Flexible endoscopy for management of intraventricular brain tumors in patients with small ventricles

Clinical article

Hideki Ogiwara, M.D., Ph.D., and Nobuhiro Morota, M.D.

Division of Neurosurgery, National Center for Child Health and Development, Tokyo, Japan

**Object.** Endoscopic surgery is generally withheld in patients with small ventricles due to difficulties in ventricular cannulation and intraventricular manipulation. The effectiveness of flexible endoscopy for management of intraventricular brain tumors in patients with small ventricles was evaluated.

**Methods.** Forty-five patients who underwent endoscopic surgery with a flexible endoscope for intraventricular brain tumors were divided into small-ventricle and ventriculomegaly groups according to the frontal and occipital horn ratio (FOR). Retrospective review of these cases was performed and achievement of surgical goals and morbidity were assessed.

**Results.** Among the 45 patients, there were 14 with small ventricles and 31 with ventriculomegaly. In the small-ventricle group, targeted tumors were located in the suprasellar region in 12 patients and in the pineal region in 2. In the ventriculomegaly group, tumors were located in the pineal region in 15 patients, in the suprasellar region in 9, in the lateral ventricle in 4, in the midbrain in 2, and in the fourth ventricle in 1. In the small-ventricle group, ventricular cannulation was successful and the surgical goals were accomplished in all patients. In ventriculomegaly group, sampling of the tumor was not diagnostic due to intraoperative hemorrhage in 1 patient. There were no significant differences in the rate of achieving the surgical goals or the morbidity between the 2 groups.

**Conclusions.** Endoscopic surgery using a flexible endoscope is useful for management of intraventricular brain tumors in patients with small ventricles. A flexible endoscope allows excellent maneuverability in introducing the device into the lateral ventricle and manipulating through small ventricles.

**Key Words**  • flexible endoscopy  • small ventricles  • intraventricular tumor  • oncology

Endoscopic surgery has been proven to be useful for management of intraventricular lesions, including tumor biopsy, resection of colloid cysts, and cystic decompression of craniopharyngiomas. Generally, ventriculomegaly has been considered a necessity in order to perform intraventricular cannulation and manipulate the endoscope with acceptable low morbidity. In small ventricles, paraventricular structures can be damaged with inaccurate cannulation or while moving the endoscope through insufficient space. Recently, 2 articles addressed the feasibility of endoscopic tumor management in patients without ventriculomegaly in whom the ventricle size was objectively measured using the frontal and occipital horn ratio (FOR). In those papers, surgical procedures were performed with a rigid endoscope. In this paper, we aim to evaluate the effectiveness of a flexible endoscope for management of intraventricular brain tumors in patients with small ventricles.

**Methods**

We reviewed 45 consecutive cases involving patients who underwent endoscopic surgery with a flexible endoscope for intraventricular brain tumors at National Center for Child Health and Development in Tokyo between November 2003 and November 2013. Retrospective analysis of the patients’ demographic and clinical characteristics, including age, sex, presenting symptoms, surgical treatment, and clinical outcomes, was performed using medical charts. The patients were divided into small-ventricle and ventriculomegaly groups according to the FOR. The ventricle size was measured on preoperative MRI, and the FOR was calculated. The FOR is an objective and reliable index for evaluation of ventricle size. The normal FOR was defined as 0.37, as accepted in the literature. An FOR equal to or less than 0.37 was considered to indicate small ventricles, and a FOR larger than 0.37, ventriculomegaly.

Endoscopic surgery was performed with the patients positioned in the supine position with the head elevated and flexed to minimize outflow of cerebrospinal fluid. A frontal approach was used in all patients. All the procedures were performed using a flexible endoscope. The outer diameter of the endoscopes was 2.7 mm, 2.8 mm, or 4.8 mm. An entry site was made at approximately 1 cm anterior to the coronal suture and over the midpupillary line.

In patients with small ventricles, initial cannulation

Abbreviations used in this paper: EVD = external ventricular drain; FOR = frontal and occipital horn ratio.
Flexible endoscopy for small ventricles

was performed with a ventricular catheter (outer diameter 1.7 mm) using neuronavigation (Stealth) or Komai's stereotactic frame. After the cannulation, approximately 10 ml of lactated Ringer's solution was gradually infused to insulate the ventricles with careful monitoring of the heart rate. After the catheter was removed, a 2.7-mm or 2.8-mm flexible endoscope (VEF-2, Olympus, or Neuro-Fiberscope, Storz) was introduced under visualization of the tract to the ventricle. Some of the fluid flowed out after removal of the catheter; however, the ventricle was still sufficiently insufflated when the endoscope was inserted. When the higher resolution was necessary, the 2.7-mm endoscope was removed and a 4.8-mm flexible endoscope (VEF-V, Olympus) was introduced down the dilated tract under visualization (Video 1).

**Video 1.** Video clip demonstrating introduction of a 2.8-mm flexible endoscope under direct visualization of the tract to the ventricular system after the initial ventricular cannulation with a ventricular catheter. Copyright Hideki Ogihara. Published with permission. Click here to view with Media Player. Click here to view with Quicktime.

When the tract debris generated from introduction of the endoscope limited visibility in the ventricles, the debris was removed using the forceps.

In patients with dilated ventricles, initial cannulation was performed with a ventricular catheter without neuronavigation. The catheter was replaced with a transparent sheath (Neuroport, Olympus), which was also introduced by freehand technique.

Tumor biopsy was performed under direct visualization of the tumor. Multiple specimens (typically 3–10) were obtained with endoscopic tumor forceps. Bleeding was controlled with irrigation, or with compression using a Fogarty balloon in several cases. For cystic decompression of craniopharyngiomas, the tumor cyst was initially penetrated using a blunt tip of forceps or a coagulator. Then, the cyst wall and part of the solid component of the tumor were removed using the tumor forceps. For decompression of Rathke's cleft cysts, the cyst wall was perforated using a blunt tip of forceps or a coagulator. Then, a sectioned Fogarty balloon catheter—from which the tip, including the balloon, had been cut off—was introduced into the cyst, and the content was aspirated. The cyst wall was resected using the tumor forceps.

Statistical analysis was performed using the Fisher’s exact test to compare categorical variables, including the rates of achieving the surgical goals and morbidity, between the small-ventricle group and ventriculomegaly group. Between-groups comparison of continuous variables, including the FORs, was performed using the Student t-test. A value of p < 0.05 was considered significant.

**Results**

From November 2003 to November 2013, 45 patients with intraventricular tumors were surgically treated primarily with flexible endoscopy at our institution. Of those, 14 (31%) had small ventricles and 31 (69%) had dilated ventricles. The characteristics of the patients in the 2 groups are shown in Table 1. The mean FOR of patients with small ventricles was 0.344 ± 0.024 (SD) (range 0.273–0.363), and that of those in the ventriculomegaly group was 0.467 ± 0.07 (range 0.384–0.77). There was a statistically significant difference in ventricle size according to the FOR (p < 0.0001).

In the small-ventricle group, 7 patients were male and 7 were female. The mean age was 9.2 years (range 0.4–25.8 years, median 8.8 years). Four patients presented with diabetes insipidus, 2 with decreased visual acuity, 2 with nystagmus, and 3 with headache. Four patients were asymptomatic. In 2 of these cases, the patients underwent surgery due to increase in lesion size. The targeted tumors were located in the suprasellar region in 12 patients and in the pineal region in 2 (Fig. 1).

In the ventriculomegaly group, 18 patients were male and 13 were female. The mean age was 7.8 years (range 0.3–28.8 years, median 7.3 years). All patients were symptomatic. Twenty-four patients presented with symptoms of intracranial hypertension, including headache, nausea, vomiting, and lethargy; 5 presented with increasing head circumference, 2 with hemiparesis, 2 with failure to thrive, one with faintness, one with nystagmus, and one with visual field impairment. Tumors were located in the pineal region in 15 patients, in the suprasellar region in 9, in the lateral ventricle in 4, in the midbrain in 2, and in the fourth ventricle in 1. Suprasellar location was significantly more common in the small-ventricle group, while pineal location was significantly more common in ventriculomegaly group.

Overall, the predetermined surgical goals were achieved in 44 (98%) cases. In 39 (98%) of the 40 cases, in which the surgical goal was diagnostic sampling alone, sampling of tissue was successful and yielded a pathologi- cal diagnosis. In all 5 (100%) of the cases in which the goals were decompression of cystic tumors and diagnostic sampling, both surgical goals were achieved. In the small-ventricle group, the intended surgical goals were accomplished in all patients, with successful 14 biopsies, 3 decompressions of cystic craniopharyngiomas, and 2 decompressions of Rathke's cleft cysts. None of the patients experienced bradycardia during insufflation of the ventricles. In the ventriculomegaly group, biopsy of the lesion was successful in 30 patients (97%). In 1 patient with a pineal tumor, sampling was not diagnostic due to intraoperative hemorrhage. The additional resection performed afterward revealed a yolk sac tumor. There was no statistically significant between-groups difference with respect to achieving the intended surgical goals (p > 0.99).

With regard to complications, there were no new neurological deteriorations or deaths related to the endoscopic procedures in either groups. In 1 patient with ventriculomegaly, sampling of the tumor was not diagnostic due to intraoperative hemorrhage. There was no significant difference between the rates of perioperative complications in the 2 groups (p > 0.99). In the small-ventricle group, no patient underwent placement of an external ventricular drain (EVD) or shunt. In ventriculomegaly group, 4 patients underwent placement of an EVD because of the surgeon’s preference (not because of intraoperative hemorrhage). Five patients eventually required placement of a ventriculoperitoneal shunt.
Ventriculomegaly has been traditionally considered a necessity for management of intraventricular tumors. In a small ventricular system, intraventricular cannulation and endoscopic manipulation without causing significant morbidity has been considered difficult.\(^8\)\(^,\)\(^22\) Paraventricular structures, such as the fornix, thalamus, or deep ventricular veins, can be damaged by inaccurate cannulation or moving the endoscope through insufficient working space. Recently, 2 articles reported the feasibility of endoscopic tumor management in small ventricles using a rigid

**TABLE 1:** Summary of demographic and clinical characteristics of 45 patients with intraventricular brain tumors who underwent endoscopic surgery*

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Small Ventricles (n = 14)</th>
<th>Ventriculomegaly (n = 31)</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>sex</td>
<td></td>
<td></td>
<td>0.75</td>
</tr>
<tr>
<td>male</td>
<td>7 (50)</td>
<td>18 (58)</td>
<td></td>
</tr>
<tr>
<td>female</td>
<td>7 (50)</td>
<td>13 (42)</td>
<td></td>
</tr>
<tr>
<td>age (yrs)</td>
<td></td>
<td></td>
<td>0.47</td>
</tr>
<tr>
<td>mean</td>
<td>9.2</td>
<td>7.8</td>
<td></td>
</tr>
<tr>
<td>range</td>
<td>0.4–25.8</td>
<td>0.3–28.8</td>
<td></td>
</tr>
<tr>
<td>lesion location</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>suprasellar</td>
<td>12 (86)</td>
<td>9 (29)</td>
<td>0.0008</td>
</tr>
<tr>
<td>pineal</td>
<td>2 (14)</td>
<td>15 (48)</td>
<td>0.046</td>
</tr>
<tr>
<td>lateral ventricle</td>
<td>0 (0)</td>
<td>4 (13)</td>
<td>0.29</td>
</tr>
<tr>
<td>midbrain</td>
<td>0 (0)</td>
<td>2 (6)</td>
<td>&gt;0.99</td>
</tr>
<tr>
<td>fourth ventricle</td>
<td>0 (0)</td>
<td>1 (3)</td>
<td>&gt;0.99</td>
</tr>
<tr>
<td>pathological diagnosis</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>germinoma</td>
<td>3 (21)</td>
<td>8 (26)</td>
<td>&gt;0.99</td>
</tr>
<tr>
<td>mature teratoma</td>
<td>0 (0)</td>
<td>1 (3)</td>
<td>&gt;0.99</td>
</tr>
<tr>
<td>immature teratoma</td>
<td>1 (7)</td>
<td>3 (10)</td>
<td>&gt;0.99</td>
</tr>
<tr>
<td>choriocarcinoma</td>
<td>0 (0)</td>
<td>1 (3)</td>
<td>&gt;0.99</td>
</tr>
<tr>
<td>embryonal carcinoma</td>
<td>1 (7)</td>
<td>0 (0)</td>
<td>0.31</td>
</tr>
<tr>
<td>low-grade astrocytoma</td>
<td>2 (14)</td>
<td>8 (26)</td>
<td>0.47</td>
</tr>
<tr>
<td>high-grade astrocytoma</td>
<td>0 (0)</td>
<td>1 (3)</td>
<td>&gt;0.99</td>
</tr>
<tr>
<td>Rathke's cleft cyst</td>
<td>2 (14)</td>
<td>0 (0)</td>
<td>0.09</td>
</tr>
<tr>
<td>craniopharyngioma</td>
<td>3 (21)</td>
<td>0 (0)</td>
<td>0.026</td>
</tr>
<tr>
<td>PNET</td>
<td>0 (0)</td>
<td>1 (3)</td>
<td>&gt;0.99</td>
</tr>
<tr>
<td>pineocytoma</td>
<td>0 (0)</td>
<td>1 (3)</td>
<td>&gt;0.99</td>
</tr>
<tr>
<td>pineoblastoma</td>
<td>0 (0)</td>
<td>1 (3)</td>
<td>&gt;0.99</td>
</tr>
<tr>
<td>retinoblastoma</td>
<td>0 (0)</td>
<td>1 (3)</td>
<td>&gt;0.99</td>
</tr>
<tr>
<td>medulloblastoma</td>
<td>0 (0)</td>
<td>2 (6)</td>
<td>&gt;0.99</td>
</tr>
<tr>
<td>ETANTR</td>
<td>0 (0)</td>
<td>1 (3)</td>
<td>&gt;0.99</td>
</tr>
<tr>
<td>hamartoma</td>
<td>1 (7)</td>
<td>0 (0)</td>
<td>0.31</td>
</tr>
<tr>
<td>lymphocytic hypophysitis</td>
<td>1 (7)</td>
<td>0 (0)</td>
<td>0.31</td>
</tr>
<tr>
<td>hyperplasia of choroid plexus</td>
<td>0 (0)</td>
<td>1 (3)</td>
<td>&gt;0.99</td>
</tr>
<tr>
<td>not diagnostic</td>
<td>0 (0)</td>
<td>1 (3)</td>
<td>&gt;0.99</td>
</tr>
<tr>
<td>FOR</td>
<td></td>
<td></td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>mean</td>
<td>0.344</td>
<td>0.467</td>
<td></td>
</tr>
<tr>
<td>SD</td>
<td>0.024</td>
<td>0.07</td>
<td></td>
</tr>
<tr>
<td>a priori goal(s) of the procedure</td>
<td></td>
<td></td>
<td>0.0016</td>
</tr>
<tr>
<td>biopsy</td>
<td>9 (64)</td>
<td>31 (100)</td>
<td></td>
</tr>
<tr>
<td>biopsy &amp; aspiration of the cyst</td>
<td>5 (36)</td>
<td>0 (0)</td>
<td></td>
</tr>
<tr>
<td>achievement of surgical goal(s)</td>
<td>14/14 (100)</td>
<td>30/31 (97)</td>
<td>&gt;0.99</td>
</tr>
<tr>
<td>operative complications</td>
<td>0/14 (0)</td>
<td>1/31 (3)</td>
<td>&gt;0.99</td>
</tr>
</tbody>
</table>

* Values represent numbers of patients (%) unless otherwise indicated. ETANTR = embryonal tumor with abundant neuropil and true rosettes; PNET = primitive neuroectodermal tumor.

**Discussion**

Ventriculomegaly has been traditionally considered a necessity for management of intraventricular tumors. In a small ventricular system, intraventricular cannulation and endoscopic manipulation without causing significant morbidity has been considered difficult.\(^8\)\(^,\)\(^22\) Paraventricular structures, such as the fornix, thalamus, or deep ventricular veins, can be damaged by inaccurate cannulation or moving the endoscope through insufficient working space. Recently, 2 articles reported the feasibility of endoscopic tumor management in small ventricles using a rigid
Flexible endoscopy for small ventricles

Fig. 1. Sagittal (left) and coronal (right) Gd-enhanced T1-weighted MR images showing small ventricles and suprasellar and pineal lesions. The pathological examination of the suprasellar lesion revealed germi-

noma.

endoscope in adult and pediatric populations. In this article, we aimed to evaluate the effectiveness and safety of a flexible endoscope for management of intraventricular brain tumors in patients without ventriculomegaly.

With regard to ventricular cannulation and introduc-
tion of the endoscope into a ventricular system, Souwei-
dane reported that initial cannulation was performed with a 1.7-mm ventricular catheter mostly using stereotactic guidance. After controlled insufflation of ventricles with Ringer’s solution, he replaced the catheter with a 6-mm endoscopic sheath, using freehand technique. Naftel et al. also performed initial cannulation with a ventricular catheter using neuronavigation. After insufflation and re-
moval of the catheter, they introduced a 12.5-Fr introduc-
er sheath and trocar under direct visualization of the tract with a 1.1-mm endoscope integrated within the trocar to dilate the tract to the ventricles. Then, the sheath and tro-
car were removed and the rigid endoscope was introduced down the dilated tract under visualization. In our se-
ries, initial ventricular cannulation was also performed with a 1.7-mm ventricular catheter using neuronavigation or stereotactic guidance in all cases. After insufflation and re-
moval of the catheter, a 2.7-mm or 2.8-mm flexible en-
doscope was introduced under direct visualization of the tract to the ventricle. When higher resolution was neces-
sary, the 2.7-mm or 2.8-mm endoscope was replaced with a 4.8-mm endoscope also under direct visualization of the tract. By this method of using stereotactic navigation in initial cannulation and direct visualization of the tract to the ventricle by endoscope, we could eliminate the freehand procedures, which may increase the possibility of inaccurate cannulation or misguided introduction of the endoscope, as previously described. A flexible endo-
scope has excellent maneuverability with its tip flexion in any direction with rotation of the shaft, allowing an accu-
rate tracing of the tract to the ventricles. Such maneuver-
ability could be more advantageous than that of a rigid endoscope in introducing the endoscope down the tract.

A flexible endoscope can also allow accurate and safe manipulation in a limited ventricular space, as Yamamoto et al. demonstrated. The working dimension can be changed by rotating the shaft of the endoscope. By adjusting the dimension to the wider axis, tip flexion (up to 90° upward and 90° downward) can be safely performed.

Such rotation and tip flexion of an endoscope allows accu-
rate intraventricular manipulation for biopsy and decom-
pression of tumors, especially in the corner of the third ventricle. Movements of only the distal portion of the en-
doscope allow the surgeon to avoid undue torque on the cortex or structures around the foramen of Monro, includ-
ing the fornix, thalamus, and deep veins, which resulted in a high success rate with low morbidity in our series.

Generally, endoscopic manipulation in the posterior third ventricle is considered technically more demand-
ing. In our series, endoscopic biopsy of pineal lesions was successfully performed in 3 patients with small ven-
tricles, 2 with pineal tumors and 1 with bifocal tumors in the suprasellar and pineal regions. The ability to obtain flexion of the tip of the flexible endoscope was particularly useful for operating in this region.

We used a 2.7-mm or 2.8-mm flexible endoscope (VEF-2, Olympus, or Neuro-Fiberscope, Storz) or a 4.8-
mm flexible endoscope (VEF-V, Olympus), when higher resolution was required. The resolution of the 4.8-mm flexible endoscope was similar to that of a rigid endoscope (Video 2) and was sufficient for tumor biopsy or decom-
pression of a cystic tumor in the suprasellar region.

Video clip demonstrating introduction of a 4.8-
mm flexible endoscope under direct visualization of the tract. Pathological examination of a suprasellar lesion revealed a craniopharyngioma. Copyright Hideki Ogawa. Published with permission. Click here to view with Media Player. Click here to view with Quicktime.

Given the similar resolution to that of a rigid endoscope, a flexible endoscope with excellent maneuverability and tip flexion might be as useful as or more useful than a rigid endoscope in the management of intraventricular tumors in patients with small ventricles.

There were no significant differences in the rates of successful accomplishment of the surgical goals or mor-
bidity between the small-ventricle group and ventriculo-
megaly group in our series, as previous studies have also demonstrated. For patients with small ventricles in those series and ours, the success rate ranged from 83% to 100% (15 of 15 cases, 5 of 6, 14 of 14, respectively), and the morbidity rate was 0% in all series. In the case series reported by Naftel et al. and our own series, all 3 hemor-
rhagic complications occurred in patients with ventricu-
losegaly and with malignant histopathology including pineoblastoma, glioblastoma multiforme, and yolk sac tu-
mor. The low morbidity in patients with small ventricles may be partly due to a relatively low rate of malignant histopathology in this subset of cases (range 14% to 33% in these 3 series).

Although considerable experience and specific tech-
niques are required, endoscopic surgery can be an appro-
priate and effective treatment modality for management of intraventricular tumors with small ventricles.

Conclusions

Endoscopic surgery using flexible endoscope is con-
sidered to be useful for management of intraventricular brain tumors in patients with small ventricles. A flexible endoscope allows excellent maneuverability in introduc-
ing the endoscope into the lateral ventricle and manipulating through small ventricles.

**Disclosure**

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

Author contributions to the study and manuscript preparation include the following. Conception and design: both authors. Acquisition of data: Ogiwara. Analysis and interpretation of data: Ogiwara. Drafting the article: Ogiwara. Critically revising the article: both authors. Reviewed submitted version of manuscript: both authors. Approved the final version of the manuscript on behalf of both authors: Ogiwara. Statistical analysis: Ogiwara. Study supervision: Morota.

**References**


H. Ogiwara and N. Morota