Drainage Pathway of the Superior Petrosal Vein Evaluated by CT Venography in Petroclival Meningioma Surgery

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Abstract

Keywords

- ▶ petrosal vein
- ▶ computed tomography venography
- ▶ petroclival meningioma
- ▶ transpetrosal approach

Objectives This study aimed to clarify the drainage location of the superior petrosal vein (SPV) in relation to Meckel's cave and the internal acoustic meatus (IAM) and to discuss its significance in petroclival meningioma surgery.

Design Prospective clinical study.

Setting Hospital-based.

Participants Five patients with petroclival meningioma and 50 patients (primarily unruptured supratentorial aneurysm patients, with a few hemifacial spasm patients) with no posterior fossa lesions.

Main Outcome Measures On computed tomography venography (CTV), the drainage site was classified into three patterns based on its relationship to Meckel's cave and the IAM: Meckel's cave type, Intermediate type, and Meatal type.

Results In all patients, the SPV was patent and emptied into the superior petrosal sinus (SPS). In patients without posterior fossa lesions, 35% had Meckel's cave type, 54% had Intermediate type, and 11% had Meatal type. Of the five patients with petroclival meningioma, three had Intermediate type, and two had Meckel's cave type.

Conclusion The SPV is a significant vein that should be preserved to prevent venous complications. Preoperative knowledge of the SPV drainage site is helpful for planning the approach and preserving the SPV in petroclival meningioma surgery.

Introduction

Surgical outcomes of petroclival meningioma have been improved dramatically by technical advances in skull base surgery.^{1–3} However, venous infarction has been reported as a serious complication of lateral approaches, including the transpetrosal approach (TPA).^{4–8} The vein of Labbé has been reported to be responsible in most of these reports, but we realized that the superior petrosal vein (SPV) is also an

important vein that should be preserved to prevent cerebellar and/or brain stem venous infarction.⁹ In April 2004, we saw a large petroclival/petrosal meningioma patient who, immediately after removal of the tumor through a posterior TPA, developed progressive consciousness disturbance by acute hydrocephalus due to ipsilateral cerebellar swelling. As an emergency procedure, ipsilateral cerebellar decompression was performed; the patient recovered and is now doing well. Precise analysis through review of the operative video

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Figure 1 Petroclival meningioma showing an equivocal flow void sign (arrow). Review of the operative video suggested that this was the superior petrosal vein (see the text).

and preoperative imaging strongly suggested that the equivocal flow void in the preoperative magnetic resonance imaging (MRI) may be the SPV in the rostral and basal aspect of the tumor (→**Fig. 1**), and that intraoperative occlusion of this vein (the video demonstrated a “blue” petrosal vein [PV] that meant this vein was normally functioning) led to acute cerebellar swelling in this patient. This case was an early case, and computed tomography venography (CTV) was not done. This experience prompted us to investigate the significance of the SPV in petroclival meningioma surgery. In this study, CTV was used to demonstrate the drainage pathways of the SPV and to anatomically categorize these drainage sites into the petrosal sinus. This anatomical analysis of the SPV is of significant value for preservation of this vein in petroclival meningioma surgery.

Methods

This study was performed between January 2009 and January 2011 and included five patients (one male, four females; age range 41 to 62 years) with petroclival meningioma who underwent surgery in our hospital (→**Table 1**) and two sides of 50 patients (primarily unruptured supratentorial aneurysm patients, with a few hemifacial spasm patients; 19 males, 31 females; age range 37 to 79 years) with no posterior fossa lesions who consented to undergo contrast-enhanced computed tomography (CT). The definition of “petroclival meningiomas” is widely used and includes petrosal and petrotentorial meningiomas; this wide definition did not impede the purpose of the study. All patients provided informed consent, and formal approval from our institute was obtained. All examinations were performed with contrast-enhanced CT imaging (64-multislice, Aquilion, Toshiba, Tokyo, Japan) using the following scan parameters: pipe voltage, 120 kV; pipe electric current, 300 mA; slice thickness, 0.5 mm; scan time, 0.6 second/round. The protocol used was as follows: helical acquisition using 100 mL of OMNIPA-QUE350 (iodine concentration 350 mg/mL; Daiichi-Sankyo,

Table 1 Summary of Five Cases of Petroclival Meningioma Surgery with Perioperative CT Venography

Case	Age (Years)/Sex	Type of Drainage Pathway of PV	Collateral Drainage	Surgical Approach	Tumor Size	Resection (Simpson's grade)	Preoperative Symptoms	Postoperative Symptoms	Preservation of SPV
1	59/F	Intermediate type	Lateral mesencephalic vein	CSA	43 mm	II	None	Facial numbness	No
2	45/F	Meckel's cave type	Equivocal	OZA + ATP	66 mm	II	Headache	Mild diplopia Facial numbness	Yes
3	54/F	Intermediate type	Equivocal	OZA + ATP	32 mm	II	None	None	Yes
4	62/F	Intermediate type	Equivocal	ATP	52 mm	II	None	Mild diplopia Facial numbness	Yes
5	41/F	Meckel's cave type	None	OZA + ST	30 mm	III	Trigeminal neuralgia	Trochlear nerve palsy	Yes

For the decision-making process related to the choice of approach in each case, see discussion in the text.

ATP, anterior transpetrosal approach; CSA, combined pre- and retrosigmoid approach; F, female; M, male; OZA, orbitozygomatic approach; SPV, superior petrosal vein; ST, subtemporal approach.

Figure 2 Computed tomography venography–based classification of the drainage pathway of the superior petrosal vein (all arranged on the left side). (A) Meckel's cave type. (B). Intermediate type. (C) Meatal type.

Tokyo, Japan) injected at a rate of 4 mL/s into the antecubital vein with a power injector and acquisition starting 35 seconds after the beginning of the injection. CTV was created from the dataset by perspective volume-rendering algorithms. The patterns of the drainage pathway of the SPV were analyzed in relation to Meckel's cave and the internal acoustic meatus (IAM), and they were classified into three groups based on the drainage site into the petrosal sinus: Meckel's cave type, Intermediate type, and Meatal type (►Fig. 2). Because other smaller veins are difficult to identify, the dominant drainage vein into the SPS on CTV was regarded as the SPV. In the tumor patients, collateral venous drainage other than the SPV was also evaluated. In this classification, three anatomical landmarks were used: Meckel's cave, the midway point between Meckel's cave and the IAM, and the IAM. The drainage site of the SPV signifies which landmark is nearest to the site of this venous drainage. Three scorers (K.S., M.K., F.K.) agreed in all cases.

Results

In all patients, the SPV was patent and emptied into the SPS. In patients without posterior fossa lesions, 35% had Meckel's cave type (►Fig. 2A), 54% had Intermediate type (►Fig. 2B), and 11% had Meatal type (►Fig. 2C). Of the five patients with petroclival meningioma, three were Intermediate type and two were Meckel's cave type.

The SPV was patent preoperatively in all five patients with petroclival meningioma. Based on the pattern of the drainage pathway of the SPV, the surgical approach was the orbitozygomatic approach (OZA), the TPA, or a combination. Simpson's grade II operation was performed in four patients, and Simpson's grade III was performed in the remaining patient. Postoperative CTV demonstrated that the SPV was preserved in four patients, but the vein could not be detected in one patient (Case 1, ►Table 1).

Illustrative Case

Case 5

A 41-year-old woman presented with a history of right hemifacial pain for 6 months. MRI with contrast medium showed a meningioma involving Meckel's cave, the petro-

clival region, and the posterior portion of the cavernous sinus (►Fig. 3A, B). Preoperative CTV showed that the SPV was patent and of the Meckel's cave type (►Fig. 3C). Because the lesion partially involved the cavernous sinus, an OZA combined with a subtemporal approach was chosen to obtain a wide operative field and preserve the SPV. Simpson's grade III operation was also performed, leaving in place the intracavernous sinus portion of the tumor. Postoperative CTV confirmed preservation of the SPV (►Fig. 3D). After surgery, the patient had no obvious postoperative venous complications, although she had mild trochlear nerve palsy and was treated with rehabilitation therapy. The patient was discharged 20 days after surgery. Postoperative follow-up MRI at 1.5 years after surgery showed no enlargement of the residual tumor (►Fig. 3E, F). She is also being followed up at a radiosurgery institute in case she requires radiosurgery in the future.

Discussion

Lateral approaches, especially the TPA, are often used in surgery for petroclival meningioma because the tumor attachment site and feeding arteries can be attacked at an early stage of the operation.^{1,3,10,11} However, a considerable number of experts have warned that venous infarction is the most dangerous postoperative complication of these lateral approaches. They also claim that vein of Labbé injury is the most common cause of this complication.^{4–8} There is, however, another important vein that is almost invariably involved in petroclival meningiomas, the SPV. In some cases, the SPV has already been obstructed or turned to be a “red” vein, allowing safe division of this vein. On the other hand, in some cases, especially in small lesions, the SPV often maintains its normally functioning drainage pathway of the lateral pontine vein, the vein of the great horizontal fissure, and the lateral mesencephalic vein. Taking into consideration the above described drainage pathway of these veins, surgical division of the SPV should be avoided as far as possible to eliminate the potential risk of brain stem and/or cerebellar venous infarction. For the same reason, the combined anterior and posterior TPA involves an inherent risk of venous infarction by trapping the drainage pathway of the SPV.^{4,12} Our previously mentioned experience and literature review of petroclival

Figure 3 Preoperative T1-weighted axial (A) and coronal (B) magnetic resonance imaging (MRI) with gadolinium diethylenetriaminepentaacetate (Gd-DTPA) showing a petroclival meningioma on the right side (case 5). (C) Preoperative computed tomography venography (CTV) showing the superior petrosal vein draining near Meckel's cave (Meckel's cave type). (D) Postoperative CTV showing patency of the superior petrosal vein. Postoperative T1-weighted axial (E) and coronal (F) MRI with Gd-DTPA showing the amount of resection of the tumor. White asterisk, draining point of the superior petrosal vein (SPV); yellow asterisk, internal acoustic meatus (IAM); pink asterisk, Meckel's cave; white arrow, SPV.

meningioma surgery prompted us to investigate the normal drainage patterns of the SPV. We analyzed the drainage pathway of the SPV in 100 sides of 50 patients who had no posterior fossa lesions and gave their consent to participate in the study. This investigation showed that the Intermediate type was present in 54% of the studied sides, Meckel's cave type was present in 35%, and the Meatal type was present in 11%. Therefore, according to this study, the SPV drainage nearer to Meckel's cave (Intermediate type plus Meckel's cave type) rather than to the IAM accounted for 89% of the total sides. These figures are similar to those of Tanriover's investigation based on cadaver dissection.⁹ These findings also indicate that, to not interfere with the drainage of the SPV, great care must be taken in dividing the SPS near Meckel's cave through the anterior TPA. Although preservation of the posteriorly directed drainage pathway of the SPV is physiologically desirable, the postoperative drainage pathway of this vein is bound to be anterior to the cavernous sinus when the posterior TPA is selected. Therefore, we must emphasize that preoperative evaluation of the SPV drainage pathway is essential if the posterior TPA is considered. In the present petroclival meningioma cases, regardless of tumor size, the SPV was patent preoperatively in all patients, with the location of drainage being the Intermediate type in three cases and Meckel's cave type in two.

In Case 1, because the tumor spread widely posteriorly and the collateral venous pathway (lateral mesencephalic vein) was clearly demonstrated preoperatively, a combined pre- and retrosigmoid approach, as a variation of the posterior TPA, was chosen, and a wide surgical field was obtained.¹³ Although the SPV could not be visualized on postoperative CTV, no obvious venous complications occurred. In Case 2, despite the large size of the tumor, the Meckel's cave type SPV drainage was patent preoperatively. Because the tumor involved Meckel's cave and the collateral pathway was not clearly demonstrated on CTV, the surgical approach was decided to be a combination of the anterior TPA and the OZA to obtain a wide operative field and to preserve the SPV. The tumor was excised without venous complications, and preservation of the SPV was confirmed postoperatively. In Case 3, the tumor was small but extended into Meckel's cave. To preserve the intermediate type venous drainage in the lateral direction, a combination of OZA and anterior TPA was chosen. In Case 4, although the tumor was large but relatively localized in the anterior petrosal region, the anterior TPA was considered to be enough to preserve the intermediate venous drainage in the lateral direction. In Case 5, because most portions of the tumor were located in the supratentorial area and the Meckel's cave type SPV was patent preoperatively, the OZA combined with the subtemporal approach was selected, and the tumor was excised without

venous complications. The postoperative CTV demonstrated that the Meckel's cave-type drainage was preserved. Based on these surgical experiences, we emphasize that evaluation and classification of the SPV drainage pathway by CTV are very valuable for establishing surgical strategies for petroclival meningioma. Furthermore, the fact that the SPV may be patent and functioning regardless of tumor size strongly suggests the importance of surgical preservation of this vein. The SPV on CTV may be difficult to identify when this vein is closely adherent to, or runs through, the tumor. In the present five cases, the SPV was recognized without much difficulty, probably because this vein was somewhat separate from the tumor.

Conclusion

The SPV is one of the important veins that should be preserved during surgical removal of petroclival meningiomas. An analysis of the SPV drainage pathway using CTV is helpful for planning the surgical approach and the amount of exposure in petroclival meningioma surgery.

Disclosure

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

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