Original Article

# Endoscopic Third Ventriculostomy for Treatment of Obstructive Hydrocephalus

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**Background:** Endoscopic third ventriculostomy has become the preferred treatment for obstructive hydrocephalus. The purpose of this paper is to present our experience with ventriculostomy at our center.

**Methods:** Twenty-four patients underwent ventriculostomy for the treatment of obstructive hydrocephalus between May 2000 and May 2006. The follow-up period lasted between one and 51 (median: four) months. The mean age of the patients was 31 (range: 0.5 – 67) years. It was determined that the obstructive hydrocephalus was caused by space-occupying lesions in nine patients (eight tumors and one with calcified arteriovenous malformation), aqueductal stenosis in 14 patients, and shunt infection and entrapped fourth ventricle in one patient. Kaplan-Meier survival analysis showed that the proportion of functioning ventriculostomies became stable at rates of 80% to 90% after the third postoperative month.

**Results:** There was no statistically significant difference in the aqueductal stenosis and tumor subgroups ($P$=0.716). A high rate of functioning ventriculostomies was found in both subgroups: 12 of 14 in the aqueductal stenosis subgroup and eight of nine in the tumor subgroup.

In cases of intraventricular tumors, in addition to ventriculostomy, biopsy was performed that successfully helped the patient management. In the present study, the procedure failed in three patients (13%). Ventriculostomy failures occurred within three months after the operation. The cases of treatment failure were one with aqueductal stenosis, one with Chiari I, and one with pineocytoma. There was no permanent morbidity after ventriculostomy in our patients.

**Conclusion:** The results indicated that ventriculostomy is an effective treatment in cases of obstructive hydrocephalus that is caused by aqueductal stenosis and space-occupying lesions. This procedure is worthy for controlling hydrocephalus without shunt and its complications. Early clinical picture after the operation plays an important role in predicting patient's outcome after endoscopic third ventriculostomy.

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**Keywords:** Aqueductal stenosis • endoscopic third ventriculostomy • hydrocephalus



## Introduction

Since the development of valve-regulated shunts in the 1950s, many surgeries have been widely used to treat hydrocephalus. Nevertheless, high failure rates and numerous complications have been reported. With the introduction of neuroendoscopic methods, endoscopic third ventriculostomy (ETV) has become the preferred treatment for obstructive hydrocephalus, because the approach is minimally invasive and offers the surgeon brilliant visual control of the maneuver. In the present study, we retrospectively analyzed the indications for ETV, the surgical technique itself, and outcomes in a consecutive group of 24 patients who underwent ETV for obstructive hydrocephalus at our center.

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## Patients and Methods

### Patients

Twenty-four patients underwent ETV for the treatment of obstructive hydrocephalus at our institution between May 2000 through May 2006. Patient selection was based on findings of computed tomography (CT) and magnetic resonance (MR) imaging studies, which indicated the presence of obstructive hydrocephalus with the obstruction located in the posterior aspect of or distal to the third ventricle. Patients who experienced meningitis, ventriculitis, and intraventricular or subarachnoid hemorrhage who met the above-mentioned criteria were also included.

Outcome of ETV was evaluated according to patients' follow-up data or patients' status before they were lost to follow-up. The treatment was recorded as a success or failure. Success of the ETV was defined as partial or complete relief of symptoms. Failure was defined as no change or deterioration in the condition. Any patient who died as a direct result of the ETV procedure or had to undergo a shunt implantation operation after the ETV procedure was described as having treatment failure. Considering the potential predictive role of the early clinical appearance of patients after ETV, we defined it as clinical presentation in the first two weeks after ETV and classified it with the same criteria as those used for the ETV outcome evaluation. Repeated CT or MR images (the initial study was completed within two weeks after ETV) were obtained in each patient to evaluate the results of surgery and during the follow-up period.

**Endoscopic procedure**

Endoscopic third ventriculostomy was performed using the freehand method in all 24 cases under general anesthesia. For each patient we used a 6.5-mm rigid neuroendoscope (Gaab Endoscope, Storz, Tutlingen, Germany), which was equipped with three channels for instruments, suction, and irrigation. Observation and 30° lens endoscopes were applied in some cases for confirmation of anatomical orientation and for tumor biopsy. Before surgery, the relationship between the floor of the third ventricle and the tip of basilar artery was carefully evaluated on the sagittal MR images to reduce the risk of injury to the basilar artery and its branches.

The surgical technique was performed as described fully elsewhere.[1] We used blunt forceps and a Fogarty balloon catheter in most cases for perforation and widening of the stoma, the diameter of which was usually larger than five mm. The Liliequist membrane acts as a barrier between them in some patients; thus, it was essential to combine a Liliequist membranostomy with all the afore-mentioned procedures to reduce the incidence of failure. External ventricular drains were not routinely inserted.

**Statistical analysis**

Kaplan-Meier survival analysis was performed to compare the success of ETV in subgroups of aqueductal stenosis and tumor using SPSS statistical software (SPSS, Inc.; Chicago, IL).

## Results

Twenty-four ETVs were performed in 24 (16 males and eight females) patients. The symptoms of obstructive hydrocephalus included headaches in 20 patients, mental disturbances in five, gait disturbances in six, decreased level of consciousness in two, cranial nerve dysfunction in five, urinary incontinence in two, and head enlargement in one patient. It was found that the obstructive hydrocephalus was caused by space-occupying lesions in nine patients—eight with tumors and one with calcified arteriovenous malformation (AVM)—aqueductal stenosis in 14 patients, and shunt infection and subsequent entrapped fourth ventricle in another patient. The follow-up period lasted between one and 51 (median: 4) months.

All patients survived during the follow-up. The median follow-up period was four months. One month after ETV, an overall clinical improvement was observed in 22 (92%) patients. Kaplan-Meier survival analysis showed that the proportion of functioning ETVs became stable at rates of 80% to 90% after the third postoperative month (Figure 1). The log-rank test did not show any statistically significant differences in the aqueductal stenosis and tumor subgroups ($P$=0.716).

The procedure failed in three patients. The first was a six-month-old infant with three-ventricle hydrocephalus in whom the pathologic head enlargement progressed, despite a successful ventriculostomy. He underwent ventricular shunting one month after the ETV. The second failure was a patient with pineal tumor who underwent ventriculostomy and biopsy of the tumor. The tumor was pineocytoma. The tumor was resected totally through an occipital trans-tentorial approach. After operation, there was a third ventricular hematoma that was managed by temporary external ventricular drainage (EVD). Hydrocephaly became apparent after EVD removal

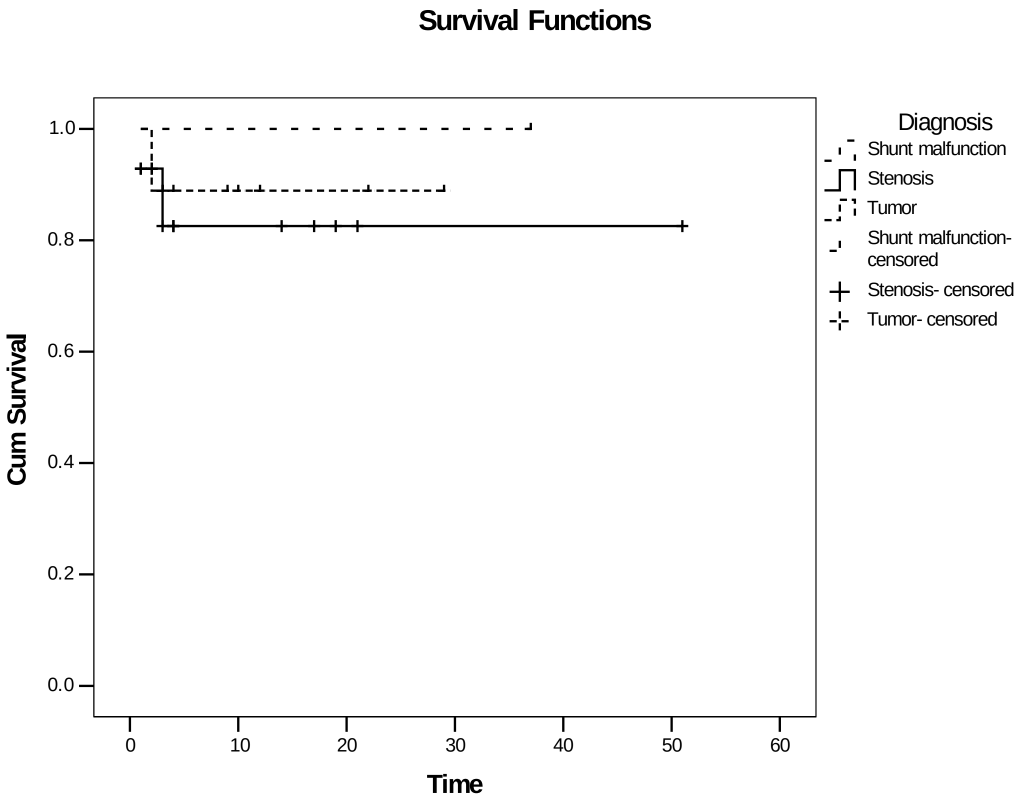


**Figure 1.** Kaplan-Meier survival plot showing functioning ETVs as proportions of the subgroups (aqueductal stenosis, tumor, and shunt malfunction).



and a ventricular shunt was inserted after two months. The third patient was a 24-year-old man with Chiari type I, presented with visual problems due to high intracranial pressure, headache, and three-ventricle hydrocephalus. His visual symptoms recurred and he developed bulging at the site of incision one month after ETV. The patient underwent a ventriculo-peritoneal (VP) shunt.

There was one patient who had previously received ventricular shunt and presented with entrapped fourth ventricle and shunt infection. The patient was managed by temporary EVD and watchful waiting for infection resolution. Third ventriculostomy and aqueductoplasty was performed. The patient left the hospital with no shunt.

A high rate of functioning ETVs was found in both subgroups: 12 of 14 patients in the aqueductal stenosis subgroup and eight of nine patients in tumor subgroup had functioning ETVs. ETV was also successful in the last patient with shunt malfunction.

By performing endoscopic biopsy in patients who underwent ventriculostomy, pathologic diagnoses were confirmed for four pineocytomas, two germinomas, and two tectal gliomas (type II astrocytoma) and one meningioma.

There were two patients who developed intra-operative intraventricular hemorrhage due to rupture of ependymal veins. This complication was overcome by temporary tamponade and irrigation in the first case; the operation was then continued. Poor visualization hindered carrying out the ventriculostomy in the second patient who underwent a successful ETV after clearance of cerebrospinal fluid (CSF) two weeks later. Minor self-limited bleeding occurred in two patients with pineocytoma that was cleared by EVD.

Twelve of 14 patients with aqueductal stenosis improved after ETV. The improvement was most striking and rapid in those who had symptoms of acute increased intracranial pressure, including severe headaches and vomiting. There was no deterioration after ETV in our patients. One patient in this group developed infectious meningitis due to *Acinetobacter calcoaceticus* which was treated with three weeks of imipenem. Transient diabetes insipidus occurred in another patient which lasted for one week and resolved without any complications.

Aspiration pneumonia occurred in one patient with pineocytoma that was treated successfully. *Acinetobacter calcoaceticus* meningitis occurred in another patient with pineocytoma, which was successfully treated with imipenem.

A brain CT scan within two weeks of ETV demonstrated a significant reduction in the size of ventricles in five of 24 and minor reductions in 12 of 24 patients. The ventricle size remained unchanged in seven of 24 patients.

After shunt removal from a patient with aqueductal stenosis and shunt infection, who was treated for the infection, ETV was considered. However, the floor of the third ventricle was thick and ventriculostomy was a difficult procedure in this patient. We performed aqueductoplasty in addition to ETV in this patient. The patient did well after surgery and left the hospital without shunt.

## Discussion

Endoscopy has changed neurosurgical treatment in many ways.[1 – 6] Obstructive hydrocephalus represents the most important indication for endoscopic intervention. Third ventriculostomy has been considered to be an effective and safe treatment for occlusive hydrocephalus by many authors,[7 – 12] but indications, surgical techniques, and outcomes related to different pathologic findings are still under intensive investigation.

Although flexible fiberoscopes have been used for ETV,[13 – 15] they offer a considerably inferior image quality and there is difficulty with their orientation, guidance, and fixation. In our series, all ETVs were performed using rigid endoscopes for freehand procedures. When ETV and a biopsy needed to be performed at the same time, we routinely adjusted the burr hole site for the convenient use of a rigid endoscope according to preoperative MR imaging studies.

### Patient selection and outcome evaluation

The goal of ETV and, to date, the best objectively-quantifiable measure of a successful outcome, is shunt independence. Authors of recent reports on ETV trials have claimed success rates greater than 75% (50 – 94%) for carefully selected patients.[7,10,11,16,18–23] In the present series, the overall shunt independence after ETV was 88% (21 of 24 patients). According to the results of Kaplan-Meier survival analysis, the rate of functioning ETVs stabilized at 80% to 90% after the third postoperative month.

Endoscopic third ventriculostomy is commonly used to treat patients with noncommunicating hydrocephalus in whom there are patent subarachnoid space and adequate CSF absorption. Our studies have demonstrated that patients with aqueductal stenosis and tumors obstructing outflow from the third or fourth ventricle are good candidates for ETV. The success rates are 86% for patients with aqueductal stenosis and 89% for those with tumors.

The duration of functioning ETV in patients with malignant neoplasms depends on their length of survival. Radiotherapy and chemotherapy, which are used in patients with malignant tumors to prolong their lives, had effects on evaluation of functioning ETV when compared with that of patients with benign space-occupying lesions. Patients with a reduced CSF resorption capacity, which may be seen after intraventricular hemorrhage, meningitis, or myelomeningocele, were usually thought to have a low success rate if they underwent ETV.[22, 24–25]

Some studies have demonstrated a trend toward a more successful outcome of ventriculostomy in patients with existing shunt systems.[26–28] In our study, one patient who had previously received shunt became shunt-free after ETV.

According to recent studies, the failure rate of ETV ranged from 6% to 50%.[7,11,16,18–23,29–30] In the present study, the procedure failed in three patients (13%). Time to failure after ETV for the whole group was two to three months after the surgery. Our cases of treatment failure were two patients with aqueductal stenosis (postoperative intraventricular hemorrhage and undeveloped subarachnoid space in an eight-month-old infant) and one with pineocytoma who developed postoperative intraventricular hemorrhage.

There was no permanent morbidity after ETV in our patients. Two (8%) patients experienced ETV-related complications in this study. The first was intraventricular hemorrhage in a patient in whom intensive irrigation led to termination of the bleeding. The other patient required external ventricular drainage for clearance of the CSF for ten days.

Most studies have demonstrated a gradual decrease in ventricle size over months to years postoperatively, coinciding with a clinical improvement.[8 – 14] The size of the ventricle is not a good predictor for neurosurgeons to use in the evaluation of the outcome within three months of surgery.[17] In the early postoperative period, a decrease in the size of the ventricle is often minimal and not visible before three to four weeks. Using a reduction in the size of the ventricle as a sole indicator of success in this procedure is questionable because patients with clinically successful outcome may have no change in ventricle size. Neuroimaging outcomes alone may be misleading and reliance on them should be avoided.[8]

In conclusion, our results indicated that ETV is most effective in patients with obstructive hydrocephalus caused by aqueductal stenosis and space-occupying lesions. Blunt perforation of the floor of the third ventricle is the preferred method of the procedure. Early clinical results play an important role in predicting the outcome of ETV. The predictive value of an alteration in the size of the ventricle, especially during the early stage after ETV, is unsatisfactory. ETV failures occur within three months after the operation. If performed correctly, ETV is a safe, simple, and effective treatment option with an acceptable level of complications.

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