

Technical strategies for the transcallosal transforaminal approach to third ventricle tumors: expanding the operative corridor

Clinical article

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Object. There are a number of surgical approaches to the third ventricle, each with advantages and disadvantages. Which approach to use depends on the location of the lesion within the ventricle, the goals of the operation, and the surgeon's experience. The authors present their results in children with a modified approach through the expanded foramen of Monro.

Methods. A retrospective study was conducted to identify and analyze all children who underwent what the authors term the “expanded transforaminal” approach to the third ventricle between 2010 and 2013. Perioperative data included patient demographics, signs and symptoms on presentation, tumor characteristics (type, origin, and size), complications, and clinical and radiographic outcome at final follow-up.

Results. Twelve patients were identified (5 female, 7 male) with a mean age of 9 years (range 2–19 years). Two patients underwent gross-total resections, whereas 10 resections were less than total. There were no instances of venous infarction, significant intraoperative bleeding, or short-term memory deficits. Of the 12 patients, 7 suffered a total of 17 complications. Disruption of neuroendocrine function occurred in 4 patients: 2 with transient diabetes insipidus, 2 with permanent panhypopituitarism, and 1 with central hypothyroidism (1 patient had 2 complications). The most common group of complications were CSF-related, including 2 patients requiring a new shunt. There was 1 approach-related injury to the fornix, which did not result in any clinical deficits. One child with an aggressive malignancy died of tumor progression 6 months after surgery. Of the remaining 11 patients, none have experienced tumor recurrence or progression to date.

Conclusions. The expanded transcallosal transforaminal approach is a safe and relatively easy method of exploiting a natural pathway to the third ventricle, but there remain blind zones in the anterosuperior and posterosuperior regions of the third ventricle.

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KEY WORDS • expanded transforaminal approach • third ventricle • tumor • interhemispheric • oncology

THE third ventricle is a narrow midline cavity located between the thalami and is challenging to approach microsurgically. It is surrounded by many critical neurovascular structures, which if injured as a result of direct compression, ischemia, invasion, or surgical manipulation, can result in significant morbidity (Fig. 1). Lesions found within the third ventricle of children are primarily neoplasms, the most notable exception of which are colloid cysts.

Abbreviation used in this paper: EVD = external ventricular drain.

Various operative approaches to the third ventricle have been described, each with its advantages and disadvantages. The selected approach depends on a number of variables, including the goal of surgery (such as biopsy, decompression of a cyst, reestablishment of CSF pathways, or complete surgical extirpation); the size, location, and displacement of the surrounding neurovascular structures by the lesion; and the surgeon's experience and preference. In general, the lateral ventricle can be accessed via the transcortical or transcallosal routes. Once the surgeon is in the lateral ventricle, the third ventricle can be entered in a number of ways. The transchoroidal or “suprachoroi-

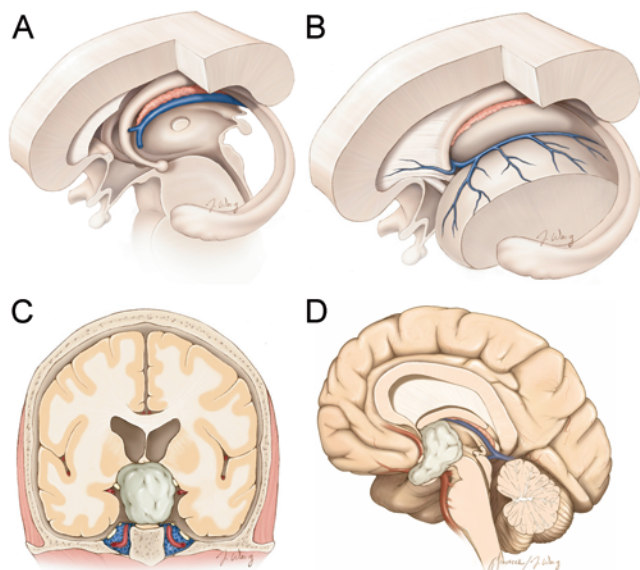


FIG. 1. Illustrations of the third ventricle. The third ventricle is bordered anteriorly by the lamina terminalis and anterior commissure, laterally by the thalami, inferiorly by diencephalic structures anteriorly and the mesencephalon posteriorly, superiorly by the foramina of Monro and the tela choroidea/velum interpositum (with the internal cerebral veins), and posteriorly by multiple structures including the suprapineal recess, habenular commissure, pineal body and pineal recess, posterior commissure, and aqueduct of Sylvius (A). The thalamostriate vein picks up a number of draining veins as it flows toward the venous angle, where it is joined by the anterior septal vein (B). Coronal and sagittal views show a mass within the anterior third ventricle (C and D). © The Neurosurgical Atlas, Aaron A. Cohen-Gadol. Used with permission.

dal” approach involves opening the ependymal reflection (the choroidal fissure) along the medial border or fornical side of the choroid plexus, called the taenia fornicis.⁹ This approach will provide access to the roof of the third ventricle, known as the velum interpositum, with the surgical corridor located between the internal cerebral veins. Alternatively, the choroidal fissure lateral to the choroid plexus can be opened (the taenia choroidea) in what is called the “subchoroidal” approach.^{1,2} The interforaminal approach has been described for pathology located in the hypothalamic region of the third ventricle, particularly hamartomas.¹⁰ This approach is easier if the patient has an existing cavum septum pellucidum so as to minimize manipulation of both fornical columns. This approach, as well as the translamina terminalis route, provides excellent access to lesions located in the anterior-most portion of the third ventricle.⁶

In this paper we present a simple variant of another well-described operative corridor to the third ventricle. The transforaminal approach is a natural route to the third ventricle because one can usually visualize the lesion immediately and the foramen of Monro is often expanded by the lesion or by attendant hydrocephalus.⁵ However, this approach requires passing instruments in and out of it, thereby placing the ipsilateral fornical column and the venous structures at the venous angle at risk. We review our experience with this modified expanded transforaminal approach, emphasizing surgical technique and clinical outcomes, and complications.

Methods

Study Design and Data Collection

Institutional review board approval from the University of Tennessee Health Science Center in Memphis, Tennessee, was obtained prior to data collection. We reviewed the operative notes of all children who underwent a craniotomy for resection of a third ventricular mass since 2010 at Le Bonheur Children’s Hospital. Only those consecutive patients who underwent the approach as described below and who had a minimum of 6 months follow-up were eligible for inclusion. Those patients in whom another approach to the third ventricle was used or where the approach was not clearly delineated were excluded. Recorded variables were age, sex, race, symptoms and presence of hydrocephalus on presentation, tumor size and pathology, intra- and postoperative complications (categorized as vascular, endocrine, CSF-related, approach-related, wound, and nonneurological), and radiological and clinical status on follow-up. We also recorded whether the patient received any adjuvant therapy, such as radiation and/or chemotherapy.

Operative Technique

The patient is positioned supine, the neck is flexed with the vertex toward the ceiling, and the head is immobilized with a skull clamp. Extra caution is required when using pins on children less than 2 years of age or with chronic hydrocephalus and thin calvaria. There are several options for the skin incision: coronal, midline, or U-shaped (Fig. 2). The bone flap is typically made on the right side, and is approximately 6 cm anterior to posterior, either centered on the coronal suture or two-thirds anterior (4 cm) and one-third (2 cm) posterior to the suture, depending on whether a more posteriorly directed trajectory is required. The dura is opened in a semilunar fashion with the base located along the superior sagittal sinus. It may be necessary to sacrifice 1 or possibly 2 small bridging veins to gain access to the interhemispheric fissure, but this should be of little consequence in this region.

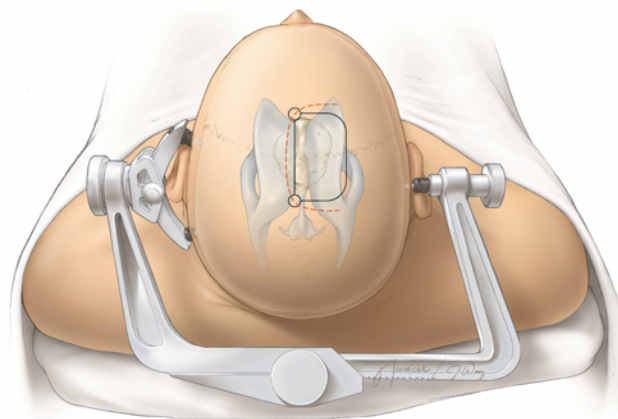


FIG. 2. Positioning and planning of the skin incision (dashed red line) and underlying bone flap (solid black line). The craniotomy may be centered over or just anterior to the coronal suture. © The Neurosurgical Atlas, Aaron A. Cohen-Gadol. Used with permission.

Expanded transforaminal approach

Neuronavigation is helpful to orient the operator with respect to the desired trajectory to reach the ventricle through an appropriately located incision along the corpus callosum. A 2-cm callosotomy is situated just to the right of midline, exposing the lateral ventricle. Release of CSF at this point relaxes the frontal lobe and obviates the need for sustained brain retraction through the use of fixed retractors. A small section of choroid plexus just posterior to the venous angle and foramen is coagulated (Fig. 3A). The anterior septal vein is coagulated and sharply cut just above the venous angle, allowing gentle medial retraction of the ipsilateral fornix and lateral displacement of the thalamostriate vein (Fig. 3B). A nonabrasive cottonoid is placed over the exposed fornix and gentle traction is applied to the cottonoid rather than directly to the fornix. There is typically a small section of ependyma lying under the choroid plexus between the posterior edge of the foramen and the anterior margin of the ipsilateral thalamostriate vein. This ependyma can be opened with microdissectors and gentle spreading of the bipolar tips (Fig. 3C). Collectively, these maneuvers significantly expand the foramen of Monro, facilitating improved visualization of the posterior third ventricle and resection of the pathology at hand (Fig. 4). Dissection within the velum interpositum along the medial wall of the ipsilateral internal cerebral vein may be performed to further expand the operative corridor into the third ventricle. There are a number of small perforating arteries adjacent to the veins, which are thalamoperforators; care should be taken to protect and preserve these vessels.

Once the mass is removed or debulked, the aqueduct should be visualized and an angled mirror or a 70° endoscope may be placed into the third ventricle to visualize the contralateral foramen of Monro. We routinely make a generous septostomy as our last maneuver. The ventricle and subdural space are filled with fluid to eliminate as much air as possible. The bone flap is replaced

and the wound is closed in a standard fashion. A video demonstrating this anterior transcallosal expanded transforaminal approach for third ventricle tumors is available (Video 1).

VIDEO 1. Clip showing the anterior transcallosal expanded transforaminal approach for third ventricle tumors. Copyright Aaron A. Cohen-Gadol. Published with permission. [Click here to view with Media Player.](#) [Click here to view with Quicktime.](#)

Results

Presentation

Twelve patients met our study criteria (Table 1). There were 5 female patients (42%) and 7 male patients (58%) with a mean age of 9 years (range 2–19 years). Nine patients (75%) were Caucasian, 2 (17%) were African American, and 1 (8%) was of Asian descent. The mean follow-up duration for patients was 16 months (range 6–34 months).

Most patients presented with symptoms of raised intracranial pressure, specifically headaches with or without emesis but with normal mentation ($n = 7$, 58%) and lethargy with a history of headaches ($n = 5$, 42%). Nine patients (75%) had acute hydrocephalus at presentation; 4 (33%) of these patients required placement of an emergency external ventricular drain (EVD). Of the remaining 3 patients who were not found to have acute hydrocephalus at presentation, 2 had existing ventriculoperitoneal shunts. Two patients with large midbrain tumors filling the third ventricle had bilateral oculomotor nerve palsies on presentation.

Perioperative Outcomes and Status at Last Follow-Up

All craniotomies except one were performed on the right side. One patient required a 2-stage resection. Tumor type, origin, and estimated volume for each patient

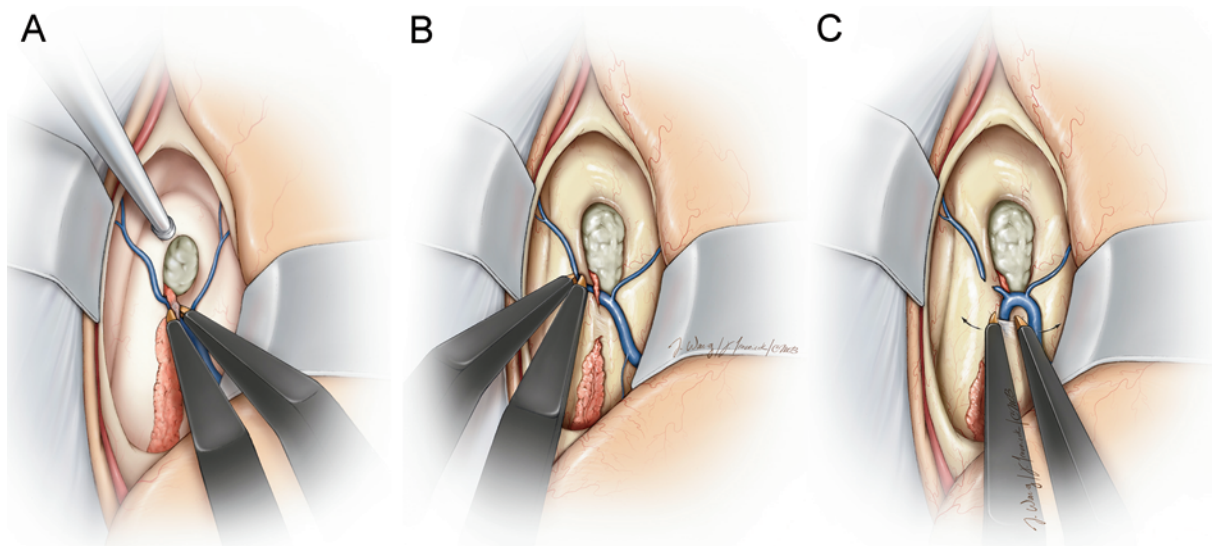


Fig. 3. Maneuvers to expand the foramen of Monro. **A:** Coagulation of a small amount of choroid plexus as it enters the foramen. **B:** Coagulation of the septal vein, which allows gentle medial retraction of the septum and fornix without risk of avulsion. **C:** Further dissection of the taenia fornicis at the posterior aspect of the foramen toward the velum interpositum. © The Neurosurgical Atlas, Aaron A. Cohen-Gadol. Used with permission.

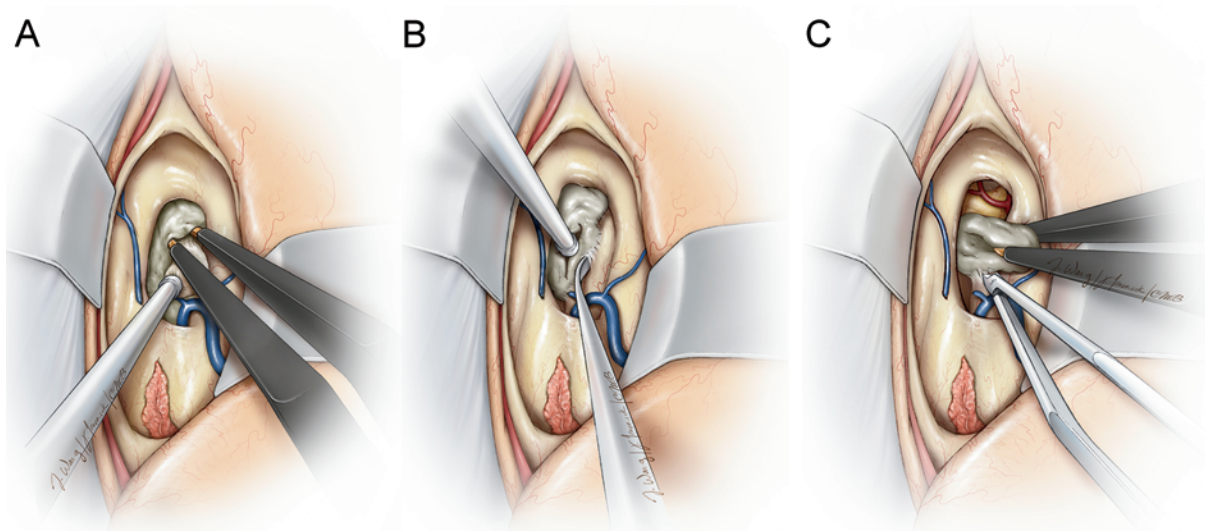


Fig. 4. Illustrations showing resection of the mass through the expanded foramen of Monro. © *The Neurosurgical Atlas*, Aaron A. Cohen-Gadol. Used with permission.

are shown in Table 1. The most common pathology was pilocytic astrocytoma ($n = 6$, 50%) and the most common origin was the optic pathway/hypothalamic region. The mean tumor volume was 31.3 cm^3 . Varying degrees of resection were achieved: 2 gross-total (no residual tumor noted on postoperative imaging) and 10 less than total.

Postoperative complications are detailed in Tables 1 and 2. Seven patients suffered a total of 17 complications. Issues related to CSF dynamics were the most common postoperative complication: CSF leakage from the wound ($n = 1$), temporary pseudomeningoceles ($n = 2$), new shunts ($n = 2$), and shunt revisions ($n = 1$). Four patients developed neuroendocrine complications. Two suffered from temporary diabetes insipidus, while 1 patient's sodium level was overcorrected, leading to hyponatremia and a seizure. The same patient also acquired hypothyroidism requiring chronic supplementation. Two patients sustained a complete loss of hypothalamic-pituitary function with resultant life-long multi-hormone replacement.

Three patients developed vascular complications. Two patients suffered strokes, 1 of which (thalamic infarct) was believed to be due to injury or sacrifice of an en passage posterior thalamoperforator coursing through the patient's large midbrain tumor, and the other (multifocal bilateral watershed zone infarcts primarily between the anterior and middle cerebral artery distributions) due to hypotension from a severe postoperative gastrointestinal bleed. The same patient with the gastrointestinal bleed also developed an intracranial hemorrhage along the prior interhemispheric dissection requiring evacuation after undergoing anticoagulation therapy for a lower-extremity deep venous thrombosis. There were no cerebral or deep venous infarctions. The oculomotor palsies in the 2 patients with midbrain tumors were unchanged at last follow-up.

There was one approach-related complication, which occurred in a 3-year-old girl with a third-ventricle rhabdoid glioblastoma that originated from the hypothalamic region. Her ipsilateral (right) fornix was injured due to

traction while trying to remove the tumor located in the anterosuperior part of the third ventricle. This injury did not appear to result in any noticeable short-term memory deficit, but formal testing was not performed. This child died of tumor progression 6 months after surgery.

Discussion

In our experience, the “expanded transforaminal” approach is an effective means of resecting pathology that originates in or expands into the third ventricle. This route allows adequate resection in a group of children whose tumors (optic pathway gliomas) are not readily amenable to complete extirpation. This approach has several advantages. It utilizes an existing passageway to the third ventricle—the foramen of Monro—that is often expanded by the tumor or associated hydrocephalus. We use 3 maneuvers that expand the operative corridor through the foramen: 1) coagulation of the choroid plexus; 2) disconnection of the septal vein; and 3) opening the ependyma (choroidal fissure) at the posterior margin of the foramen and medial to the ipsilateral internal cerebral vein. Longitudinal opening of the choroidal fissure allows safer manipulation of the ipsilateral fornix.

Alternative methods of expanding the foramen have been reported previously. Shucart and Stein described expanding the foramen by “gentle pressure with a small blunt dissector in all directions except medially” or by incising the ipsilateral column of the fornix.⁵ Others have also advocated sectioning the fornix.^{3,4} Similar to our approach, Türe et al. enlarged the foramen 4–5 mm by opening the choroidal fissure along the taenia fornicis as far as the junction between the anterior septal vein and internal cerebral vein.⁷ Hirsch et al. sacrificed the thalamostriate vein as a means of increasing the aperture of the foramen posteriorly.²

Transection of the anterior septal vein, which allows medial mobilization of the fornix and lateral retraction of the thalamostriate vein, did not result in any venous complications in our series. We could not find any report

TABLE 1: Summary of 12 patients who underwent the expanded transforaminal approach to the third ventricle*

Case No.	Age (yrs), Sex	Presenting Signs & Symptoms	Hydrocephalus on Presentation	Tumor Type & Origin	Estimated Tumor Volume (cm ³)	Complications	Adjuvant Therapy	Extent of Resection	Status at Last Follow-Up
1	2, M	CN VII palsy & ptosis	no, existing shunt	midbrain fibrillary astrocytoma	14.8	required shunt revision	yes	less than total	no progression at 2 yrs
2	10, F	known tumor, headache for 4 mos	yes	optic pathway pilocytic astrocytoma	20.1	none	no	less than total	no progression at 2.5 yrs
3	4, F	lethargy & ataxia	no, existing shunt	midbrain pilocytic astrocytoma	39.2	suffered small thalamic stroke w/ hemiparesis; DI & hypothyroidism; seizure	no	less than total	no progression at 2.5 yrs
4	3.5, F	headache & lethargy	yes	hypothalamic rhabdoid glioblastoma	39.2	panhypopituitarism, injury to fornix	no	less than total	deceased at 6 mos due to tumor progression
5	15, M	headache & nausea	yes, required EVD	optic pathway pilocytic astrocytoma	61.7	severe GI bleed leading to hypotension & multiple infarcts; intracranial hemorrhage due to anticoagulation for DVT requiring evacuation; panhypopituitarism	no	less than total (after 2nd op)	no progression at 2 yrs, persistent panhypopituitarism
6	12, M	headache	yes	optic pathway pilocytic astrocytoma	2.4	none	yes	less than total	no progression at 1.5 yrs
7	8, M	lethargy & nausea	yes	craniopharyngioma	112.3	none	yes	less than total	no progression at 1 yr
8	19, F	history of headache, unresponsive in extremis, lethargy	yes, required EVD	colloid cyst	1.4	CSF leak from incision	no	gross-total	no recurrence at 1 yr
9	5, M	unresponsive in extremis, lethargy	yes, required EVD	choroid plexus papilloma	16.1	pseudomeningocele	no	gross-total	no recurrence at 1 yr
10	14, M	headache	no	optic pathway pilocytic astrocytoma	43.2	none	yes	less than total	no progression at 6 mos
11	10, M	asymptomatic	yes	third ventricular pilocytic astrocytoma	7.4	none	no	less than total	no progression at 6 mos
12	12, F	headache & nausea	yes, required EVD	craniopharyngioma	17.9	DI, pseudomeningocele	yes	less than total	no progression at 6 mos

* DI = diabetes insipidus; DVT = deep venous thrombosis; GI = gastrointestinal.

TABLE 2: Complications by category

Category (total)	Complications (no.)
CSF-related (6)	CSF wound leak (1); pseudomeningocele (2); new shunt (2); shunt revision (1)
neuroendocrine (5)	temporary diabetes insipidus (2); hypothyroidism (1); panhypopituitarism (2)
vascular (3)	stroke (2); hemorrhage (1)
wound	none
approach-related (1)	forniceal injury (1)
non-neurological (2)	GI hemorrhage (1); DVT (1)

in the literature that described a complication with this maneuver. The anterior septal vein courses medially from the tip of the frontal horn, curves posteriorly along the septum pellucidum and over the column of the fornix, and then passes above the foramen of Monro to join the internal cerebral vein.⁷ Türe et al. described 4 variations of the junction of the anterior septal vein and the internal cerebral vein with respect to the foramen.⁷ In 80% of their brain specimens, this anastomosis was located beyond the posterior margin of the foramen of Monro. They argued that this posterior location allowed the foramen to be opened along the choroidal fissure without having to sacrifice any venous structures. Dissection through the tela choroidea into the vessel-rich velum interpositum is not necessary with our technique, but is an option if further posterior expansion of the operative corridor is needed.

The most notable limitation to our approach is the restricted view to the anterosuperior and posterosuperior portions of the third ventricle (Fig. 5). Even with a larger opening into the third ventricle through a transchoroidal approach, the columns of the fornix limit direct access to the area of the third ventricle around the anterior commissure.⁸ If the third ventricle is divided into 3 zones (an-

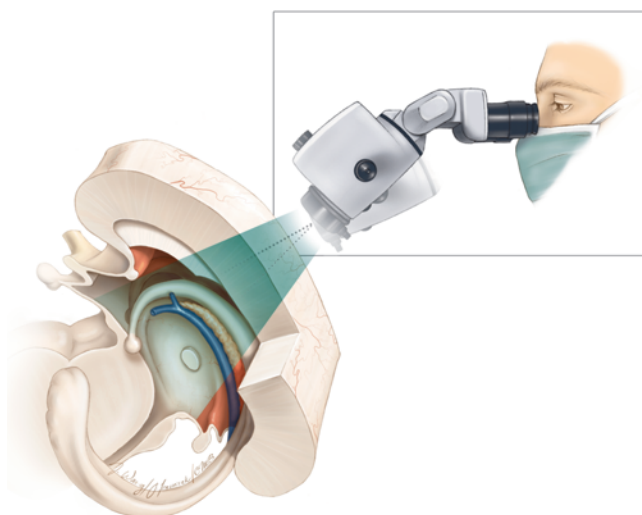


FIG. 5. The cone of view (green) allowed by the expanded transforaminal approach by angling of the microscope. The blind zones (red) for this approach are the anterosuperior and posterosuperior regions of the third ventricle. © *The Neurosurgical Atlas*, Aaron A. Cohen-Gadol. Used with permission.

terior, middle, and posterior), then our expanded transforaminal approach provides excellent visualization of the antero-inferior part of the anterior zone (the infundibular recess), all of the middle zone, and the postero-inferior aspect of the posterior zone. The anterior view allows the surgeon to perform a direct third ventriculostomy through the tuber cinereum if CSF flow through the cerebral aqueduct cannot be reliably established. The single approach-related injury to the fornix in our patients occurred in an effort to resect tumor in this anterosuperior blind zone. Fortunately, this injury did not appear to result in any obvious functional deficits.

Irrespective of the approach used, these patients have a high risk of sustaining a complication (Table 2). We considered a complication as any untoward postoperative event, which some may consider too strict. A postoperative pseudomeningocele, for example, could arguably not be a complication. Nonetheless, 7 of our 12 patients did suffer from a “complication,” with CSF-related being the most common type. Despite the challenges these patients offer surgically and postoperatively, all surviving patients thus far have shown no evidence of disease recurrence or progression after an average follow-up duration of 16 months.

Conclusions

There are several surgical approaches to the third ventricle, each with their own advantages and disadvantages. The expanded transcallosal transforaminal approach is a safe method of exploiting a natural pathway to the third ventricle, but blind zones are located anterosuperiorly and posterosuperiorly. Postoperative issues and complications are high in this patient population, but most are a consequence of the tumor’s location as opposed to the surgical approach.

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Disclosure

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Author contributions to the study and manuscript preparation include the following. Conception and design: Klimo, Cohen-Gadol. Acquisition of data: Klimo, Patel. Analysis and interpretation of data: Klimo, Patel. Drafting the article: all authors. Critically revising the article: all authors. Reviewed submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: Klimo. Administrative/technical/material support: Cohen-Gadol. Study supervision: Klimo, Cohen-Gadol.

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Supplemental online information:

Video 1: http://mfile.akamai.com/21490/wmv/digitalwbc.download.akamai.com/21492/wm.digitalsource-na-regional/peds14-52_video_1.asx (Media Player).

http://mfile.akamai.com/21488/mov/digitalwbc.download.akamai.com/21492/qt.digitalsource-global/peds14-52_video_1a.mov (Quicktime).

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