Acta Neurochir (2013) 155:1011–1016
DOI 10.1007/s00701-013-1689-x

CLINICAL ARTICLE - BRAIN TUMORS

Transcerebellomedullary fissure approach to lesions of the fourth ventricle: less is more?

Sheng Han · Zixun Wang · Yunjie Wang · Anhua Wu

Received: 17 January 2013 / Accepted: 21 March 2013 / Published online: 7 April 2013

Abstract
Background The transcerebellomedullary fissure (trans-CMF) approach is safe and effective. Nevertheless, previous research documented a few differences in the use of this approach with regard to the opening portion of the fissure and roof of the ventricle. Here, we present a series of patients with fourth ventricular lesions and our experience using the trans-CMF approach.
Methods Fifty patients who underwent the trans-CMF approach were analyzed. The tela choroidea was simply incised in 32 patients: 27 unilaterally and 5 bilaterally. Both the tela and inferior medullary velum were cut in 18 patients: 16 unilaterally and 2 bilaterally. Unless the tumor extended below the C1 level, C1 was preserved intact. Brainstem mapping (BSM) and corticobulbar tract (CBT) motor-evoked potential (MEP) monitoring were used.
Results Gross total removal was achieved in 41 (82 %) cases, and sub-total removal was achieved in 9 (18 %) cases. Two deaths occurred 1–2 months postoperatively because of pulmonary complications. Four patients developed temporary mutism, all of whom underwent the bilateral trans-CMF approach (this rate is significantly higher than that of the unilateral approach, $P<0.05$). No permanent neurological deficit occurred.
Conclusion The trans-CMF approach provides excellent access to fourth ventricular lesions without splitting the vermis. The opening portion of the fissure and roof of the ventricle should be determined by the location, extension and size of the lesion. In most cases, the unilateral trans-CMF approach with only a tela choroidea incision is adequate; this procedure is mini-invasive and possibly prevents postoperative mutism.

S. Han · Z. Wang · Y. Wang · A. Wu (✉)
Department of Neurosurgery, The First Hospital of China Medical University, Nanjing Street 155, Heping District, Shenyang 110001, China
e-mail: cmuwuanhua@yahoo.com.cn

Keywords Cerebellomedullary fissure · Telovelar approach · Fourth ventricle · Surgical approach · Brain tumor

Introduction

The fourth ventricle is a surgically challenging area because of the severe consequences that may occur following injury to the vital structures in the ventricle wall and floor [14]. Traditionally, operative access to the fourth ventricle was obtained by splitting the cerebellar vermis or removing part of a cerebellar hemisphere [17]. However, such approaches involve normal cortical tissue damage before the surgical target is reached. The resulting undesired complications include, for instance, equilibrium disturbances and cerebellar mutism.

Matsushima et al. [9] first described an approach to the fourth ventricle without significant injury to neural tissue through the cerebellomedullary fissure, which has now become widely accepted [3, 16, 18, 21]. However, previous research has documented a few differences in the use of this approach. In this article, we offer a comparison between different types of trans-CMF approach in 50 patients.

Materials and methods

Patient details

From May 2004 to April 2012 in our hospital, 50 patients diagnosed as having a fourth ventricular tumor were operated upon via the transcerebellomedullary fissure (trans-CMF) approach. Clinical and surgical data were retrospectively reviewed. The group of patients consisted of 31 children and 19 adults. Eighteen were females, and 32 were males. Age ranged from 6 to 58 years (mean 23). Symptoms were present 2 months to 4 years before diagnosis. The most

common symptoms in our patients were headache, nausea, vomiting, dizziness and ataxia. Twenty-three patients had with hydrocephalus preoperatively, and seven patients (30.4 %) underwent emergency external ventricular drainage. All patients underwent magnetic resonance imaging (MRI) or computed tomography (CT) pre- and postoperatively.

Surgical technique

The trans-CMF approach has been described previously in the literature [13]. The surgical technique employed in this series is characterized as follows.

All patients were operated on in the prone position with the head flexed at the craniocervical junction. After making a midline occipitocervical incision extending from the inion to the spinous process of C2, the posterior arch of C1 and occipital bone were exposed. Midline suboccipital craniotomy was performed. When the lesion extended below the C1 level, C1 laminectomy was added; otherwise, C1 was preserved intact. A Y-shaped dural opening was made. The cerebellomedullary fissure (CMF) is composed of two slit spaces, the uvulotonsillar and medullotonsillar spaces [14]. These two spaces were sharply dissected to release the tonsil and the uvula. Then, the uvula was retracted superiorly, and the tonsil was retracted laterally to expose the fourth ventricle inferior roof, composed of the tela choroidea, inferior medullary velum and lateral recess. The branches of the posterior inferior cerebellar artery (PICA) were well protected.

In this article, we subdivide the trans-CMF approach into two types.

1 Simple tela choroidea opening approach

   In 32 patients, the tela choroidea was incised. In this group, the lesions were primarily located in the lower 3/4 of the ventricle. The tela was opened unilaterally on the lesion side in 27 cases, while bilateral incisions of the tela were performed in the other five cases, in which lesions extended distally into the contralateral lateral recess.

2 Both tela choroidea and inferior medullary velum opening approach (telovelar approach)

   In 18 patients, both the tela choroidea and inferior medullary velum were opened. The tumors of this group majorly invaded the upper 1/4 of the ventricle. A unilateral incision was performed on the lesion side in 16 cases, and bilateral incisions were made in 2 cases, in which lesions extended distally into the contralateral superolateral and/or lateral recess (Table 1).

During surgery, brainstem mapping (BSM) was performed on the floor of the fourth ventricle and through the tumor cavity. Meanwhile, corticobulbar tract (CBT) motor-evoked potential (MEP) monitoring was carried out continuously.

Table 1 Surgical approach

Surgical approach	Number of patients
Simple tela choroidea opening approach	32
Both tela choroidea and inferior medullary velum opening approach (telovelar approach)	18
Unilateral appraoch	43
Bilateral approach	7
C1 intact	36
Partial C1 laminectomy	5
Complete C1 laminectomy	9

Results

We have used two types of trans-CMF approach to treat 50 patients with fourth ventricular tumors in the past 8 years. In most cases, the C1 was preserved intact. During the operation, sufficient exposure and operating space were obtained in each case. The illustrative cases are shown in Figs. 1 and 2.

Histopathology

The 50 cases included 19 ependymomas, 16 medulloblastomas, 7 hemangioblastomas, 3 cavernomas, 3 meningiomas and 2 epidermoid tumors (Table 2).

Degree of removal

Gross total removal (GTR) was achieved in 41 cases (82 %). In the other nine (18 %) cases, sub-total removal was obtained, including six ependymomas and three medulloblastomas. In four of them, the tumors infiltrated the obex; in three of them, the tumors attached focally to the facial colliculus; in the other two cases, the tumors engulfed lower cranial nerves.

Complications and outcomes

Four patients (8 %) developed temporary mutism, and all of them underwent the bilateral trans-CMF approach (2 patients underwent the bilateral tela choroidea opening approach and 2 patients underwent the bilateral telovelar approach). The rate of mutism was significantly higher in the bilateral approach group (57.1 %) than in unilateral approach group (0 %) ($P< 0.05$). Nevertheless, the symptom disappeared within 1 month. Other transient symptoms included ataxia, hypotaxia, mild facial palsy, mild abducent palsy and dysphagia. After symptomatic supportive treatment, recovery was achieved for all of

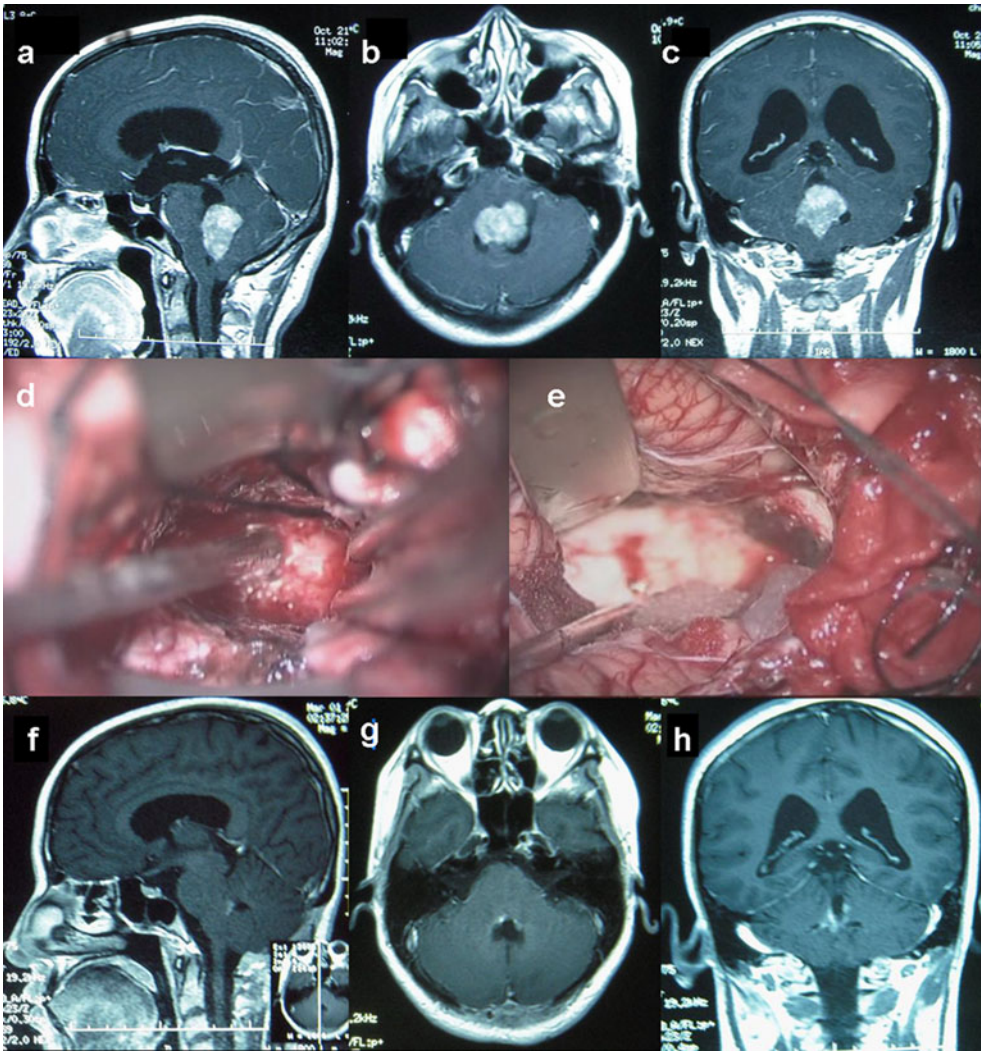

Fig. 1 Unilateral trans-CMF approach with a simple tela choroidea incision for fourth ventricular ependymoma. **a–c** Preoperative enhanced MRIs. T1-WI show an enhancing mass filling the fourth ventricular cavity. **d–e** Intraoperative photos. **d** Exposure of the tumor. **e** Complete removal. **f–h** Postoperative enhanced T1-WI MRIs. The tumor was totally removed and hydrocephalus apparently relieved

these symptoms within 1–3 weeks. Seven patients (14 %) developed symptomatic hydrocephalus requiring placement of a ventriculoperitoneal shunt.

In the follow-up period of 3 months to 8 years, the preoperative symptoms disappeared in 43 cases and remained unchanged in 5. There was no permanent neurological deficit due to operation. Two deaths (3.6 %) occurred 1–2 months after surgery because of pulmonary complications.

Discussion

Approaching the fourth ventricle is a surgically formidable task. Devastating morbidity can occur at any step. The traditional approach has involved incision of the cerebellar vermis. However, vermian incision correlates with a higher incidence of the "cerebellar mutism" or "posterior fossa syndrome," along with chronic neurocognitive sequelae [1, 15, 19, 20].

The discovery of the cerebellomedullary fissure (CMF) was monumental for fourth ventricle surgery [8, 9, 14]. The CMF is a natural cleft between the cerebellum and medulla ablongata, and incision of the tela choroidea and inferior medullary velum causes no neurological deficits. Thus, the trans-CMF approach provides a relatively mini-invasive and vermian-sparing access to lesions of the fourth ventricle. Furthermore, this approach also offers a greater angle of exposure and more capacious working space than the transvermian approach [2]. However, previous studies described differing opinions concerning the description and employment of this approach. Authors have different perspectives on the method of exposing the ventricle. They also described different parts of the fourth ventricular roof that should ideally be incised. Some authors advocate a simple tela choroidea opening approach [10, 11], while others prefer incision of the inferior velum [3, 5, 13, 16, 21]. Some authors reported the usefulness of a bilateral approach [7, 10, 11], while others believe a unilateral approach is quite sufficient [4]. There are fibrous adhesive tissues and many blood vessels in the CMF. In order to make this approach safer and less invasive, the part of the fissure and

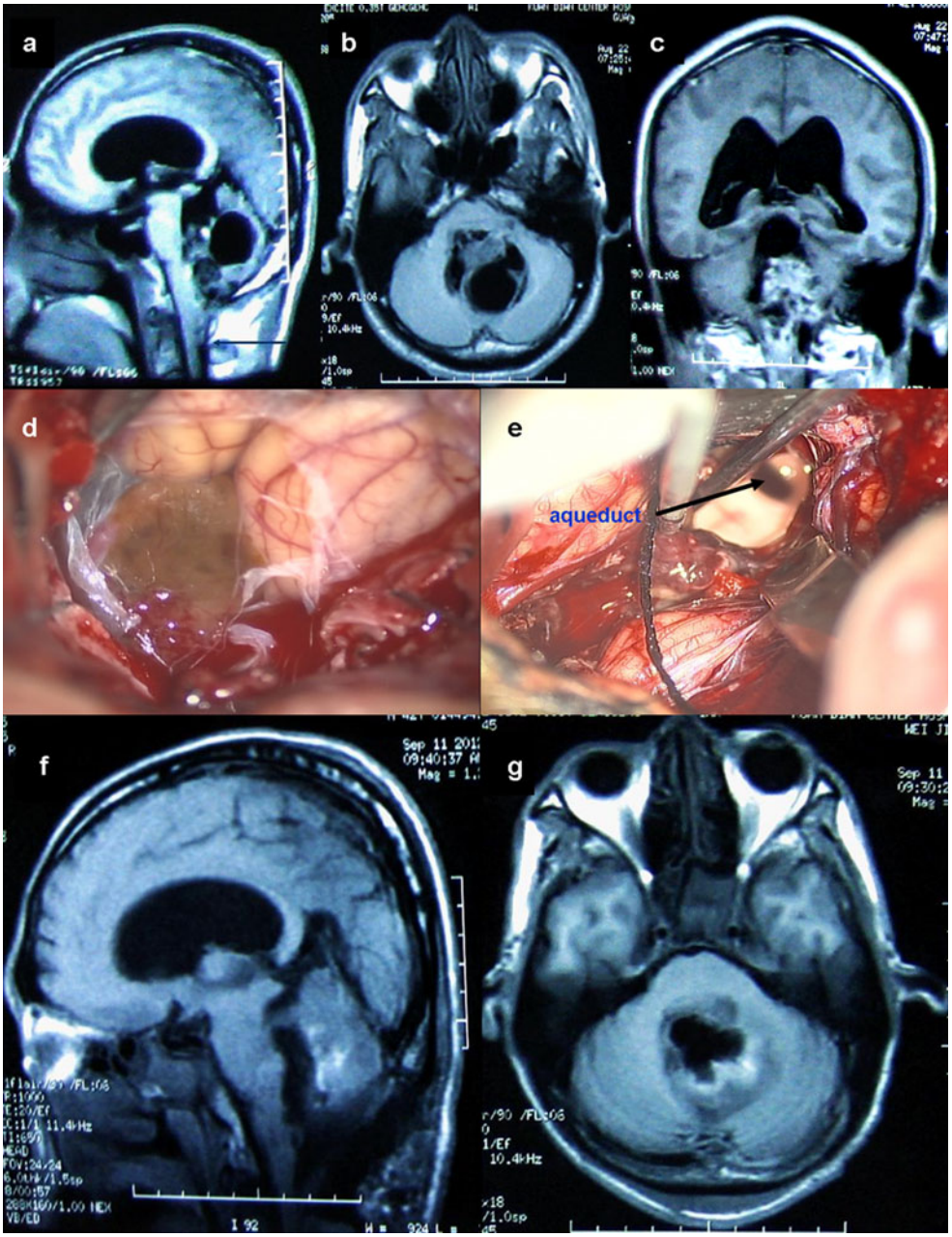

Fig. 2 Bilateral telovelar approach for large fourth ventricular ependymoma. **a–c** Preoperative T1-WI MRIs show an extensive fourth ventricular tumor. **d–e** Intraoperative photos. **d** Exposure of the tumor protruding between the hemispheres. **e** Exposure of the aqueduct. **f–g** Postoperative T1-WI MRIs. The tumor was subtotally removed and hydrocephalus partially relieved

the fourth ventricular roof that should be incised needs to be carefully considered.

1. Tela choroidea only or combined with inferior medullary velum?

Utilizing trans-CMF approach, we operated on 50 patients with different fourth ventricular tumors. In this series of patients, we used two different methods of exposing the fourth ventricle. In our opinion, simply opening the tela is sufficient in most cases. First of all, the taenia (the lateral margin of the tela choroidea) from the foramen of Magendie to the ventricular entrance of the lateral recess is incised, then the cutting line is deviated laterally to the posterior margin of the lateral recess, with appropriate retraction of the tonsil and uvula; this allows at least the lower 3/4 of the fourth ventricle to be adequately exposed (Fig. 3b). Second, if the tumor is confined to the lateral recess of one side, only dissection of the ipsilateral medullotonsillar fissure with a simple tela choroidea incision is enough. Third, because of the expansion and extrusion of the tumor, the uvulotonsillar and medullotonsillar spaces can be naturally widened. Moreover, during surgery, if the tumor is relatively large, central debulking will create additional operating space. Thus, in this series of patients, 32 (57 %) underwent this method of exposure, and all obtained satisfying exposure

Table 2 Histopathology and degree of removal

Histopathology	Number of patients	Gross total removal	Sub-total removal
Ependymoma	19	13 (68.4 %)	6 (31.6 %)
Medulloblastoma	16	13 (81.25 %)	3 (18.75 %)
Hemangioblastoma	7	7 (100 %)	-
Cavernoma	3	3 (100 %)	-
Meningioma	3	3 (100 %)	-
Epidermoid tumor	2	2 (100 %)	-
Total	50	82 %	18 %

and resection. Only if the tumor extends superiorly to the upper 1/4 of the ventricle (the fastigium, superolateral recess and/or the superior half of the roof) is additionally opening the inferior medullary velum helpful (Fig. 3c). Mussi et al. named this the telovelar approach [13]. We used this approach in 18 (32 %) patients. However, we beleive that, during the operation, the detachment and manipulation of the tonsil were far more important for ventricular exposure. To increase the exposure of the lateral recess and the angle of approach to the cerebral aqueduct, Preul et al. studied the approach using cadaver specimens and proposed tonsillar resection in the telovelar approach [6]. In our experience, tonsillar resection is not necessary. In actual surgery, unlike cadaver specimens, after release of cerebrospinal fluid, via flexible retraction of elastic brain tissue and gradual resection of the tumor, sufficient exposure and operative space can be obtained.

2. Unilateral or bilateral approach?

In this series, 43 patients underwent the unilateral approach, while 7 underwent the bilateral approach. In this study, we found that in most cases, dissection of the contralateral CMF was not necessary. The unilateral trans-CMF approach with contralateral tonsillar retraction could sufficiently expose most lesions of the fourth ventricle unless the lesion obviously invaded the contralateral superolateral and/or lateral recess (Fig. 3d). Contralateral tonsillar retraction also improves access to the lateral recess by widening the surgical view from the contralateral side [6].

Four (8 %) patients developed temporary mutism; this is a little lower than the rate reported previously (which is between 8 and 30 %) [12]. It is worth noting that all four patients underwent the bilateral trans-CMF approach. Although the definite mechanism is unclear, the dentate nuclei and their connections through the brainstem to the thalamus have a role in speech function, and injury to this pathway may result in mutism. Consistent with our results,

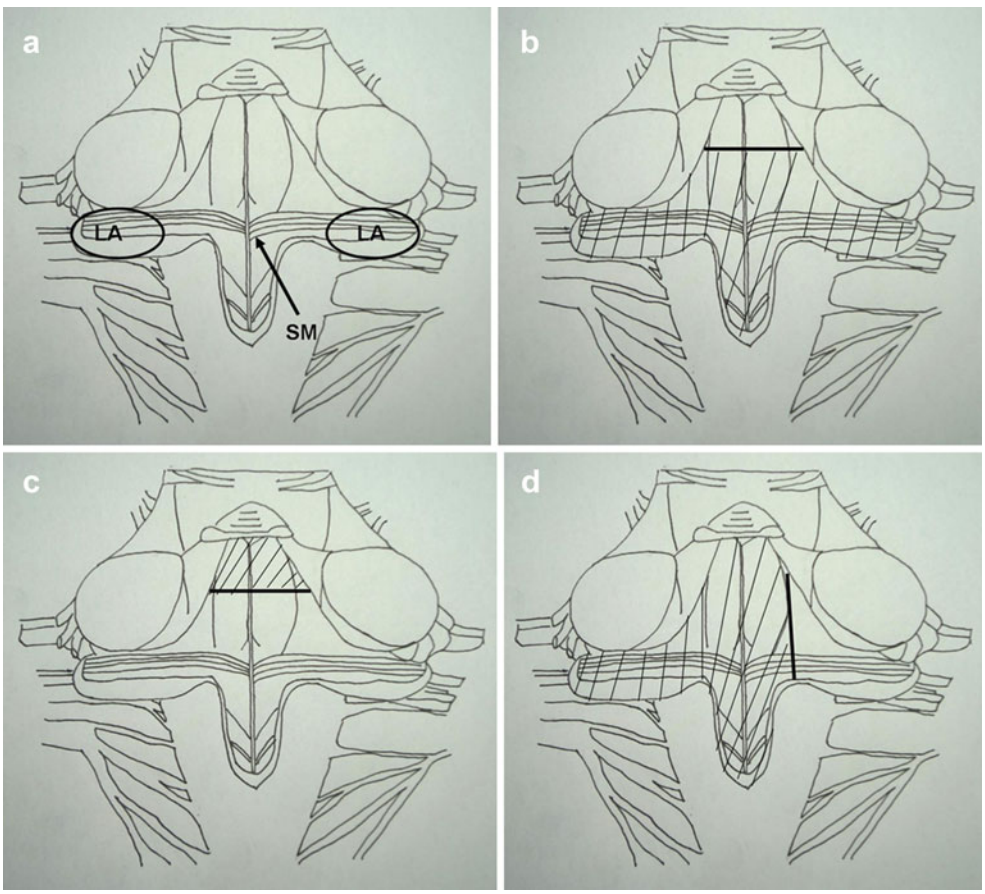

Fig. 3 Illustration of the fourth ventricle and the area that each approach can expose. **a** The fourth ventricle. LA: Lateral recess. SM: Striae medullaris. **b** Oblique lines demonstrate the area that the simple tela choroidea opening approach can expose. **c** Oblique lines show the area that the telovelar approach can expose in addition. **d** Oblique lines demonstrate the area that unilateral approach can expose

Matsushima et al. reported that postoperative neurological deficit was only seen with the bilateral approach [10]. In contrast, Gök et al. used the unilateral trans-CMF approach in a group of 21 patients, and none developed mutism [4]. In our study, patients who underwent the unilateral trans-CMF approach were all free of cerebellar mutism. Another explanation for this may be that preserving the contralateral CMF reduces the chance of blood vessel injury (especially branches of PICA) during the unilateral approach. Thus, the unilateral approach is possibly a good way to avoid postoperative neurological deficits, although our patient number is too small to draw any conclusions. And it is true that the bilateral approach was applied to large tumors, resection of which was essentially more invasive.

3. Histopathology and GTR

The trans-CMF approach provides excellent exposure for lesions of the fourth ventricle. However, GTR is still difficult to achieve in many cases. In our study, the GTR rate was 82 % and closely related to the tumor's histopathology (Table 2). As for hemangioblastomas, meningiomas and epidermoid tumors, usually there are clear boundaries and planes between the tumors and the floor of the ventricle. Thus, it is relatively easy to obtain GTR in these cases. However, as for ependymomas and medulloblastomas, the tumors sometimes infiltrate deeply into the floor or engulf the lower cranial nerves, so they cannot be completely removed safely.

Conclusion

Our study illustrates the utility of the trans-CMF approach in 50 cases of fourth ventricular tumors. The versatility of this approach helps in accessing the fourth ventricle without splitting the vermis. The opening portion of the fissure and roof of the ventricle should be determined by the location, extension and size of the lesion. In most cases, the unilateral trans-CMF approach with only a tela choroidea incision is adequate and should be the first choice, because it is minimally invasive and possibly prevents the incidence of postoperative mutism.

Conflicts of interest None.

References

1. Dailey AT, McKhann GM 2nd, Berger MS (1995) The pathophysiology of oral pharyngeal apraxia and mutism following posterior fossa tumor resection in children. J Neurosurg 83:467–475
2. Deshmukh VR, Figueiredo EG, Deshmukh P, Crawford NR, Preul MC, Spetzler RF (2006) Quantification and comparison of telovelar and transvermian approaches to the fourth ventricle. Neurosurgery 58:ONS-202-6; discussion ONS-206-7
3. El-Bahy K (2005) Telovelar approach to the fourth ventricle: operative findings and results in 16 cases. Acta Neurochir (Wien) 147:137–142, discussion 142
4. Gok A, Alptekin M, Erkutlu I (2004) Surgical approach to the fourth ventricle cavity through the cerebellomedullary fissure. Neurosurg Rev 27:50–54
5. Hermann EJ, Rittierodt M, Krauss JK (2008) Combined transventricular and supracerebellar infratentorial approach preserving the vermis in giant pediatric posterior fossa midline tumors. Neurosurgery 63:ONS30-35, discussion ONS35-37
6. Jittapiromsak P, Sabuncuoglu H, Deshmukh P, Spetzler RF, Preul MC (2010) Accessing the recesses of the fourth ventricle: comparison of tonsillar retraction and resection in the telovelar approach. Neurosurgery 66:30–39, discussion 39–40
7. Kellogg JX, Piatt JH Jr (1997) Resection of fourth ventricle tumors without splitting the vermis: the cerebellomedullary fissure approach. Pediatr Neurosurg 27:28–33
8. Matsushima T, Rhoton AL Jr, Lenkey C (1982) Microsurgery of the fourth ventricle: Part 1. Microsurgical anatomy. Neurosurgery 11:631–667
9. Matsushima T, Fukui M, Inoue T, Natori Y, Baba T, Fujii K (1992) Microsurgical and magnetic resonance imaging anatomy of the cerebello-medullary fissure and its application during fourth ventricle surgery. Neurosurgery 30:325–330
10. Matsushima T, Inoue T, Inamura T, Natori Y, Ikezaki K, Fukui M (2001) Transcerebellomedullary fissure approach with special reference to methods of dissecting the fissure. J Neurosurg 94:257–264
11. Matsushima T, Abe H, Kawashima M, Inoue T (2012) Exposure of the wide interior of the fourth ventricle without splitting the vermis: importance of cutting procedures for the tela choroidea. Neurosurg Rev 35:563–571, discussion 571–572
12. Mei C, Morgan AT (2011) Incidence of mutism, dysarthria and dysphagia associated with childhood posterior fossa tumour. Childs Nerv Syst 27:1129–1136
13. Mussi AC, Rhoton AL Jr (2000) Telovelar approach to the fourth ventricle: microsurgical anatomy. J Neurosurg 92:812–823
14. Parkinson D (2001) The posterior cranial fossa: microsurgical anatomy and surgical approaches. Neurosurgery 48:1196
15. Pollack IF, Polinko P, Albright AL, Towbin R, Fitz C (1995) Mutism and pseudobulbar symptoms after resection of posterior fossa tumors in children: incidence and pathophysiology. Neurosurgery 37:885–893
16. Rajesh BJ, Rao BR, Menon G, Abraham M, Easwer HV, Nair S (2007) Telovelar approach: technical issues for large fourth ventricle tumors. Childs Nerv Syst 23:555–558
17. Rhoton AL Jr (2000) Cerebellum and fourth ventricle. Neurosurgery 47:S7–S27
18. Shimoji K, Miyajima M, Karagiozov K, Yatomi K, Matsushima T, Arai H (2009) Surgical considerations in fourth ventricular ependymoma with the transcerebellomedullary fissure approach in focus. Childs Nerv Syst 25:1221–1228
19. Talacchi A, Sala F, Alessandrini F, Turazzi S, Bricolo A (1998) Assessment and surgical management of posterior fossa epidermoid tumors: report of 28 cases. Neurosurgery 42:242–251, discussion 251–252
20. Van Calenbergh F, Van de Laar A, Plets C, Goffin J, Casaer P (1995) Transient cerebellar mutism after posterior fossa surgery in children. Neurosurgery 37:894–898
21. Zaheer SN, Wood M (2010) Experiences with the telovelar approach to fourth ventricular tumors in children. Pediatr Neurosurg 46:340–343