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TECHNICAL NOTE

Microvascular decompression on patients with trigeminal neuralgia caused by ectatic vertebrobasilar artery complex: technique notes

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Abstract
Background Due to its anatomical features, the vertebrobasilar artery complex (VBA) seldom contributes to the neurovascular conflict in patient with trigeminal neuralgia (TN). However, once it offends the trigeminal root, this large artery is really difficult to manipulate during microvascular decompression (MVD) surgery. Therefore, the surgical strategy for such cases needs to be detailed in order to obtain a satisfactory outcome.
Methods From 2009 through 2011, 475 consecutive TN patients underwent MVDs in our department. Among them, ten were found in which an ipsilateral deviating ectatic vertebrobasilar artery complex (VBA) offended the trigeminal nerve. Those cases were focused on in this study and each operation was analyzed retrospectively.
Results During the operation, the vertebral artery was regarded as the direct culprit in six (60 %) patients, while the basilar artery in four (40 %). As companions, some smaller vessels were also observed to be close to the nerve, including the superior cerebellar artery (SCA) in five, veins in two and anterior inferior cerebellar artery (AICA) in two. The neurovascular conflict was discovered in the cisternal segment of the trigeminal root in eight, while in the root entry zone (REZ) in two. In six out of the ten cases, the affected nerves were demonstrated to be squeezed towards the tentorium by the ectatic VBA. Postoperatively, the symptom of pain totally disappeared immediately in eight (80 %) patients, while it was relieved apparently in two (20 %). During the follow-up period of 3–30 months, no recurrence or complication was found, except for one patient who had numbness of the face.
Conclusion With a proper strategy, MVD is probably the most effective therapy for the TN cases caused by ectatic vertebrobasilar artery complex. The substance of the surgery is to withdraw the proximal vertebral artery caudally via a lateroinferior cerebellar approach.

Keywords Trigeminal neuralgia · Microvascular decompression · Surgical strategy · Vertebrobasilar artery complex

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Introduction

The etiology of trigeminal neuralgia (TN) is widely believed to be a compression of the trigeminal nerve root (V) by surrounding arteries, such as the superior cerebellar artery (SCA) and the anteroinferior cerebellar artery (AICA) as well as their branches. Sometimes, multiple vessels including veins come to be the culprits [5]. Although several cases have been reported concerning the facial nerve compressed by a large vertebral artery (VA) in patients with hemifacial spasm, it is really rare in the trigeminal cases. Because of its anatomical features, the vertebrobasilar artery complex (VBA) has only a 2 % chance of being the offending artery in patients with TN [10], and the postoperative outcome of those with etiological VBA was relatively poor [10] because the large and tortuous artery is hard to mobilize during the operation. Therefore, the surgical technique to deal with these offending VBA needs to be further addressed. In the present study, with analysis of

these cases, the surgical strategy regarding decompression of the trigeminal nerve by an ectatic vertebrobasilar artery complex is detailed.

Material and methods

From 2009 through 2011, 475 consecutive TN patients underwent MVDs in the Department of Neurosurgery, XinHua Hospital, Shanghai JiaoTong University School of Medicine. Among them, ten were found to be caused by VBA in the surgery. Those patients included five males and five females, with an average age of 64 years. Their history of symptoms ranged from 1 month to 30 years, with the equal occurrence on both sides. The pain located in the area innervated by one or more trigeminal branches. The frequency of the involved trigeminal branch was the first in two, the second in nine and the third in five patients (Table 1)

Magnetic resonance imaging

A 3.0-Tesla magnetic resonance imaging (MRI) scanner (General Electric Vectra, IGF Medical, Milwaukee, WI, USA) was employed for neuroradiological examination for each patient preoperatively. To elucidate the structure of vessels, three-dimensional time-of-flight (3D-TOF) sequence was adopted [3].

The surgery

The operative process anterior to the craniectomy has been described previously [2, 4, 14, 16–18]. As the petrosal veins usually locate on the surgical approach and block the exploration of the trigeminal nerve, we suggest to start the intracranial dissection from the caudal cranial nerves (Fig. 1a, b) [18]. Usually, a tortuous vertebral artery was found ventrally to the caudal cranial nerves in these cases (Fig. 1c). Through the interstices between the caudal nerves, the proximal segment of VBA was mobilized caudolaterally and small pieces of shredded Teflon sponge were gradually placed between the VA and the medulla oblongata to keep the artery free from the brainstem (Fig. 1d). With the arachnoid membrane around the nerves being opened thoroughly, the cerebellum was gradually raised until the pontomedullary sulcus was visualized. Then, ventrally to the facial nerve, other pieces of Teflon wadding were added between the VA and the pons in order to further remove the vertebrobasilar artery caudolaterally. By that time, the neurovascular confliction could be distinguished without difficulty in most cases. With exposure of the whole intracranial root of the trigeminal nerve, any vessel contacting the nerve was transposed and Teflon was then put between them (Fig. 1e). Those small veins attaching to the nerve tightly were coagulated and cut. Finally, the dura mater was closed with sutures in a watertight pattern and a cranioplasty of titanium wire mesh was completed.

Intraoperative observations under the operative microscope

In order to delineate the surgical finding more precisely, we divided the trigeminal nerve root into the root entry zone (REZ) and cisternal segments. The REZ is the medial portion where the nerve fibers enter the pons; the cisternal segment is the lateral portion where the nerve comes from the Meckel's cave [12]. Each segment was then subdivided into four parts,

Table 1 Clinical summary of the ten cases

Case	Age (years)/sex	Side	Trigeminal divisions involved	History	Conflict sites	Offending vessels	Severity of conflicts[a]	Outcome	Complications
1	67/M	L	2nd, 3rd	3 years	Ven/Cis	VA with vein	V	Excellent	Nil
2	54/M	L	1st, 2nd	1 month	Cau/REZ	BA with SCA	IV	Good	Nil
3	77/F	R	2nd	3 years	Cau/Cis	VA with AICA	V	Excellent	Nil
4	86/M	R	2nd	30 years	Ros/Cis	BA with SCA	II	Excellent	Nil
5	57/M	L	1st, 2nd	2 years	Cau/Cis	VA with SCA	V	Excellent	Nil
6	58/F	L	2nd, 3rd	2 years	Cau/Cis	VA	III	Excellent	Nil
7	76/F	R	2nd, 3rd	2 years	Cau/Cis	BA with SCA/vein	V	Good	Facial numbness
8	70/F	R	3rd	6 months	Ven/Cis	VA(bilateral) with SCA	V	Excellent	Nil
9	47/F	R	2nd	2 years	Cau/Cis	BA with AICA	IV	Excellent	Nil
10	47/M	L	2nd, 3rd	20 years	Ros/REZ	VA	V	Excellent	Nil

M male, *F* female, *L* left, *R* right, *V* trigeminal nerve, *Ros* rostral portion, *Ven* ventral portion, *Cau* caudal portion, *REZ* the root entry zone of the TN, *Cis* cisternal segment of the TN, *VA* vertebral artery, *BA* basilar artery, *SCA* superior cerebellar artery, *AICA* anterior inferior cerebellar artery

[a] Classification of severity of trigeminal nerve conflict: *II* contact and indentation, *III* single adhesion, *IV* adhesion and indentation, *V* trigeminal nerve atrophy

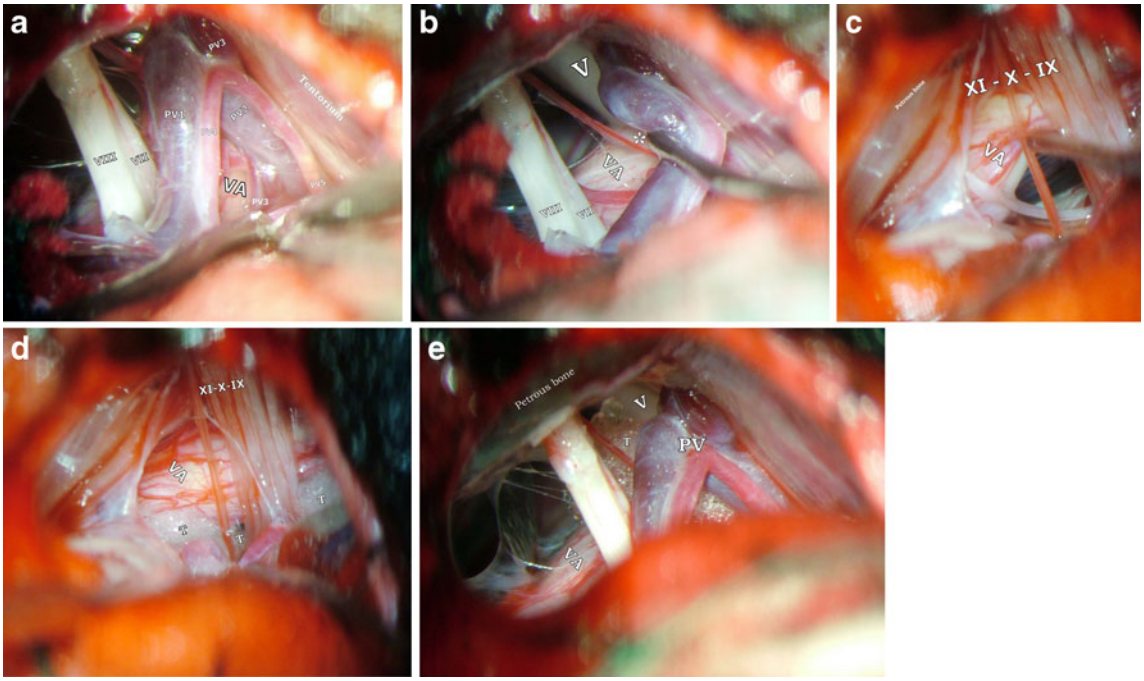

Fig. 1 Intraoperative photos. On the way of the routine approach, five tributaries of the petrosal vein (*PV*) were firstly encountered in case 1. Despite those veins covered the trigeminal root, an ectatic vertebral artery (*VA*) was revealed behind. **a** It was not until the veins were retracted off, the trigeminal nerve (*V*) was visualized a bit, which was compressed by the VA caudally (*). **b** The dissection was started from the caudal cranial nerves (*XI-X-IX*). **c** Through the interstices between the caudal nerves, the proximal segment of VA was mobilized caudolaterally and small pieces of shredded Teflon (*T*) were gradually placed between the VA and the medulla oblongata to keep the artery free from the brainstem. **d** After the VA was withdrawn caudally away, the V nerve had been actually decompressed. Teflon waddings were added between the nerve and the artery. All the petrosal veins (*PV*) were saved. (* The neurovascular conflict site, *VII* the facial nerve, *VIII* the vestibulocochlear nerve)

i.e., the dorsal, ventral, caudal and rostral [8]. The degree of neurovascular compression was classified into five categories according to the criteria published previously [7].

Outcome evaluation

The outcome was appraised by the patients themselves and was classified as "excellent" (the pain disappeared totally and immediately), "good" (the symptom improved apparently) or "poor" (the patient was not satisfied) [4].

Results

MRI findings

A bigger VA loop was found in the affected side in all the patients. Meanwhile, the BA was also observed to shift to the ipsilateral side as the direct culprit in four patients. The affected trigeminal root became deformed and was barely recognized in six of the ten patients in the MRI scan (Fig. 2a, b).

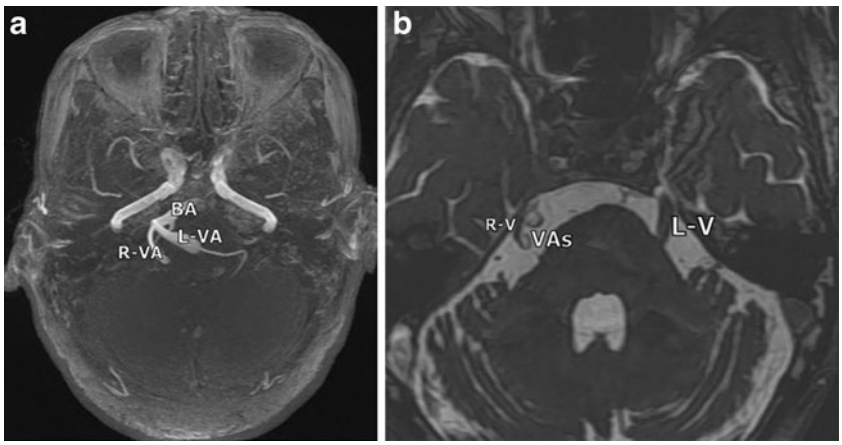

Fig. 2 Preoperative MRI findings. **a** The 3D-TOF MRI depicted the vertebrobasilar artery was lateralized to the suffered side with the basilar artery (*BA*) shifted ipsilaterally and both vertebral arteries (*VA*) located in the right side. **b** Compared with the left trigeminal nerve (*L-V*), the right one (*R-V*) looked very thin, which was compressed and shifted by both vertebral arteries (*VAs*)

Intraoperative findings

The preoperative MRI delineations were confirmed by the surgery. A tortuous VBA with atherosclerosis was discovered in all the cases. A large, looped VA contacting the trigeminal nerve was identified in six patients, while a BA in four. In one case, both the bilateral VAs were visualized ipsilaterally in the surgical view (Fig. 3). Besides the VBA, some smaller vessels were also observed to be close to the nerve, including the SCA in five, veins and AICA in two. While in two cases the VA was discovered to be the only culprit. The neurovascular conflict was observed in the cisternal segment in eight (five on the caudal portion, two on the ventral portion, and one on the rostral portion), and REZ in two (one on the caudal portion and the other on the rostral portion). The severity of the compression of the nerve was exhibited as type V in six, IV in two, III and II in one, respectively (Table 1).

Outcomes

Postoperatively, the symptom of pain relieved as soon as the patient awoke from the anesthesia in all the cases. According to the evaluation scale mentioned above, the results were "excellent" in eight and "good" in two. No hearing loss or facial palsy was observed, and there was only one patient with facial numbness. During up to a 30-month follow-up period, no recurrence was found.

Discussion

TN is a symptom composed of paroxysms of facial pain usually confined to the innervation of the second and/or third divisions of the trigeminal nerve. It is most frequently caused by a loop of the SCA and/or AICA compressing the fifth intracranial nerve [5]. The chance of a vertebrobasilar artery offending the trigeminal nerve is very small. So far, the highest figure reported in the literature has been 7.7 % [1, 9, 11]. In a published large series of 1,404 consecutive patients with vascularly determined neuralgia, only 31 (2 %) were found to have vertebrobasilar compression [9], which is analogous to our series of about 475 cases (unpublished data). In our data, about 90 % patients have the second branch of trigeminal nerve involved, which might be related to the special intracranial courses of the three branches respectively from the Meckel's cave to the brain stem. The other phenomenon was that of a tortuous VBA often compressed against the cisternal segment of the nerve, which might be concerned with the anatomical relationship between the VBA and TN.

For the incompliance of those shifted VBAs, the indentation and atrophy was usually demonstrated in the affected nerve, and sometimes the nerve was even squeezed towards the tentorium. Since it is difficulty to remove an ectatic VBA complex, the surgical strategy needs to be further considered.

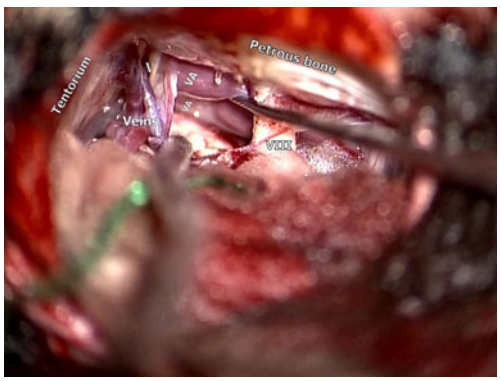

Fig. 3 Both the vertebral arteries compressing the trigeminal nerve. This operative view is corresponding to the MRI findings of Fig. 2. Both the vertebral arteries (*VA*) were found in the right side, which compressed the cisternal segment of the trigeminal nerve root (*V*) simultaneously

Preoperative preparations

MRI study provides accurate information on the mutual location of the nerve and the vessel in the cerebellopontine angle. Our previous study [2] found a coincidence between idiopathic hemifacial spasm and the MRI characteristics of the vertebral artery, i.e., in 86.4 % of the patients with hemifacial spasm it was observed that their VA deviated to the symptomatic side. Similarly, the preoperative MRI delineated a huge tortuous vertebrobasilar artery deviating ipsilaterally in all the ten cases, which was then confirmed by the surgery as the culprit or the predominant one of the offending vessels. Evidently, MRI study is helpful for identifying the offending artery and to forecast the difficulty of the surgery, in addition to excluding other aetiologies such as neoplasm or cerebrovascular diseases. Furthermore, with MRI study, a rational surgical strategy could be planned preoperatively.

Surgical techniques

Because the tortuous or ecstatic VBA is likely to rebound after transposition, it is not good to merely tuck Teflon into the vessel-nerve conflict site, which would actually compress the nerve all the worse. As a result, some neurosurgeons would abandon the MVD and attempt rhizotomy [3] or thermocoagulation [10], which might lead to incomplete relief and side-effects such as facial numbness. One alternative was to adhere the VBA to the petrous bone with glue or suture [6, 13]. But it still had the possibility of rebounding for a large and ectatic artery. Eventually, we realized that the point of the surgery is to move the VBA proximally. Therefore, instead of the routine

infratentorial and superior cerebellar approach, we chose the lateroinferior cerebellar approach and dissect the caudal cranial nerves at the beginning. The reasons are as follows:

1. Opening the arachnoids around the caudal nerves firstly facilitates the proximal mobilization of the VBA.
2. Upon the VBA being moved away from the brainstem and separated from the pons by Teflon, the trigeminal nerve might be decompressed spontaneously since the offending artery has already been removed from the nerve.
3. A few veins may block this surgical approach, which usually could not be avoided when the infratentorial approach was employed (sometimes it would be a disaster to sacrifice those petrosal veins ad libitum [4, 16]).
4. Furthermore, the offending vessel should be separated from the nerve by ample opening of the surrounding arachnoids rather than merely squeezing in the Teflon between them [2, 4, 7, 8, 16, 18]. The Teflon actually plays a role in preventing the vessel from rebounding rather than isolation. Therefore, the Teflon has not necessarily to be placed at the conflict site—it could be put anywhere it causes minimal pressure to the nerve [15].

Conclusions

Although it is very difficult to manipulate an ectatic vertebrobasilar artery complex, MVD seems to be the most effective therapy for TN as long as a proper surgical strategy is conducted. With a lateroinferior cerebellar approach and caudal movement of the proximal vertebrobasilar artery, a successful surgery is achievable.

Conflicts of interest None.

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Comment

The report by Xiao-Sheng Yang et al. presents a series of ten patients who suffered from trigeminal nerve compression by an ectatic vertebrobasilar artery complex and were subjected to microvascular decompression. The presented manuscript is quite original, important in its field and shows a rather large series of patients suffering from a rare syndrome. We like this paper since it supports the decision for surgery even in very difficult and risky situations. The authors report very good results; and the paper underlines that even in complex anatomical situations microvascular decompression is feasible. Some literature on this topic is already available; however, the case numbers are rather small and include only a rather short-term follow-up. Although the results reported are very favourable, the decision for surgery has to be based on the individual anatomical situation and general condition of each patient.

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