Transcavum interforniceal endoscopic surgery of the third ventricle

Clinical article

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Object. Intraventricular anatomy has been detailed as it pertains to endoscopic surgery within the third ventricle, particularly for performing endoscopic third ventriculostomy (ETV) and endoscopic colloid cyst resection. The expanding role of endoscopic surgery warrants a careful appraisal of these techniques as they relate to frequent anatomical variants. Given the common occurrence of cavum septum pellucidum (CSP) and cavum vergae (CV), the endoscopic surgeon should be familiar with that particular anatomy especially as it pertains to surgery within the third ventricle.

Methods. From a prospective database of endoscopic surgical cases were selected those cases in which the defined pathology necessitated surgery within the third ventricle and there was coexistent CSP and CV. Pertinent radiographic studies, operative notes, and archived video files were reviewed to define the relevant anatomy. Features of the intracavitary anatomy were assessed regarding their importance in approaching the third ventricle.

Results. Four cases involving endoscopic surgery within the third ventricle (2 colloid cyst resections and 2 ETVs) were identified in which the surgical objective was accomplished through a septal cavum. In each case the width of the body of the lateral ventricle was reduced and the foramen of Monro was obscured. Because of the ventricular distortion, a stereotactic transcavum route was used for approaching the third ventricle. Entry into the third ventricle was accomplished through an interforniceal fenestration immediately behind the anterior commissure. The surgical goal was met in each case without any neurological change or postoperative morbidity. During the follow-up period, there has been no recurrence of a colloid cyst and no need of a secondary cerebrospinal fluid diversionary procedure.

Conclusions. In the presence of a CSP and CV, endoscopic navigation into the third ventricle can be problematic via a transforaminal approach. Alternatively, a transcavum interforniceal route for endoscopic surgery in the third ventricle is suggested, with the rostral lamina and the anterior commissure as important anatomical landmarks. Endoscopic third ventriculostomy and endoscopic colloid cyst resection performed via a transcavum interforniceal route in patients with a coexistent septal cavum is a feasible and safe option. (DOI: 10.3171.PED.2008.2.10.231)

KEY WORDS • cavum septum pellucidum • cavum vergae • colloid cyst • neuroendoscopy • third ventricle

The techniques of ETV and endoscopic colloid cyst resection have been thoroughly described. All of these descriptions have been based on normal and relatively predictable intraventricular anatomy, however. Anatomical variants of the ventricular compartment, when encountered, would undoubtedly present some degree of unfamiliarity and potential morbidity during endoscopic intraventricular surgery. The CSP and CV occur with enough regularity, especially in the pediatric age group, that they may coexist in some patients who would normally benefit from endoscopic third ventricular surgery. How these variants affect the surgical technique of ETV or endoscopic colloid cyst resection has hitherto not been defined. Recent experience in patients with a cystic variant of the septum pellucidum who underwent either ETV or endoscopic colloid cyst resection has afforded us the opportunity to detail the germane intraventricular anatomy and make recommendations with respect to a safe endoscopic approach into the third ventricle.

Methods

Patients were selected from a prospective database maintained by the first author (M.M.S.) between 1995 and 2007. We selected cases in which endoscopic third ventricular...
surgery was performed in the presence of a coexistent septal cavum. Patients were excluded from review if the primary objective of the surgical procedure was fenestration of a symptomatic CSP or CV because such procedures did not include entry into the third ventricle. Pertinent radiographic studies, operative notes, and archived intraoperative video files were reviewed in an attempt to clarify the relevant anatomy and the surgical technique. Patient charts were evaluated for associated morbidity and clinical outcome. All procedures were performed using a rigid-lens endoscope with a 30°-angled lens (B. Braun Aesculap). An endoscope holder was not used according to the preference of the first author (M.M.S.) given the frequent need for subtle manipulations (rotational and depth) in the endoscope position. Frameless stereotaxy (BrainLAB) was used in all cases for the purpose of selecting the optimal trajectory and localizing the entry site. The surgical techniques of ETV and endoscopic colloid cyst resection have been detailed. 1,8,12,14–16,19,20,25,29,35,36

The institutional review board/privacy board at the Weill Cornell Medical College granted an exemption for the review of medical records and conduction of this study.

Results

Four patients who fulfilled the aforementioned criteria were identified. These patients ranged in age from 4 to 40 years. In each of the patients a CSP-CV complex was present rather than an isolated CSP or CV. All patients had a variable degree of ventriculomegaly. Two of the patients underwent endoscopic resection for a colloid cyst of the third ventricle, and 2 patients underwent ETV for noncommunicating hydrocephalus. Among these latter patients, 1 had a radiographically defined tectal glioma and the other a tectal lipoma. Clinical and radiographic findings are outlined in Table 1 and Fig. 1, respectively.

Each patient underwent an endoscopic transcavum interforniceal procedure without intra- or postoperative complication. Postoperative MR imaging was used to confirm total resection of the colloid cyst and patency of the ETV. Formal neuropsychological testing was not used, but there was no postoperative sign of any cognitive change according to either the patient or his or her family members. During a follow-up of 10, 24, 30, and 38 months, there have been no radiographic or clinical findings of a recurrent colloid cyst or symptomatic hydrocephalus.

Illustrative Cases

Case 1. This 32-year-old woman was evaluated for several days of worsening headache and symptoms of gait instability. A funduscopic assessment was notable for bilateral papilledema. Contrast-enhanced MR imaging revealed a spherical mass situated in the anterior aspect of the third ventricle together with severe bilateral ventriculomegaly (Fig. 2). The images were supportive of the diagnosis of a colloid cyst with noncommunicating hydrocephalus and a persistent CSP and CV. A right frontal endoscopic resection was performed via a transcavum interforniceal approach. A postoperative MR image confirmed total excision of the colloid cyst and noncommunicating hydrocephalus.

<table>
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<th>Case No.</th>
<th>Age (yrs)</th>
<th>Pathology</th>
<th>Follow-Up (mos)</th>
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<td>1</td>
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<td>colloid cyst</td>
<td>38</td>
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<tr>
<td>2</td>
<td>40</td>
<td>colloid cyst</td>
<td>24</td>
<td>See Fig. 1B</td>
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<td>10</td>
<td>See Fig. 1C</td>
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<tr>
<td>4</td>
<td>26</td>
<td>noncommunicating hydrocephalus/ tectal glioma</td>
<td>30</td>
<td>See Fig. 1D</td>
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Fig. 1. Axial MR images indicating the presence of a CSP-CV complex in each of 4 patients.

Fig. 2. Case 1. Left: Preoperative axial T2-weighted MR image showing a colloid cyst and noncommunicating hydrocephalus. A CSP and interforniceal separation appear anterior to the colloid cyst. Transepidermal signal changes consistent with increased intraventricular pressure are obvious. Right: Postoperative sagittal T1-weighted MR image with contrast confirming total resection of the colloid cyst. Note the preservation of major venous tributaries surrounding the third ventricle.
Endoscopy and septal cava

cyst, and the patient was discharged from the hospital on the 2nd postoperative day. She has no elevated intracranial pressure, memory disturbance, or radiographic evidence of a recurrence 38 months after treatment.

**Case 3.** This 1-year-old boy, the product of a 29-week gestational pregnancy, was evaluated for developmental delay. An MR image revealed a tectal lipoma, a persistent CSP and CV, and no hydrocephalus. Three years later he was reevaluated because of bilateral papilledema. An MR image at that time showed progressive ventriculomegaly, dilation of the CSP-CV complex, and an interval increase in the size of the presumed tectal lipoma (Fig. 3). An ETV was performed via a right-sided transcavum interforniceal approach. The patient has remained without symptoms of increased intracranial pressure at the 10-month follow-up. Postoperative MR images have shown a mild reduction in ventricular size and a persistent flow void at the site of the ETV.

**Discussion**

Endoscopic resection of a colloid cyst and ETV have been well described over the past 2 decades. These publications have justifiably focused on patients with normal intraventricular anatomy. Through such experience, the endoscopic surgeon has come to rely on the familiarity of the foramen of Monro with its surrounding structures of the choroid plexus, columns of the fornix, and septal and thalamostriate veins for safe transforaminal navigation into the third ventricle. An increasing reliance on endoscopic surgery in the third ventricle will demand that predictable anatomical variants are described with respect to the pertinent anatomy and their respective surgical implications.

Cysts of the septum pellucidum have been well described and are seldom the cause of any clinically recognized syndromes warranting treatment. The CSP, the more anteriorly located variant, is separated from the CV by the columns of the fornices. The septum is composed of 2 individual laminae that fuse during embryological development in a predictable caudal to cranial orientation. The CSP and CV, inappropriately referred to as the fifth and sixth ventricles, respectively, result when the 2 primordial leaflets of the septum fail to fuse. These variants are thus more accurately defined as persistent primitive cavities rather than anomalies. Testimony to their normal developmental structure and ultimate regression is their age-dependent prevalence. Cava septal pellucida are estimated to occur in 100% of prenatal children and 85% of newborns and decrease in frequency with advancing age. The prevalence of CSP by adulthood in normal individuals is debated, given the varying methods of detection and anatomical definition, and ranges from 4 to 74%. What is certain is that the prevalence of CV is less than that of CSP, and CV is seldom found in isolation. These developmental cysts occasionally have been posited to represent a marker of neuropsychological dysfunction and isolated or repeated head trauma.

The neurosurgical interest in cysts of the septum pellucidum relates to the rare occasion of compartmentalization with or without hydrocephalus. The CV and CSP have also been discussed in relation to the described technique of the transcavum interforniceal approach into the third ventricle. The microsurgical transcavum interforniceal approach has been described for various third ventricle pathologies, most notably colloid cysts and hypothalamic hamartomas. Coexistent cystic cavae are rarely discussed in these cadaveric and clinical studies, and the intracavitary anatomy has not been detailed. In the patient with normal septal anatomy these microsurgical series describe an interforniceal dissection through the “raphe fornix.” One of the more detailed descriptions of third ventricular entry via a transeptal route is found in the 2005 publication by Siwanuwan et al., in which the authors state that access into the third ventricle is achieved through a “corridor bounded by the anterior commissure anteriorly and the choroid plexus at the foramen of Monro posteriorly.”

The current study is intended to provide a clinical series involving the endoscopic interforniceal approach for third ventricular surgery in the presence of a cystic cavum. Although this endoscopic technique has been described in a case report of colloid cyst resection, the technique used to enter the third ventricle was not detailed. The exceptional image resolution offered by the solid-lens endoscope has allowed us to supplement previous microsurgical and endoscopic reports of the interforniceal approach with detailed anatomical images and illustrations of the internal cystic anatomy.

**Endoscopic Transcavum Interforniceal Technique**

The presence of midline cysts within the septum pellucidum have predictable effects on the dimensions and morphology of the lateral ventricles. More specifically, the presence of a septal cavum creates a condition in which the septal leaflets are displaced laterally and the fornicical columns are shifted inferiorly and laterally. These features have 2 important effects on proposed endoscopic intraventricular surgery. The first of these changes, a reduction in the width of the lateral ventricle, can create difficulty in cannulating the lateral ventricle (Fig. 4). To optimize entry into the body of the lateral ventricle we have used integraded frameless stereotaxy in each case. The second variation in the lateral ventricle, a diminished or occluded foramen of Monro by the fornicial column, precludes a safe transforaminal approach into the third ventricle (Fig. 5). Thus, a transcavum interforniceal route was planned for entry into the third ventricle.

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**Fig. 3.** Case 3. **Left:** Sagittal T1-weighted MR image showing a hyperintense tectal lipoma and mild ventriculomegaly. **Right:** Coronal T2-weighted MR image obtained after an ETV via a transcavum interforniceal route, demonstrating fenestration in the right septal lamina and the flow void of the ETV stoma.
Given the vertical orientation of the septal leaflets, the base of each being attached to the body of the fornix, a trajectory in the coronal plane that most closely parallels the septal laminae will minimize torque against the fornix. This entry site, defined with stereotactic planning, was typically ~2 cm from the midline. The optimal entry site in the sagittal plane is dependent on the surgical goal—a standard coronal entry for ETV and a more anterior precoronal approach for a colloid cyst. Again, this trajectory is best established using navigational guidance prior to surgical preparation.

Once the lateral ventricle is successfully cannulated the cystic cavum is entered by wide fenestration of the ipsilateral septal lamina. Continuous bipolar diathermy in a linear motion is used to create a 1- to 2-cm fenestration through an avascular portion of the lamina. Unlike the ependymal surface of the lateral ventricle, the internal aspects of the septal laminae are notably void of any venous tributaries. The endoscope is navigated through the septal fenestration into the septal cavum.

Because the goal of ETV or colloid cyst resection is dependent on entering the third ventricle, a detailed understanding of the internal anatomy of the CSP-CV complex is essential. With respect to the internal anatomy of the cyst, the floor which corresponds to the roof of the third ventricle is of utmost importance. Through a review of archived video files referenced with published anatomical text, constant anatomical features of the cavum floor were identified (Fig. 6A–C). The floor (from anterior to posterior) is defined by the rostrum of the corpus callosum, rostral lamina, anterior commissure, velum interpositum, hippocampal commissure, and psalterium. The lateral margin of the floor (from anterior to posterior) is bordered by the medial olfactory striae, the anterior columns or anterior pillars of the fornix, the bodies of the fornix, and the crura or posterior pillars of the fornix.

The site of the entry into the third ventricle is of paramount importance. A constant and seemingly safe entry into the third ventricle is marked by an attenuated area of the velum interpositum immediately behind the anterior commissure (Fig. 7A). Identification of the anterior commissure is typically straightforward. In addition to the large transverse band of white matter defining the commissural tract, bilateral olfactory components of the commissure can typically be recognized as bilateral fiber bundles sweeping anteriorly and laterally. Depending on the degree of cystic dilation, the choroid plexus on the roof of the third ventricle can be visualized through the hippocampal commissure and velum interpositum. The site of preferred entry is bordered on either side by the columns or anterior pillars of the fornix. It is most important to distinguish this site from another semitransparent portion of the cavum floor that is immediately in front of the anterior commissure, the rostral lamina. The rostral lamina or copula is the most anterior and ventral extension of the corpus callosum that extends from the rostrum of the corpus callosum to the anterior commissure. Inadvertent fenestration through the rostral lamina would result in entry into the subarachnoid space of the interhemispheric fissure with potential risk to divisions of the anterior cerebral arteries. When a coexistent CV is present, as it was in all cases in the present study, the midportion of the floor is formed by the hippocampal commissure overlying the velum interpositum (Fig. 6B). The posterior aspect of the floor continues as the psalterium (lyra), which abruptly ends at the suprapineal recess and the cistern of the great vein of Galen (Fig. 6C).

In this group of 4 patients the bodies of the fornices were sufficiently separated to allow safe entry of the endoscopic instruments. Postoperatively there was no recognized or reported cognitive impairment. Admittedly, preoperative and postoperative formal neuropsychological testing, which were not performed, would be the only method for confirming the avoidance of fornical injury. The technique used to fenestrate into the third ventricle is similar to performing an ETV. Blunt perforation is followed by balloon dilation (Fig. 7B). If the initial fenestration is positioned too far posterior, the tela choroidea, choroid plexus, choroidal arteries, and internal cerebral veins are immediately recognized, and the trajectory is corrected with a more anterior direction closer to the anterior commissure. Once the fenestration is extended into the velum interpositum, a view and route into the third ventricle becomes apparent (Fig. 7C). Endoscopic third ventriculostomy or colloid cyst resection is then performed no differently than if a transforaminal route were used for third ventricular access.
The current report of 4 patients who underwent an endoscopic transcavum interforniceal approach to the third ventricle offers some unified concepts. First, an endoscopic transforaminal approach in patients with a CSP-CV complex is difficult given a reduced dimension of the foramen of Monro and the lateral ventricle. Thus, a transcavum interforniceal route is preferred. It is possible that fenestration of a septal lamina followed by a standard transforaminal approach into the third ventricle can serve as a valid alternative. We did not attempt this technique, but we believe that the chronic deformation of the fornix may not reverse in such a short time interval. Additionally, the ideal trajectories differ for a cavitary fenestration and a transforaminal route. Second, a trajectory that parallels the vertical orientation of the septal lamina is preferred. It is believed that this relatively vertical trajectory minimizes any torque on the ipsilateral fornix. Third, and most importantly, our experience has offered us the opportunity to describe reliable anatomical landmarks within the CSP-CV complex that can guide a safe interforniceal approach into the third ventricle.

Conclusions
In the presence of a CSP and CV, endoscopic navigation into the third ventricle can be problematic via a transforaminal approach. Alternatively, a transcavum interforniceal route for endoscopic surgery in the third ventricle is suggested, with the rostral lamina and the anterior commissure as important anatomical landmarks. Endoscopic third ventriculostomy and endoscopic colloid cyst resection performed via a transcavum interforniceal route in patients with a coexistent septal cavum is a feasible and safe option.

Disclosure
Mark M. Souweidane, M.D., serves as a paid consultant and member of the NeuroEndoscopy Advisory Board for Aesculap.

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References


