resulting from the pulsatile compressive force of the offending vessel.^{8,14} Basically, the AMR-disappeared after interposition of Teflon balls. Nevertheless, in some case of our series, AMRs disappeared as soon as the arachnoid was opened. Upon dissection of the offending vessel, it reappeared and then disappeared again after the decompression was finally accomplished. A similar experience that AMR-disappeared after drainage of cerebrospinal fluid was reported in previous studies.^{7,13,15,23–25} The outflow of cerebrospinal fluid also causes a shift in the neurovascular relation temporarily equivalent to decompression, and these events are reversible.^{7,12,23,26} Therefore, it is important to continue AMR monitoring until the end of the surgery. Otherwise, it would preclude identification of the real offending vessel.^{19,20}

The fact that those patients from the AMR-disappeared group showed a better postoperative outcome than those from the non-AMR-disappeared group at the present study indicated that the intraoperative AMR monitoring was helpful to predict the prognosis of MVD for HFS. Similarly, it has been reported that the chance of being cured if the AMR was abolished during surgery was 4.2 times greater than when the AMR persisted.²⁷ Eventually, the AMR has been suggested as an intraoperative guide to ensure an adequate decompression of the causative nerve.^{8,12,13,19,20,28–30}

It has been commonly believed that the target of MVD should be anterior inferior cerebellar artery (AICA) or posterior inferior cerebellar artery (PICA) in root exit zone (REZ).^{2,16,20,22} With AMR monitoring, we found that sometimes it could be caused by multiple vessels or arterioles, and in some cases the conflicting site was beyond the REZ, which was also described in other reports.^{16,23,30,31} Here is one of the illustrative cases. In this case, the PICA, branched from a tortuous vertebral artery (VA) and contacted the facial nerve was first regarded as the offending vessel. However after decompression of the artery, the AMR did not disappear, which drove the surgeon to search the real confliction continually. After the acoustic nerve was retracted off, an AICA contacted the nerve rostrally was realized. After the AICA was mobilized away from the nerve, the AMR

was finally disappeared (Fig. 2). Accordingly, the strategy that AMR remain despite decompression at a first site could drive the neurosurgeon to search for another site of vascular compression should be developed.^{19,20} Moreover, if the AMR reappeared by the end of the operation even at the moment the dura had been closed, it is worthy of reopening and making a double check unless the surgeon could ensure that a thorough decompression had been performed after reviewing the video records.³²

Nevertheless, some authors argued that there was no correlation between intraoperative AMR changes and HFS relief.^{14,16,21,22,33} Since they found some patients in non-AMR-disappeared group were also relieved from HFS after MVD. We do found that 11 patients with residual symptoms at first day of the surgery tended to exhibit gradual improvement during the 6-month follow-up period. However, this rate of delayed relief was not that high compared to the other reports. At the present study, we did find 14 relieved patients without AMR-disappeared. Yet, it was noticed that the shape of their AMR waves changed significantly, which characterized by more than 80% decrease in amplitude (Fig. 3). Therefore, we assumed that the false-positive rate may be attributable to the judgment criteria. Eventually, we believed that a disappearance of AMR is an indication of a satisfied decompression. Nevertheless, when a decrease in AMR amplitude of more than 80% was monitored, a complete decompression may also achieved and the patient may still have chance to improve.³⁴

In particular, we tracked the 10 AMR-reappeared patients. All the 5 with double check experienced spasm resolution, while 4 of the 5 without dura-reopening still had HFS postoperatively. It highly recommended that AMR persistence or reappearance may result from incomplete decompression or a residual compressing vessel.

5. Conclusion

In this large series we have demonstrated that AMR monitoring might be an effective assistant to accomplish a satisfied decompression. The disappearance or significant change of AMR at the end of surgery may indicate a high likelihood of postoperative relief from HFS.

Conflict of interest

None.

Funding

None.

Ethical approval

None.

Author contribution

Dr. Ying monitored intraoperatively and recorded the AMR data and wrote the paper.

Drs. Li and Zhong performed the MVD surgeries.

Dr. Zhong designed the study and edited the manuscript.

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