Fully endoscopic trans-cylinder trans-Magendie foraminal approach for fourth ventricular cavernoma: A technical case report

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Abstract

Background: Neuroendoscopy offers wide and close surgical views with fine illumination, even in deep surgical sites. Furthermore, transcylinder surgery has the advantage that a tubular retractor can protect critical neurovascular structures in the surgical corridor. These advantages of neuroendoscopy and transcylinder surgery can contribute to safer and less invasive surgical approaches for deep-seated fourth ventricular lesions, for which various critical neurovascular structures exist along the surgical route.

Case Description: A 54-year-old man with a fourth ventricular cavernoma underwent tumor resection via the endoscopic transcylinder trans-Magendie foraminal approach. A 6.8-mm transparent sheath (cylinder) was introduced into the fourth ventricle via the foramen of Magendie without incisions in the inferior medullary velum or the tela choroidea, resulting in the minimal retraction of and trauma to critical neurovascular structures in the surgical corridor. Under the view of a 2.7-mm rigid neuroendoscope, the lesion was completely removed with preservation of a venous anomaly on the ventral side of the aqueduct of Sylvius. Neuroendoscopy could offer a fine surgical view even under continuous irrigation with artificial cerebrospinal fluid; it prevented collapse of the fourth ventricle and facilitated anatomical understanding by the surgeons. The postoperative course was uneventful.

Conclusions: Our novel approach can be an effective surgical option for fourth ventricular lesions with minimal cerebellar retraction and injury.

Introduction

Gaining surgical access to the fourth ventricle is a challenging procedure for neurosurgeons because of the close proximity of the access route to critical neurovascular structures and the brainstem. Classically, surgical approaches for accessing the fourth ventricle often involve severe cerebellar retraction or splitting of the vermis, leading to postoperative "posterior vermal split syndrome".[1] Recently, several surgical approaches that avoid splitting the vermis have been reported with optimal postoperative outcomes in the literature.[2-6]

On the other hand, neuroendoscopic surgery has rapidly become widespread owing to the remarkable development of optical technologies and surgical instruments. In neuroendoscopic surgery, both wide and close surgical views with fine illumination can be available, even in deep surgical sites.[7] Indeed, neuroendoscopy has gradually been applied in surgical procedures for fourth ventricular lesions.[8,9] In addition, recent studies have shown various advantages of the transcylinder approach for intraventricular lesions or even for intraparenchymal lesions[10-15]; a cylinder (sheath) can minimize injury to surrounding brain tissues along a surgical route. These advantages of neuroendoscopy and transcylinder surgery should be applied in surgical approaches for deep-seated fourth ventricular lesions, for which several critical neurovascular structures exist along the access route. Herein, we present a practical illustration of the endoscopic transcylinder trans-Magendie foraminal approach for a fourth ventricular cavernoma.

Case Description

Patient

A 54-year-old male visited a nearby hospital with intermittent headache. Magnetic resonance imaging (MRI) showed a lesion in the fourth ventricle, without obvious hydrocephalus (Fig. 1A and B). The patient was placed under close observation; however, MRI obtained 4 months after the first visit showed enlargement of the lesion, with a change in the intralesional signal intensity suggesting repeated hemorrhage (Fig. 1C and D). The patient was referred to our hospital with a clinical diagnosis of fourth ventricular cavernoma. He hoped for definitive surgical treatment because the intermittent headache was becoming stronger. Informed consent for the publication of this article and to undergo surgery was obtained from the patient.

Surgical Technique

The patient was placed in a prone position with the upper body raised approximately 15 degrees and the head rotated approximately 10 degrees to the side of the surgeon to facilitate the insertion and removal of the surgical instruments (Fig. 2A). A midline, suboccipital, 6-cm, linear skin incision was made; the skin incision was more caudal than that in the conventional microscopic midline, suboccipital approach to straighten the surgical corridor to the fourth ventricle and minimize retraction of the cerebellar tonsils and vermis using a tubular retractor (Fig. 2B). Then, a craniotomy with a size of approximately 3×2 cm without a C1 laminectomy was performed. After incision of the dura mater, the arachnoid membrane covering the bilateral cerebellar tonsils was opened. The bilateral posterior inferior cerebellar arteries were identified; subsequently, the bilateral tonsils were bluntly dissected to make a midline access route to the fourth ventricle. Then, a 5.8-mm transparent acryl puncture needle (Sonne Medical Instruments, Tokyo, Japan)[16] with a 6.8-mm transparent cylinder (Neuroport Mini®, Olympus, Tokyo, Japan) was gently inserted into the fourth ventricle under close observation of the surrounding critical neurovascular structures with a 2.7-mm, 0-degree rigid neuroendoscope (Endo Arm® 4K, Olympus, Tokyo, Japan) (Fig. 2C and D). In this approach, the foramen of Magendie was gently dilated by a puncture needle and kept expanded by a sheath; incisions in the inferior medullary velum and/or tela choroidea were not required. After identification of the lesion, the transparent puncture needle was removed, and the tip of a transparent sheath was kept just before the lesion. The neuroendoscope was fixed by the pneumatic system, and a sheath was held by an assistant surgeon to minimize unexpected injuries to the surrounding neurovascular structures. First, the lesion was incised, and the old hematoma was adequately evacuated. Under neuroendoscopic observation using the “wet-field” technique,[15] the lesion was identified to not be adhered to the brainstem (Fig. 2E). The “wet-field” technique has the great advantage that the ventricular size can be maintained by continuous irrigation with artificial cerebrospinal fluid (CSF); it can facilitate exposure of the lesion and the surrounding brain tissue without additional retraction. After adequate debulking of the lesion in a piecemeal fashion, the origin of the lesion was identified in the superior medullary velum (Fig. 2F), and the attachment was thoroughly detached. Then, the lesion was completely removed with preservation of a venous anomaly (Fig. 2G). After the lesionectomy, the transparent sheath was removed; no tissue trauma was identified in the cerebellar tonsils or vermis (Fig. 2H). The dura mater was closed with an absorbable artificial dural substitute (dura wave®, Gunze, Osaka, Japan), and then dural sealant was applied to prevent postoperative CSF leakage. The bone flap was fixed with a titanium plate. The skin was closed in layers. The practical method of this surgery is shown in Video 1.

Postoperative Course

The postoperative course was uneventful, with no cerebellar dysfunction. The pathological diagnosis was hemangioma. MRI performed six months after the surgery showed gross total resection of the lesion with preservation of the venous anomaly (Fig. 3).

Discussion

"Posterior vermal split syndrome" is a well-known postoperative morbidity after surgical procedures for fourth ventricular lesions, and several surgical approaches that avoid the syndrome have been advocated in the literature.[2-6] Mussi and Rhoton[4] proposed the telovelar approach, which achieves surgical access to the fourth ventricle by opening the tela choroidea and inferior medullary velum. The authors notably presented that the whole fourth ventricular cavity could be accessed via the approach, given their abundant experience in cadaver dissection. However, adequate lateral displacement of the bilateral tonsils is needed to obtain a fine surgical view of the fourth ventricle with the microsurgical telovelar approach. Matsushima et al.[3]

showed the efficacy of the transcerebellomedullary fissure (CMF) approach, which consists of a wide opening of the CMF and exposure of the lateral recess. More recently, neuroendoscopy has gradually been applied in surgical procedures for fourth ventricular lesions.[8,9]

Our novel surgical approach to the fourth ventricle, the endoscopic transcylinder trans-Magendie foraminal approach, has various advantages. First, we can access the fourth ventricle via a transparent sheath with a minimal diameter, which only dilates the foramen of Magendie without opening the tela choroidea or inferior medullary velum, resulting in minimum retraction of the cerebellum. Second, a tubular retractor can prevent injury to critical neurovascular structures along the surgical corridor. Endoscopy has a serious disadvantage; it involves an intracranial blind area between the objective lens of the endoscope and the dural opening site.[7] A sheath can protect critical neurovascular structures in the blind area from unexpected injuries. Third, neuroendoscopy can offer excellent visibility even in fluids, which was demonstrated as the “wet-field” technique in our previous report.[15] In the “wet-field” technique, the dimension of the ventricle is preserved by water pressure, facilitating anatomical understanding by surgeons. Every corner of the fourth ventricle can be inspected and approached under the wide surgical view of neuroendoscopy.

The major drawback of this technique is the high degree of interference between surgical instruments and the neuroendoscope within the narrow sheath. Monoshaft surgical instruments with fine tips are essential to perform surgical maneuvers by two-handed manipulation in a narrow corridor. Bipolar forceps with fine tips are also useful for prompt hemostasis; they can be used even in the "wet-field". Although a tubular retractor with a wider diameter can offer a more comfortable working space, it would increase the retraction of the cerebellum. Therefore, the diameter of the sheath should be determined based on the tumor size and consistency. When a sheath with a wide diameter is introduced into the fourth ventricle, attention should be paid to prevent damage to the floor of the fourth ventricle. Therefore, opening the tela choroidea only, that is, the telovelar approach, may be useful for obtaining sufficient space for inserting a sheath with a wide diameter into the fourth ventricle.

As mentioned above, the endoscopic transcylinder trans-Magendie foraminal approach can provide a fine surgical access to the fourth ventricle with minimal retraction of the cerebellum. However, the lesion is removed in a piecemeal fashion with this technique because of the narrow corridor; tumors with hypervascularity, such as hemangioblastomas, might not be indicated for this approach. Tumors with high malignancy are also not indicated; the "wet-field" technique might facilitate tumor dissemination. Thus, we advocate that the approach is indicated for a select group of patients with fourth ventricular lesions that: (1) exist in the midline of the fourth ventricle without lateral extension to the lateral recess; (2) have a maximum diameter of less than 3 mm; and (3) do not have hypervascularity or high malignancy.

Conclusions

In this article, we demonstrate a novel surgical approach for fourth ventricular lesions: the endoscopic transcylinder trans-Magendie foraminal approach. This approach can offer an excellent surgical route to the fourth ventricle for selected cases with minimal retraction of the cerebellar tonsils and vermis.

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None.

Declarations of Interest

None

Ethics Approval

This study was approved by the institutional review board.

Informed Consent

Informed consent for the publication of this article was obtained from the patient.

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Figure Captions

Fig. 1. Preoperative magnetic resonance imaging (MRI) of the patient. A lesion with heterogeneous signal intensity was detected in the fourth ventricle. Hydrocephalus was not apparent. **A)** Gadolinium (Gd)-enhanced T1-weighted sagittal imaging and **B)** T2-weighted sagittal imaging. MRI obtained 4 months after the first MRI showed enlargement of the lesion. The alteration in the signal intensity of the lesion suggested repeated hemorrhage. The presence of a hemosiderin rim on T2-weighted imaging indicated that the lesion was a cavernoma. **C)** Gd-enhanced T1-weighted sagittal imaging and **D)** T2-weighted sagittal imaging.

Fig. 2. A) Head fixation of the patient during surgery. The head was rotated approximately 10 degrees to the side of the surgeon to facilitate the insertion and removal of the surgical instruments and neuroendoscope. **B)** Schematic of the surgical corridor. A tubular retractor was introduced into the fourth ventricle from a more caudal side than that in conventional microscopic surgery to minimize retraction of the cerebellum. **C)** Photograph of a 5.8-mm transparent acryl puncture needle (black arrow) and a 6.8-mm transparent sheath (white arrow). **D)** A 2.7-mm, rigid neuroendoscope can be inserted in the puncture needle, which enables sheath insertion under endoscopic observation. **E-H)** Intraoperative findings by the “wet-field”

technique. By continuous irrigation with artificial cerebrospinal fluid (CSF), the ventricular size was maintained, and the lesion and the surrounding brain tissue were well exposed. The black asterisk in E and H shows an irrigation tube for continuous irrigation with artificial CSF. **E)** The lesion was not adhered to the pons and was successfully detached from it. **F)** The attachment of the lesion was detected on the superior medullary velum. **G)** The lesion was completely removed with preservation of the venous anomaly on the aqueduct of Sylvius (white arrow). **H)** After tumor resection and sheath removal, no tissue trauma was detected in the cerebellar vermis (white asterisk) or bilateral tonsils. Cav: cavernoma, SMV: superior medullary velum, Ton: tonsil.

Fig. 3. Postoperative gadolinium (Gd)-enhanced T1-weighted sagittal imaging 6 months after the surgery. The fourth ventricular lesion was completely removed with preservation of the venous anomaly (white arrow) on the aqueduct of Sylvius.