Neuroendoscopic approach to tectal tumors: a consecutive series

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The authors report a consecutive series of 10 patients who presented with signs and symptoms caused by tectal tumors. Clinical findings, radiographic features, neuroendoscopic management strategies, and histological findings are reported and discussed.

Since January 1990, 11 neuroendoscopic procedures were performed in 10 patients who harbored tectal tumors. The patients were followed for an average of 5 years (range 2 months to 12 years), and a retrospective study was conducted in which case notes, radiological findings, operative notes, and histopathological findings were assessed. Magnetic resonance (MR) imaging was performed, and the images were used to classify patients into three groups: those with hypertrophy of the tectum in whom isointensity appeared on T1-weighted images (Group 1); those with a tectal tumor occupying the cerebral aqueduct in whom decreased signal intensity appeared on T1-weighted images, as well as no enhancement after gadolinium administration (Group 2); and those with a tectal tumor in whom mixed signal intensity appeared on T1-weighted images and conspicuous evidence of contrast enhancement (Group 3). The results of histological examination were consistent with MR imaging features: in Group 1, glial tissue or gliosis; in Group 2, benign astrocytoma; and in Group 3, malignant astrocytoma. Cerebrospinal fluid diversion was the only surgical treatment that provided relief from obstructive hydrocephalus. One patient in Group 3 underwent radiotherapy and subsequent partial tumor removal under neuroendoscopic guidance. Thereafter, the tumor remained in decline. All patients had normal intellectual status after undergoing surgery in which a neuroendoscope was used.

Neuroendoscopic procedures can provide histological diagnosis, define the tumor-midbrain interrelationship, and be highly effective in treating obstructive hydrocephalus and in removing tectal tumors. This procedure may receive clinical application as a new management strategy for tectal glioma.

Key Words * tectum * glioma * cerebral aqueduct * hydrocephalus * neuroendoscopy

Tectal tumors are very rare.[1-4,6-16] To date, there has been no review of neuroendoscopic treatment for tectal tumors based on minimally invasive surgery. The clinical features of tectal tumors are
summarized as follows: although the appearance of neurological deficits are infrequent in patients who harbor tectal tumors, symptoms related to obstructive hydrocephalus occur early in the development of the disease. The advent of magnetic resonance (MR) imaging has facilitated the clinicopathological evaluation of these disorders.

We have favored the treatment of obstructive hydrocephalus by using a flexible neuroendoscope. Since January 1990, we have been assessing the pathogenesis of aqueductal occlusion. We now assembled data from a large series of patients who presented with obstructive hydrocephalus related to various causes. Thus, the primary purpose of this study was 1) to evaluate the neuroradiological status of the mesencephalon as depicted by MR imaging; 2) to review the actual status of the aqueductal orifice in patients with tectal tumors; 3) to evaluate how the cerebral aqueduct is obliterated by tectal tumors; and 4) to assess the significance of these findings by using neuroendoscopy.

**CLINICAL MATERIAL AND METHODS**

**Patient Population**

Of 100 consecutive patients with aqueductal stenosis/occlusion who presented between January 1990 and December 1998, 10 patients who harbored a histologically verified tectal tumor were selected for this study and were classified into three groups (Table 1). Group 1 was composed of three patients in whom a histological diagnosis of glial overgrowth or gliosis had been made; Group 2 consisted of five patients who harbored a low-grade astrocytoma; and Group 3 was composed of the remaining patients who harbored malignant astrocytoma.

![Table 1](image)

All patients underwent treatment regardless of tumor size or degree of hydrocephalus. Neither the size of the tectal tumor nor the size of the ventricles were factors in the decision to choose one procedure over another. At no time were we required to convert a neuroendoscopic procedure to an open craniotomy. All
patients underwent preoperative MR imaging studies, and in each the diagnosis was confirmed histologically.

**Clinical Presentation**

Patients who underwent flexible neuroendoscopy included four males and six females who ranged in age from 8 to 73 years (mean 26.1 years); (Table 1). The ages of patients in Group 1 ranged from 8 to 15 years, in Group 2 from 21 to 48 years, and in Group 3 from 24 to 73 years. The 11 neuroendoscopic procedures were performed in 10 patients.

Eight patients presented only with headache. In the patient in Case 3 (Group 1), who sustained a small head trauma, computerized tomography scanning detected hydrocephalus. The patient in Case 10 (Group 3) experienced headaches and bilateral third and fourth cranial nerve palsies.

**Endoscopic Technique**

After a general endotracheal anesthetic is administered, the patient is placed supine in a neutral position and the vertex elevated 15°. A linear skin incision is made parallel to the midline and centered 4 cm lateral to the midline and 1 cm in front of the coronal suture. The burr hole is created using a hand drill. The dura is incised, and the ventricle is cannulated using a No.16 French peel-away sheath and stylet (Cook Inc., Bloomington, IN). After withdrawal of the stylet, a 4-mm steerable fiberscope (Olympus Optical Company, Tokyo, Japan) with a 1.8-mm-diameter working channel is inserted into the ventricle. We used a contact (Nd:YAG) laser endoprobe (Surgical Laser Technology, Tokyo, Japan) for coagulation and vaporization of the tissue and tumor. Laser power is set at 8 to 15 W of continuous energy. An endoscopic ultrasonic aspirator (prototype; Olympus Optical Company) is used for aspiration of the tumor under 20 to 30 W continuous energy. Continuous irrigation with artificial cerebrospinal fluid (CSF) is used to maintain a fluid interface, to cool the CSF, and to prevent brain collapse. A 1.6-mm biopsy forceps is used to excise the tumor tissue. Hemorrhage from the tumor is controlled by using irrigation with the artificial CSF or by the contact laser endoprobe.

After irrigation is used to wash away floating pieces of the tumor tissue, a third ventriculostomy is performed. The infundibular recess and mammillary bodies are useful landmarks along the floor of the third ventricle. A tiny stoma is made with a punctured needle in the center of the tuber cinereum among the infundibular recess and mammillary bodies. A percutaneous transarterial balloon catheter (Target Therapeutics, Fremont, CA), inserted into the stoma, is inflated to enlarge the stoma to 4 mm in diameter.

The fiberscope sheath is then withdrawn, and a piece of Gelfoam is placed over the dura. A ceramic button is placed over the burr hole for cosmetic purposes.

Treatment included three variables: 1) third ventriculostomy and biopsy in Group 1; 2) third ventriculostomy and biopsy or partial excision in Groups 2 and 3; and 3) third ventriculostomy and biopsy followed by a 40-Gy (Case 8) and 50-Gy (Case 9) dose of radiation (the patient in Case 8 later underwent partial excision and was then represented as Case 10).

**RESULTS**

**Magnetic Resonance Imaging**

In Group 1, the typical MR imaging (Fig. 1) was a bulbous tectal mass that was isointense with the...
surrounding brain on T1-weighted images, hyperintense on T2-weighted images, and without enhancement following administration of gadolinium.

Fig. 1. Case 4 (Group 1). Magnetic resonance images demonstrating tectal hypertrophy. Upper Left: Sagittal T1-weighted image revealing isointense tectal lesion. Upper Right: Sagittal T2-weighted image revealing hyperintense tectal lesion. Lower Left: Sagittal T1-weighted image demonstrating stationary status for 10 years.

In Group 2, MR imaging (Fig. 2) revealed a tectal mass with low signal intensity on T1-weighted and hyperintensity on T2-weighted images, with exophytic growth into the cerebral aqueduct and extension into the diencephalon and the midbrain tegmentum, and with lack of contrast enhancement. Magnetic resonance imaging demonstrated little deterioration over a longer follow-up period (Fig. 3). Except for the patient represented in Cases 8 and 10 (see Table 1), all patients are in a stable condition after more than 3 years postsurgery.
Fig. 2. Case 6 (Group 2). Magnetic resonance images demonstrating tectal benign astrocytoma. Upper Left: Axial T₁-weighted image revealing hypointense tectal lesion. Upper Right: Axial T₂-weighted image revealing hyperintense tectal lesion. Gadolinium-enhanced T₁-weighted axial (lower left) and sagittal (lower right) images demonstrating a lack of enhancement.
Fig. 3. Case 6 (Group 2). Follow-up MR images demonstrating stationary status for 4 years. Axial T₁- (upper left) and T₂-weighted (upper right) images and gadolinium-enhanced axial (lower left) and sagittal (lower right) images demonstrating stationary status.

In Group 3, MR imaging (Fig. 4) documented a larger mass with mixed signal intensity on T₁- and T₂-weighted images, with prominent contrast enhancement, and with exophytic growth into the cerebral aqueduct and the third ventricle, and with oppression of the posterior diencephalon and the midbrain tegmentum.
Fig. 4. Case 9 (Group 3). Magnetic resonance images demonstrating tectal anaplastic astrocytoma. Upper Left: Sagittal T1-weighted image revealing hypo- and isointense tectal lesion. Upper Right: Sagittal T2-weighted sagittal image revealing hyper- and hypointense tectal lesion. Gadolinium-enhanced T1-weighted axial (lower left) and sagittal (lower right) images demonstrating prominent enhancement.

Prior to undergoing radiotherapy, in the patient in Case 8 this mass did not show enhancement after gadolinium administration (Fig. 5); however, irregular and dense enhancement was present 2 years after receiving 40 Gy. There was some suspicion that the imaging studies demonstrated malignant changes (Fig. 5). This is supported by histopathological evidence. More recent MR images suggest a remarkable reduction in size of the tumor and a deterioration of contrast enhancement (Fig. 5).
Fig. 5. Cases 8 and 10 (same patient). Upper Left: Gadolinium-enhanced T₁-weighted sagittal image revealing huge tumor without contrast enhancement. Upper Right: (Case 10) After a 40-Gy dose of radiation, gadolinium-enhanced T₁-weighted sagittal image demonstrating prominent enhancement. Lower Left: After neuroendoscopic surgery, gadolinium-enhanced sagittal T₁-weighted image demonstrating results after partial removal of the tumor. Lower Right: Sagittal T₁-weighted image revealing a remarkable reduction in tumor size and a deterioration of contrast enhancement.

**Neuroendoscopic Findings**

In three cases in Group 1, the cerebral aqueduct was occupied by a grayish mass that was ill defined, evenly flat, and the same consistency as the white matter. In this group the posterior commissure showed no deviation or deformity (Fig. 6).
In the patient in Case 4 (Group 2), the orifice of the cerebral aqueduct was widely opened, and a grayish mass was seen protruding from its orifice. The tumor was ill defined, humped, translucent, soft, and elastic-like. Important features of the aqueduct were described as an upward deviation of the posterior commissure with the widely opened orifice and tumor growth that appeared to be protruding like a navel (Fig. 7).

In the patients in Group 3, the orifice of the cerebral aqueduct was occupied by a large, globular, sharply demarcated, and evenly smooth mass. Its endoscopic features were summarized as follows. The tumor was well defined, humplike, reddish, soft, elastic-like and hemorrhagic (Fig. 8). The tumor developed in the tectum, protruded into the aqueduct, spread to the cerebral aqueduct, and was extruded from the aqueductal orifice into the posterior part of the third ventricle. The posterior commissure was stretched out and deviated upward (Fig. 9).
Clinical Features

In the patients in Groups 1 and 2, preoperative signs and symptoms have resolved.

In the patients in Group 3, clinical symptoms and signs due to hydrocephalus have disappeared, but the signs related to the tectal tumors remained. In the patient in Case 10, double vision became apparent with improvement in the ptosis just after a second operation (Fig. 9). However, her clinical status is stable 5 years after undergoing 40-Gy radiotherapy and 3 years after undergoing partial removal of the tumor by using an ultrasonic aspirator under neuroendoscopic guidance. The patient in Case 9 received a total radiation dose of 50 Gy. The patient in Case 10 refused additional treatment.

Histopathological Findings

The patients in Group 1 were diagnosed as having glial tissue or gliosis after biopsy specimens were examined.
The patients in Group 2 were diagnosed as having benign astrocytoma after biopsy specimens were examined. This histological feature was uniform appearance. Fibrillated cells that were often fusiform or polar with looser microcystic areas were well demonstrated in the biopsy specimen.

The patient in Case 8 (Group 2) was diagnosed as having benign astrocytoma before undergoing radiotherapy, which changed to anaplastic astrocytoma (thereafter represented as Case 10) after receiving a 40-Gy radiation dose. This tumor was highly cellular and had marked pleomorphism. The patients in Cases 9 and 11 were also diagnosed as having anaplastic astrocytoma.

**DISCUSSION**

Tectal tumors are very rare.[1-4,6-16] With the availability of MR imaging, tectal tumors are revealed more frequently in adolescents and adults who present with supratentorial hydrocephalus. The clinical presentation of raised intracranial pressure secondary to hydrocephalus in the absence of brainstem signs is characteristic of tectal tumors. Tectal tumors have been reported to be particularly indolent, often remaining stable in size for several years. Patients who harbor tectal tumors are managed with CSF diversion and close follow-up monitoring. However, the natural history of tectal tumors in terms of their long-term potential for clinical and radiographically demonstrated progression remains uncertain.

Whether tectal tumors are small or not, they cause occlusion of the cerebral aqueduct and subsequent hydrocephalus. According to Kernohan and Sayre[5] tectal tumors were "the smallest in the body that led to the death of patients." The difficulties of early radiographic diagnosis in the patients with tectal tumors have been emphasized before the advent of MR imaging. Now, MR imaging can reveal the way in which the tectum and the tegmentum of the midbrain are related to the tectal tumors. The majority of tectal tumors caused a disruption of the roof of the cerebral aqueduct and protrusion into the posterior part of the third ventricle. For a full realization of the distortions they cause, it is important to understand the microanatomy of the cerebral aqueduct and of the quadrigeminal plate. The length of the quadrigeminal plate varies from 10 to 18 mm, with an average length of 13.4 mm. The diameter of the superior colliculi ranged from 1 to 6 mm, with an average length of 5.5 mm. The inferior colliculi measurements varied from 1 to 7 mm, with average diameter of 5.0 mm.[13] The cerebral aqueduct is surrounded by a broad band of central gray matter. The dorsal surface of the quadrigeminal plate is covered with the pia mater and thickened arachnoid membrane, which comprises the quadrigeminal cistern, and may prevent the dorsal extension of tectal tumors. The posterior commissure overhangs the superior colliculi, contains fibers from the pretectal nuclei, the nuclei of the posterior commissure, the superior colliculi, and the interstitial nuclei of Cajal, and may limit the upward extension of tectal tumors. The inferior colliculi receive the auditory pathways mostly from the contralateral ear and may preclude the caudal and lateral extension of tectal tumors. Whether tectal tumors are benign or malignant, they may extrude from the tectum into the lumen of the cerebral aqueduct and subsequently protrude from the orifice of the cerebral aqueduct into the posterior part of the third ventricle, push away the posterior commissure, and enlarge the orifice.

These findings have provided new insights into the mode of presentation of tectal tumors and their characteristic neuroimaging and neuroendoscopic features. In our study, tectal tumors are classified into three groups depending on neuroimaging characteristics, neuroendoscopic features, and histological findings.

Neuroepithelial hamartomas are rare lesions that result from faulty embryological development. Hamartomas are encountered relatively more frequently in the hypothalamus and in the temporal lobe.
Hamartomas in the quadrigeminal plate have been reported previously in the literature,[4,6] and they were characterized as a nodular mass that protruded into the aqueductal channel and subsequently occupied the roof of the cerebral aqueduct. Histological examination of autopsy specimens has shown an overgrowth of neurons and numerous astrocytes. Pollack, et al.,[11] have reported a series of children in whom late-onset aqueductal stenosis results from benign intrinsic tectal tumors. Of the 16 children treated between 1979 and 1992, 10 children have shown no clinical or radiographic progression of disease from 1 to 12 years after CSF diversion or after onset of initial signs and symptoms of hydrocephalus, such as macrocephaly, headache, vomiting, and decreased performance at school. These 10 children fit the criteria for classification into our Group 1. Our follow-up data in this study indicated no clinical or radiographic progression of disease. A series of benign intrinsic tectal tumors in children described by May, et al.[7] may also meet the criteria for inclusion into our Group 1. If only CSF diversion were completed, the patients in Group 1 could typically have received a very good prognosis and experienced a good quality of life.

The patients in Group 2 harbored a true glial tumor originating from the tectum. Characteristic MR imaging features are nonenhanced tectal masses with high signal intensity on T₂-weighted images. Histopathological features of tectal tumors reported previously are variable: pilocytic astrocytoma,[1-3,15] low-grade astrocytoma,[9,11,14,16] oligoastrocytoma,[3,11] ganglioglioma,[10] ependymoma,[3] and subependymoma.[2] Steinbok and Boyd[14] reported two adolescents (aged 15 and 13 years, respectively) who harbored periaqueductal astrocytoma and who survived 23 and 10 years, respectively, after undergoing radiotherapy. Pollack, et al.,[11] reported that two children (aged 8.5 years and 6 months, respectively) survived 21 and 12.5 years, respectively, after onset of hydrocephalus. The patients in our Group 2 usually have a good prognosis and experience a good quality of life beyond all expectations. However, because their tumors will progress after treatment, serial MR images need to be obtained.

The patients in Group 3 are quite rare. Pollack, et al.,[11] have reported on one child with anaplastic astrocytoma who developed symptoms of progressive brainstem dysfunction 9 years after initial presentation. Therefore, this patient was treated using stereotactic radiosurgery techniques, underwent conventional radiotherapy (43 Gy) and received a boost dose of 18 Gy (50% isodose at the tumor margin). This patient remained clinically stable for 4.5 years after tumor progression. Our patient (Case 10) remains clinically stable 5 years after receiving a 40-Gy dose of radiation and 3 years after undergoing surgery in which partial removal of the tumor was achieved using neuroendoscopic procedures. Follow-up MR images revealed a remarkable reduction in size of tumor and a deterioration of contrast enhancement.

CONCLUSIONS

A variety of treatments have been proposed for management of tectal masses: direct surgical approach followed by radiotherapy and chemotherapy; biopsy and radiotherapy; and CSF diversion only followed by serial MR imaging. Tectal glioma is unique among brainstem gliomas in that its growth rushes in the direction of the ventral surface of the quadrigeminal plate and obliterates the aqueduct in the early stage of disease, thereafter preferring exophytic growth to invasion into the close neural structures and projecting into the third ventricle. We think that precise histological diagnosis of tectal tumors is crucial. In light of present evidence, tectal tumors should be considered as intraventricular lesions. It can thus be speculated that tectal glioma is different from other brainstem glioma in that a patient can have a good prognosis for life. It should be taken into account that neuroendoscopic procedures have enabled CSF...
diversion, especially third ventriculostomy, for obstructive hydrocephalus; endoscopic biopsy sampling for histological diagnosis; and enucleation for internal decompression by using an endoscopic ultrasonic aspirator.

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