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The Microsurgical Anatomy of the Infratentorial Lateral Supracerebellar Approach to the Trigeminal Nerve for Tic Douloureux

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The increasing use of microsurgical decompression for trigeminal neuralgia has created a need for more detailed anatomical information about the approach. To define better this anatomy, 10 cerebellar specimens obtained at autopsy were examined, and intraoperative findings in 30 patients with trigeminal neuralgia were analyzed. Since the infratentorial subdural space on the tentorial cerebellar surface is exposed to explore the trigeminal nerve in the infratentorial lateral supracerebellar approach, attention was directed to the following: the anterolateral margin of the cerebellar hemisphere, bridging veins on the tentorial surface, superior petrosal veins, and relationships between blood vessels and the trigeminal nerve. The lateral mesencephalic segment of the superior cerebellar artery at or near the bifurcation often compressed the nerve laterally at more than one point. With this approach, the relationship of the superior cerebellar artery to the nerve could be observed from the medial side of the tentorial surface. The infratentorial lateral supracerebellar approach is discussed and compared to Dandy's cerebellar route. (*Neurosurgery* 24:890–895, 1989)

Key words: Trigeminal neuralgia, Neurovascular decompression, Microsurgical anatomy

INTRODUCTION

Jannetta (10–12) popularized neurovascular decompression surgery for trigeminal neuralgia, using the operating microscope after Dandy's surgical experience (2, 3) and Gardner's intraoperative observation of the arterial compression (6). This decompression surgery is now widely performed (1, 4, 5, 13, 17–19). Although Jannetta (10, 12) described the approach over the supracerebellar surface, other workers (1, 2, 18, 20) described procedures involving passage through the cerebellopontine cistern.

In our experience, the infratentorial lateral supracerebellar approach to the trigeminal nerve seems more advantageous. In the approach, surgeons may first be aware of a bridging vein located medially on the tentorial cerebellar surface. When a retractor is moved over the tentorial surface along the anterolateral margin, 1 or 2 superior petrosal veins (SPVs) composed of a few tributaries are often encountered. When the anterior angle is reached, the medial aspect of the trigeminal nerve and the lateral mesencephalic segment of the superior cerebellar artery (SCA) can be seen. This segment, bifurcating into two branches, usually compresses the trigeminal nerve laterally. To obtain good orientation during the infratentorial lateral supracerebellar approach, the microsurgical anatomy of the approach was studied.

MATERIALS AND METHODS

Ten formalin-fixed cerebellar specimens provided the material for studies of the neural structures and veins. The veins were perfused with colored latex to facilitate dissection. The veins examined included the bridging veins on the tentorial cerebellar surface, the SPVs, and the veins attached to the trigeminal nerve. The arterial vascular relationships to the nerve were analyzed on 30 operative sides in 30 patients with trigeminal neuralgia. The arterial relationship was observed during surgery, and the offending arteries and segments were identified, based on vertebral angiographic findings. The nomenclature of the arteries and veins follows our previous studies (8, 15).

RESULTS

Neural structures

The lateral margin of the tentorial surface termed the anterolateral margin is the edge separating the tentorial and the petrosal surfaces (Fig. 1*A*) and is parallel to the superior petrosal sinus (Figs. 2, *A* and *C* and 3, *A* and *B*). The anterior angle is the most anterior part of the anterolateral margin (Fig. 1, *A* and *B*) (9). The entry zone of the trigeminal nerve is located just anteroinferiorly to the angle and here the trigeminal nerve can be fully exposed (Figs. 1*B* and 4, *A* and *B*). The distance from the lateral-most part of the posterolateral margin to the anterior angle ranges from 42 to 55 mm (average 49 mm).

Bridging veins on the tentorial cerebellar surface

There were two groups of bridging veins on the tentorial surface, i.e., vermian and hemispheric bridging veins. The latter were located on the lateral hemispheric surface (Fig. 2, *A*, *B*, and *C*). They were the terminal segments of the superior and inferior hemispheric veins draining into the tentorial sinus (Fig. 2, *B* and *C*). The total number of hemispheric bridging veins was 32 on 16 of the 20 sides (Table 1). The average number of veins was 1.6 on one side, and the largest number found was 3. The hemispheric bridging veins were subdivided into lateral, intermediate, and medial groups, based on location on the hemispheric surface (Fig. 2*C*). Of the 32 veins, 12 (37.5%) were of the medial type, 12 (37.5%) were of the intermediate type, and 8 (25%) were of the lateral type (Table 1). Twenty-six of the 32 veins (81%) were located near the postclival fissure (Fig. 2*C*).

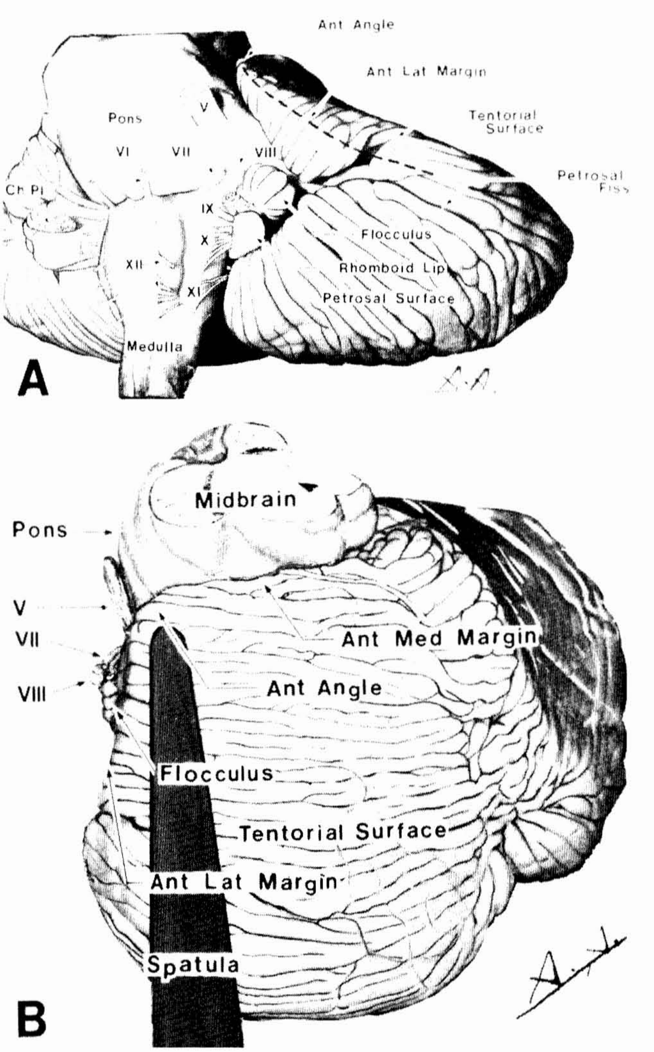


FIG. 1. *A*, anterolateral view of the left petrosal surface. The anterolateral margin is shown by the *dashed line*. It is the boundary between the petrosal and tentorial surfaces. The trigeminal nerve is situated just below the anterior angle, i.e., the anterior-most part of the anterolateral margin. *B*, posterolateral view of the left tentorial surface. The retractor is moved along the left anterolateral margin on the tentorial surface. The tip is located close to the anterior angle.

Superior petrosal veins

The SPV was formed by the terminal segment of a single vein or by the common stem formed by the union of a few veins (Fig. 3, *A* and *B*) (15). Most of the common tributaries usually left the petrosal cerebellar or brain stem surface, but a few left the anterolateral margin (Fig. 3*A*). The latter were usually the terminal segments of the hemispheric veins and/or the anterolateral marginal vein. There were 34 SPVs on

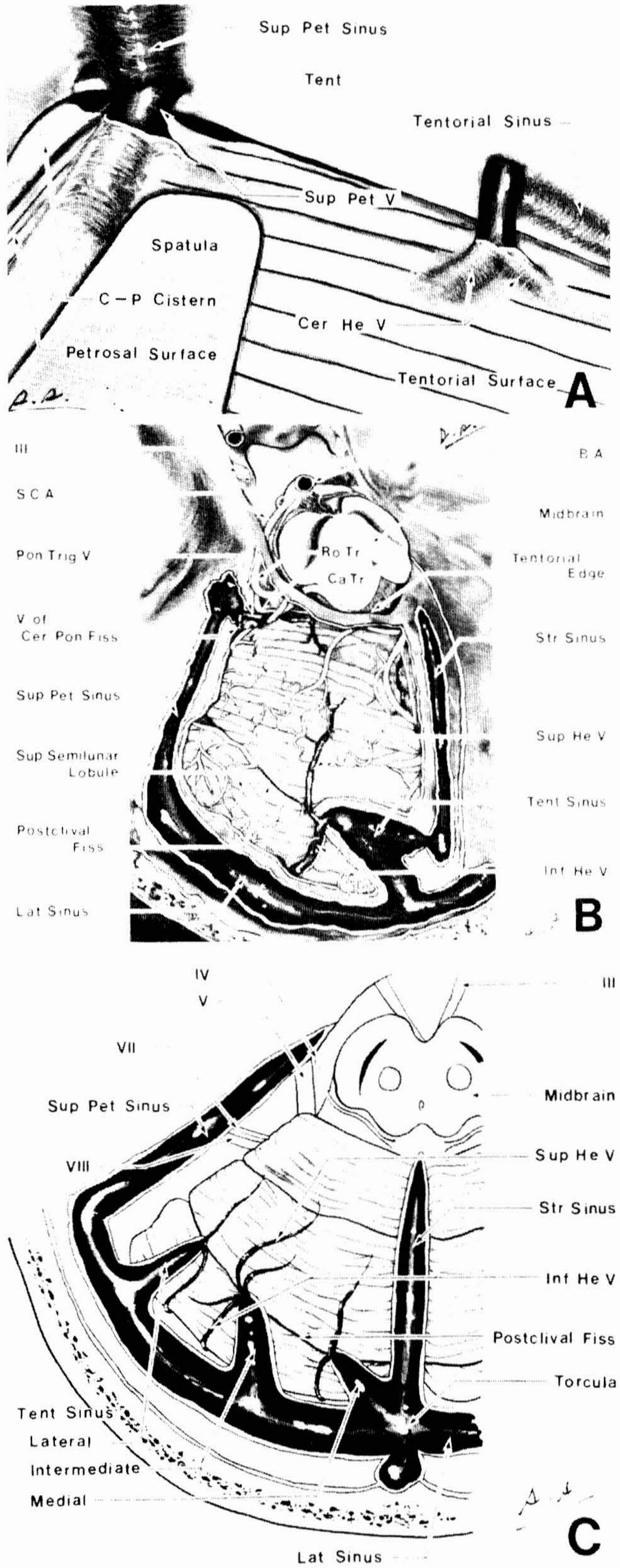
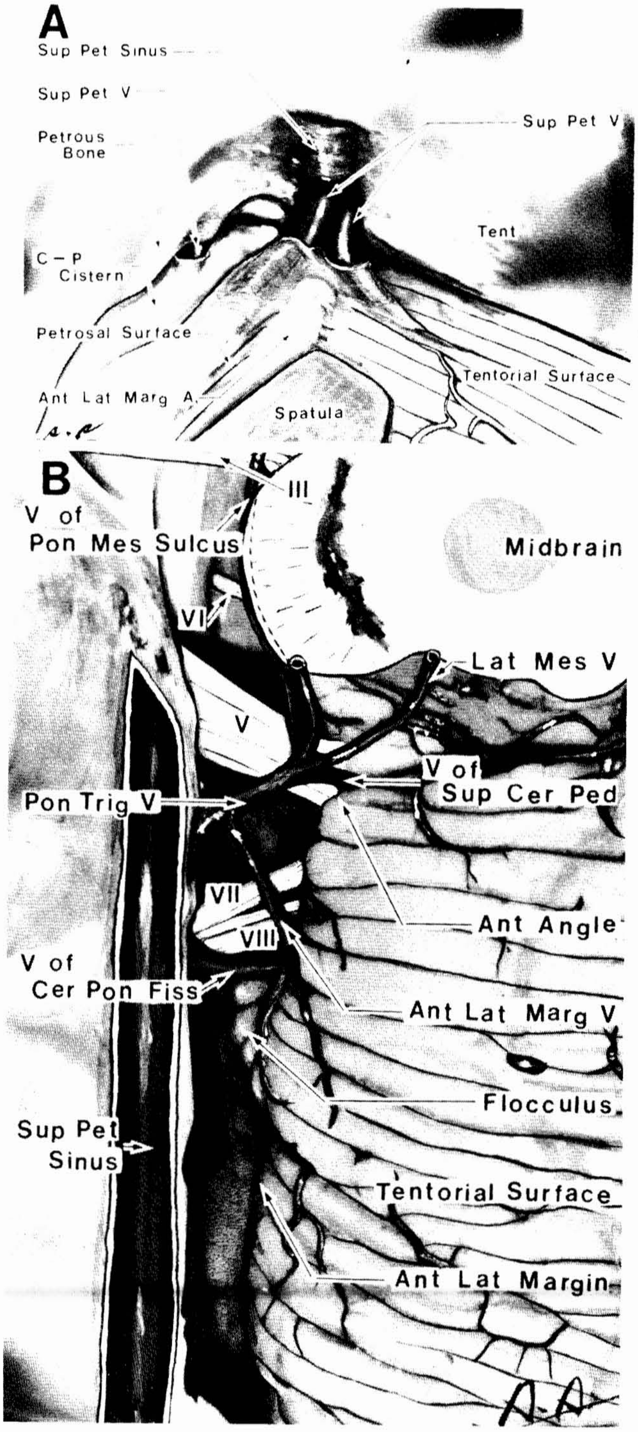


FIG. 2. *A*, intracranial view after dural opening in a case of left-sided trigeminal neuralgia. The roof is the tentorium and the lateral wall is the petrous bone. The superior petrosal sinus runs along the corner of the two. One of the petrosal veins running up on the petrosal surface drains into the sinus. Another bridging vein that is a drainer of the cerebellar hemispheric veins into the tentorial sinus is located on the tentorial surface medial to the anterolateral margin. *B*, venous drainage system on the tentorial surface of the left side (autopsy case). The superior and inferior hemispheric veins join near the postclival fissure to drain into the tentorial sinus. *C*, drawing illustrating three groups of bridging veins and tentorial sinuses on the tentorial surface.



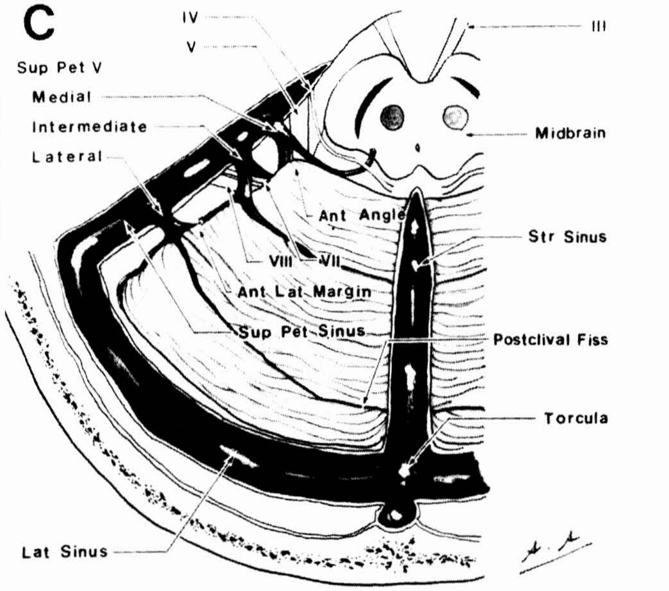


FIG. 3. *A*, intracranial view after dural opening in another case of left-sided trigeminal neuralgia. Two bridging veins join above the anterolateral margin to drain into the sinus. One runs up on the petrosal surface and the other originates from the tentorial surface. Another petrosal vein running up in the cerebellopontine cistern is also seen. *B*, veins draining into the superior petrosal sinus. Superolateral view of the left side (autopsy case). The superior petrosal veins of medial and intermediate groups are present. The former is formed by the anterior lateral marginal vein and the pontotrigeminal vein. The latter is the terminal end of the vein of the cerebellopontine fissure. *C*, drawing illustrating three groups of the superior petrosal veins.

the 20 sides (Table 2). One SPV was present on 8 sides, 2 veins on 10 sides, and 3 veins on 2 sides. The SPVs were subdivided into lateral, intermediate, and medial groups according to their sites of entry into the superior petrosal sinus (Fig. 3*C*). The intermediate group drained into the sinus above the internal acoustic meatus, the medial group drained into the sinus medially to the meatus, and the lateral group drained into the sinus laterally to the meatus. Of the 34 SPVs, 22 (64.7%) were of the medial group, 3 (8.8%) were of the intermediate group, and 9 (26.5%) were of the lateral group (Table 2). The medial group was usually a common trunk formed by the union of the following veins: transverse pontine vein, pontotrigeminal vein, and veins of the cerebellopontine fissure and middle cerebellar peduncle. Two of the 3 intermediate SPVs were formed by a single vein, the vein of the cerebellopontine fissure. The most common veins of the lateral group were the common stem formed by the union of the superior and inferior hemispheric veins.

TABLE 1
Bridging Veins on the Tentorial Cerebellar Surface

Location	Number
Vermis	15 (9 of 10 patients)
Hemisphere	32 (16 of 20 sides)
Medial group	12 (37.5%)
Intermediate group	12 (37.5%)
Lateral group	8 (25.0%)

TABLE 2
Superior Petrosal Veins (34 on 20 Sides in 10 Patients)

	Number (%)
Number	
1 vein	8 of 20 sides (40)
2 veins	10 of 20 sides (50)
3 veins	2 of 20 sides (10)
Group	
Medial	22 of 34 (64.7)
Intermediate	3 of 34 (8.8)
Lateral	9 of 34 (26.5)

Arterial neurovascular relationships

The trigeminal nerve was compressed by arteries in 28 of the 30 patients (93%) who had operations. In the remaining 2 patients the veins were attached to the nerve (Table 3). The offending arteries were the SCA, anterior inferior cerebellar artery (AICA), and/or their branches (Fig. 4*D*). The nerve was compressed by only the SCA in 21 patients (70%), by only the AICA in 3 patients (10%), and by both the SCA and AICA in 4 patients (13%) (Table 3). The AICA compressed the inferolateral surface of the nerve. The SCA compressed the nerve at several different points because the lateral mesencephalic segment of the SCA bifurcated into rostral and caudal trunks making a downward loop when this segment compressed the nerve (Fig. 4, *A*, *B*, and *D*). The bifurcation of the SCA was observed intraoperatively to be near the trigeminal nerve in 20 patients. The average number of compressing points was 1.8, and the largest number was 4. The SCA always coursed medial to the trigeminal nerve, and it always compressed the nerve from the medial side (Fig. 4, *A*, *B*, and *D*).

Venous neurovascular relationships

Contact between veins and the trigeminal nerve was found on 18 of the 20 sides of the 10 cerebellar specimens, even though an indentation of the nerve was not clearly visualized. The total number of veins was 27, the average being 1.35 on one side. The largest number was 3 on one side. The veins attached to the nerve were as follows: 9 transverse pontine veins, 7 veins of the cerebellopontine fissure, 6 pontotrigeminal veins, 2 veins of the middle cerebellar peduncle, 1 lateral mesencephalic vein, and 2 other undetermined veins. The transverse pontine vein was attached to the superior or inferior surface of the nerve. The veins of the cerebellopontine fissure and of the middle cerebellar peduncle, which ran upwards in the cerebellopontine cistern, were attached to the lateral surface of the nerve. The pontotrigeminal vein formed by the union of a few veins on the surface of the middle cerebellar peduncle coursed by or crossed over the trigeminal nerve to drain directly into the superior petrosal sinus.

TABLE 3
Neurovascular Relationships in 30 Patients with Trigeminal Neuralgia

Vessel	Number of Patients (%)
SCA	21 (70)
AICA	3 (10)
SCA and AICA	4 (13)
Veins	2 (7)

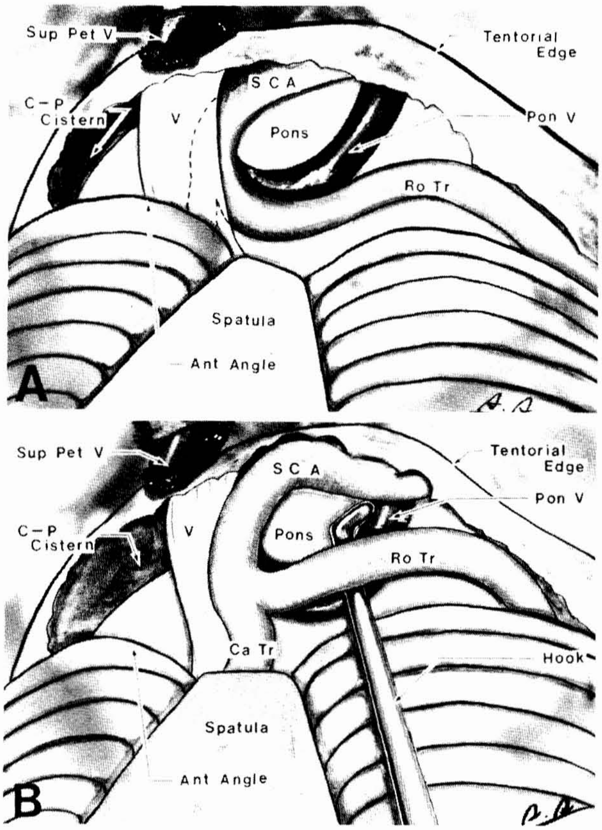
DISCUSSION

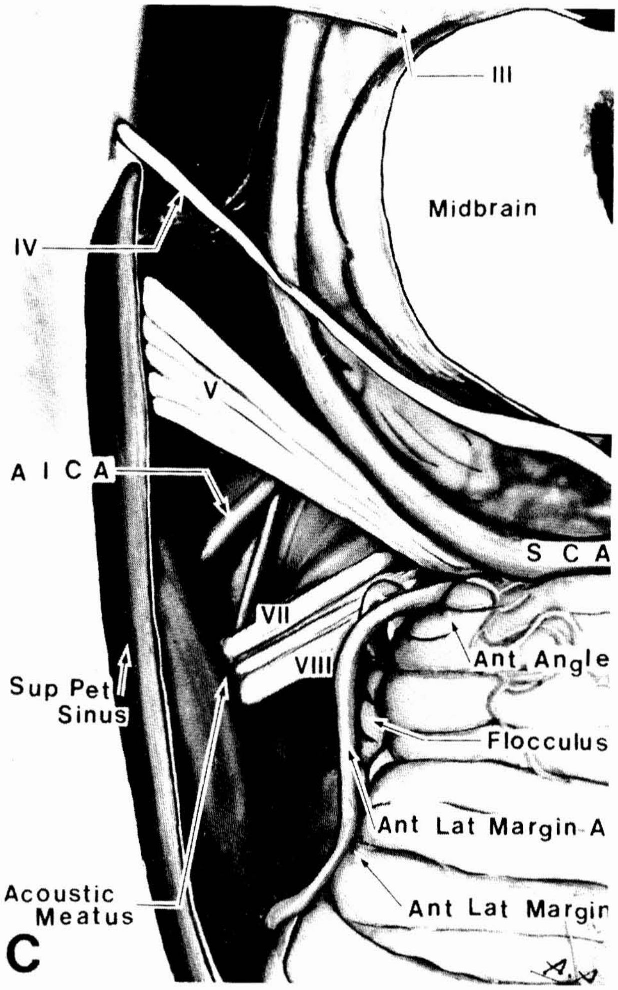
Dandy (2, 3) developed a posterior fossa approach for sectioning the trigeminal nerve, as treatment for trigeminal neuralgia. "Dandy's cerebellar route" is well known to neurosurgeons. This approach, however, seems to have weak points for microsurgical neurovascular decompression of the trigeminal nerve. One is that the 7th and 8th cranial nerves and the common stem of the petrosal draining group are obstacles to the approach. Another is that the SCA frequently compresses the trigeminal nerve from the anterior. With the development of neurovascular decompression surgery for trigeminal neuralgia, the approach to the trigeminal nerve has gradually been changed. A few authors, including Jannetta (12, 16, 17), have approached the nerve over the tentorial cerebellar surface. Petty and Southly (17), who used Jannetta's approach, called it the "subtentorial supracerebellar approach." It can be also called the "infratentorial lateral supracerebellar approach."

Rhoton and colleagues (14, 15), based on the relationships of the cerebellum to these surgical approaches, subdivided the cerebellar surface into three parts: tentorial, petrosal, and suboccipital surfaces. The trigeminal nerve can be accessed when the petrosal or the tentorial surface is exposed. In the approach in which the petrosal surface and cerebellopontine cistern are exposed, the acoustic and facial nerves or the common stem of the SPV may be injured. The tentorial surface is a better choice since it has neither cranial nerves nor large veins.

In the lateral supracerebellar approach, the important anatomical landmarks are the anterolateral margin, anterior angle, bridging veins on the tentorial surface, SPVs including the anterolateral marginal vein, and the SCA and its branches in relation to the trigeminal nerve. The approach is suitable for reaching the trigeminal nerve when the bridging veins are well managed. The number of the bridging veins on the lateral tentorial surface is small. One or two common stems of the SPV are frequently present between the acoustic meatus and the trigeminal nerve and have an inverted Y configuration. The medial-most tributary, usually the anterolateral marginal vein or the hemispheric vein, may be cut, but the vein of the cerebellopontine fissure running in the cerebellopontine cistern, which is usually a main drainer, has to be preserved.

The most frequent artery compressing the nerve is the SCA and/or its branches (5, 7, 8, 10, 12, 13). Since the SCA and its branches sometimes compress the trigeminal nerve at two or three points, the entire medial surface of the nerve should be carefully observed, particularly near the entry zone (12, 16). The SCA and its branches usually course medially to the trigeminal nerve and compress the medial surface of the nerve laterally (8, 12). Therefore, as Jannetta (10, 12) mentioned, the trigeminal nerve is better observed from the medial side of the tentorial surface. The lateral supracerebellar approach will meet this need. The inferolateral side of the trigeminal nerve can also be observed in this approach.





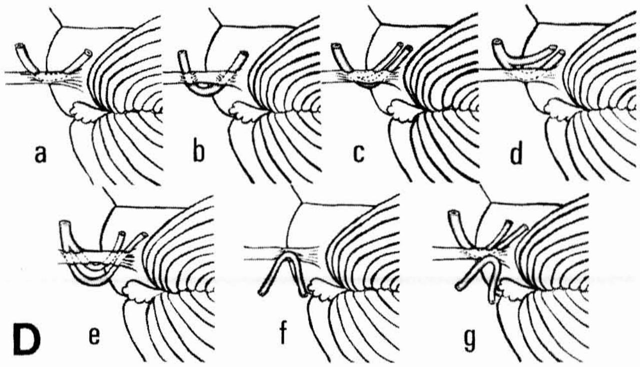


FIG. 4. *A*, left side in another patient with trigeminal neuralgia. The superior petrosal vein was cut. The superior cerebellar artery looks like one trunk, but it bifurcates into two trunks. *B*, left side of the same patient shown in *A*. Retraction of the superior cerebellar artery reveals its bifurcation and the caudal trunk, which coursed under the entry zone of the trigeminal nerve. *C*, superior view of the left trigeminal nerve and the surrounding structures in an autopsy case. The entry zone of the trigeminal nerve is situated below the anterior angle. The lateral mesencephalic segment of the superior cerebellar artery courses between the trochlear nerve medially and the trigeminal nerve laterally. *D*, drawing illustrating the relationships between the trigeminal nerve and the superior and/or the anterior inferior cerebellar artery. *a*, the main trunk of the SCA compresses the nerve at one point; *b*, the main trunk of the SCA at two points; *c*, the bifurcation of the SCA at several points; *d*, the caudal trunk of the SCA at one point; *e*, the rostral and caudal trunks of the SCA at four points; *f*, the AICA alone at one point from below; *g*, both the SCA and AICA at several points.

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REFERENCES

1. Apfelbaum RI: Surgical management of disorders of the lower cranial nerves, in Schmidek HH, Sweet WH (eds): *Operative Neurosurgical Techniques — Indications, Methods, and Results.* New York, Grune & Stratton 1982, vol 2, pp 1063–1075.
2. Dandy WE: The treatment of trigeminal neuralgia by the cerebellar route. Ann Surg 96:787–793, 1932.
3. Dandy WE: Concerning the cause of trigeminal neuralgia. Am J Surg 24:447–455, 1934.
4. Fukushima T: Posterior fossa microvascular decompression in the management of hemifacial spasm and trigeminal neuralgia [in Japanese]. No Shinkei Geka (Neurol Surg) 10:1257–1261, 1982.

5. Fukushima T: Results of microvascular decompression (Jannetta's procedure) in the management of trigeminal neuralgia and glossopharyngeal neuralgia [in Japanese]. Igaku no Ayumi 138:682–686, 1986.
6. Gardner WJ: Concerning the mechanism of trigeminal neuralgia and hemifacial spasm. J Neurosurg 19:947–958, 1962.
7. Haines SJ, Jannetta PJ, Zorub DS: Microvascular relations of the trigeminal nerve—An anatomical study with clinical correlation. J Neurosurg 52:381–386, 1980.
8. Hardy DG, Rhoton AL Jr: Microsurgical relationships of the superior cerebellar artery and the trigeminal nerve. J Neurosurg 49:669–678, 1978.
9. Huang YP, Wolf BS, Antin SP, Okudera T: The veins of the posterior fossa-anterior or petrosal draining group. A JR 104:36–56, 1968.
10. Jannetta PJ: Microsurgical approach to the trigeminal nerve for tic douloureux. Prog Neurol Surg 7:180–200, 1976.
11. Jannetta PJ: Microsurgery of cranial nerve cross-compression. Clin Neurosurg 26:607–615, 1979.
12. Jannetta PJ: Trigeminal neuralgia: Treatment by microvascular decompression, in Wilkins RH, Rengachary SS (eds): *Neurosurgery*. New York, McGraw-Hill, 1985, vol 3, pp 2357–2363.
13. Kolluri S, Heros RC: Microvascular decompression for trigeminal neuralgia. A five-year follow-up study. Surg Neurol 22:235–240, 1984.
14. Matsushima T, Rhoton AL Jr, Lenkey C: Microsurgery of the fourth ventricle: Part 1. Microsurgical anatomy. Neurosurgery 11:631–667, 1982.
15. Matsushima T, Rhoton AL Jr, Oliveira ED, Peace D: Microsurgical anatomy of the veins of the posterior fossa. J Neurosurg 59:63–105, 1983.
16. Matsushima T, Fukui M, Yamashita M, Rhoton AL Jr: Microsurgical neurovascular decompression for trigeminal neuralgia with special reference to infratentorial lateral supracerebellar approach [in Japanese]. No Shinkei Geka (Neurol Surg) 15:1047–1054, 1987.
17. Petty PG, Southby R: Vascular compression of lower cranial nerves: Observations using microsurgery, with particular reference to trigeminal neuralgia. Aust NZ J Surg 47:314–320, 1977.
18. Rand RW: Microsurgical operations in trigeminal and glossopharyngeal neuralgia, in *Microneurosurgery*, St. Louis, CV Mosby, 1978, ed 2, pp 239–249.
19. Rhoton AL Jr: Microsurgical neurovascular decompression for trigeminal neuralgia and hemifacial spasm. J Fla Med Assoc 65:425–428, 1978.
20. Sato O: Operation for trigeminal neuralgia, in *Current Encyclopedia of Surgical Operations*, vol 4, *Surgery of the Brain and Skull* [in Japanese]. Nakayama Comp, 1982, pp 362–363.

COMMENT

The authors are to be commended for a very clearly written and well-illustrated anatomical study.

Their study points out the great variability of the venous anatomy in this region, which has to be carefully observed and taken into account in any surgical approach. We have normally used an approach at the superior lateral margin of the cerebellum, which does require dividing the petrosal vein, but traverses the subarachnoid space above the seventh and eighth nerves to gain access to the fifth nerve. I think this approach rather than a more dorsal approach allows better visualization of the trigeminal nerve and more careful inspection for offending vascular channels, particularly channels which may be inferior to the nerve. As the authors point out, there are often multiple sites of compression on the nerve. Failure to identify all of these and correct them may be one of the causes of failure of the operative procedure.

The superior petrosal vein often tethers the cerebellum fairly tightly and in our experience it has to be divided, whether one approaches the trigeminal nerve from a supracerebellar or a high lateral cerebellar approach.

I do think it is important, however, to inspect the venous anatomy carefully as one proceeds with either exposure. Variations in the anatomy are such that one may have to alter course rather than sacrifice an excessive number of bridging veins. It appears that although these veins do have a significant amount of collateralization, sacrificing too many of them may be the cause of subsequent venous infarction. One should, therefore, minimize the number of veins sacrificed in this exposure, regardless of which route is taken.

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