



# Endoscopic third ventriculostomy prior to resection of posterior fossa tumors in children

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## Abstract

**Objective** Hydrocephalus is a common presenting symptom of pediatric posterior fossa tumors and often requires permanent cerebrospinal fluid diversion even after resection. Endoscopic third ventriculostomy (ETV) is a well-established treatment of obstructive hydrocephalus in children. The objective of this study is to demonstrate that ETV prior to posterior fossa tumor resection decreases the rate of postoperative ventriculoperitoneal shunt (VPS) placement.

**Methods** We performed a retrospective analysis of patients who presented with hydrocephalus and underwent posterior fossa tumor resection between 2005 and 2016 excluding pineal and tectal tumors. The rate of postoperative VPS placement was compared in patients who underwent resection and had a VPS placed perioperatively (historical controls) with patients who underwent ETV prior to resection. The two groups were matched for demographics, tumor histology, and tumor location. We also performed a literature review of prior studies that examined the role of ETV in pediatric posterior fossa tumors.

**Results** Thirty-six patients in the control group were compared to 38 patients in our study. The patients were matched across all variables (age, gender, tumor histology, and tumor locations). The rate of postoperative VPS placement was 31% in the control group compared to 16% in the ETV group. No complications were encountered during ETV.

**Conclusions** Endoscopic third ventriculostomy prior to posterior fossa tumor resection in children appears to decrease the rate of postoperative VPS placement. Given its efficacy and safety, ETV should be considered prior to tumor resection in these patients.

**Keywords** Endoscopic third ventriculostomy · Posterior fossa tumor · Pediatrics · Ventriculoperitoneal shunt

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## Abbreviations

ETV Endoscopic third ventriculostomy  
CSF Cerebrospinal fluid  
VPS Ventriculoperitoneal shunt  
EVD External ventricular drainage

## Introduction

The association between hydrocephalus and intracranial tumors has been extensively reported in the literature. Hydrocephalus may be communicating, obstructive (non-communicating), or hypersecretory; however, hydrocephalus caused by posterior fossa tumors tend to be almost exclusively obstructive [22, 25]. Fourth ventricular tumors directly occlude the CSF pathway and its foraminal outlets while larger cerebellar tumors distort the normal cisternal architecture through external compression [3, 28]. Symptomatic obstructive hydrocephalus has been reported in 70–92% of pediatric patients with posterior fossa tumors although studies have found that tumor histology and location

affect the incidence and persistence of hydrocephalus [9, 29]. Midline lesions, medulloblastomas, and ependymomas have higher rates of hydrocephalus compared to cerebellar astrocytomas [6, 15, 20].

Endoscopic third ventriculostomy (ETV) prior to tumor resection in pediatric patients with posterior fossa tumors has been reported to improve signs and symptoms of hydrocephalus and increased ICP [4, 28]. Furthermore, it may reduce the risk of postoperative pseudomeningocele and CSF leak that can occur despite external ventricular drainage (EVD) [6, 20]. Several papers have studied the efficacy of ETV compared to conventional VPS for long-term management of hydrocephalus in patients with tectal gliomas and pineal region tumors, reporting success rates of not requiring a long-term VPS ranging from 68 to 100% [16, 17, 21, 24, 26, 32]. However, the literature has been divided on the role of preoperative ETV for long-term control of hydrocephalus in patients with non-tectal/non-pineal region posterior fossa tumors [2, 10, 11, 13, 14, 17, 18, 23, 27, 28].

The aim of this study is to report our single-center experience with preoperative ETV in the management of hydrocephalus in children with posterior fossa tumors. We compared this cohort of patients to historical controls operated on by three pediatric neurosurgeons at our institution. By performing subgroup analysis on tumor histology, our goal was to determine which hydrocephalic tumor patients, if any, would benefit from a preoperative ETV.

## Methods

### Study design and clinical data

A neurosurgical database of patients with intracranial tumors who were treated surgically between 2005 and 2016 at the Children's Hospital of Philadelphia was queried. With institutional review board approval, we performed a retrospective analysis. Patient demographics, clinical presentation, tumor location and pathology, and follow-up time were abstracted from inpatient hospital records and neurosurgical outpatient clinic charts.

### Patient cohorts

Our two cohorts were defined by the year that ETVs became more routine at our hospital. Prior to 2010, ETVs were not routinely performed, therefore served as our historical control cohort. We also excluded all pineal region and tectal gliomas who presented with hydrocephalus as to not confound analysis since this population has been described in the literature with a high ETV success rate [16, 17, 21, 24, 26, 32]. For the 38 patients in the ETV group, ETV, EVD, and craniotomy for

attempted resection of the intracranial tumor were performed under one anesthesia event.

### Statistical analysis

ETV was considered successful if the patient did not require a VPS procedure for hydrocephalus in the postoperative period up to the latest follow-up or mortality. The rate of unsuccessful ETV was compared to the rate of postoperative VPS in the control group using a chi-squared test. The chi-square statistic was 2.2778. The *p* value was 0.131234.

### Literature review

To give context to our findings, a PubMed was searched for key words including posterior fossa tumor, hydrocephalus, and endoscopic third ventriculostomy. This was supplemented by using the "Related Citations" feature of PubMed and manual reviews of the references of included articles. Only studies in which subjects that could clearly be identified as having an ETV prior to tumor resection were included in our review.

## Results

We identified 409 pediatric patients who presented with intracranial tumors from 2005 to 2016. Of these 409 pediatric patients, 210 presented with hydrocephalus. Between January 2005 and September 2009, 36 patients with posterior fossa tumors excluding tectal gliomas and pineal region tumors who underwent attempted gross total resection and had a ventriculostomy placed at the time of tumor resection served as historical controls. Between July 2010 and October 2016, 38 patients who presented with hydrocephalus from a posterior fossa tumor excluding tectal tumors and underwent an ETV prior to attempted resection of the intracranial tumor were examined. For these 38 patients, ETV, EVD, and craniotomy for attempted resection of the intracranial tumor were performed under one anesthesia event. After the completion of the ETV, an antibiotic impregnated ventricular catheter was placed into the ventricle via a soft pass. Once the EVD was adequately secured, the patient was then repositioned into a prone position for resection of the posterior fossa mass. Of the 38 patients in the ETV group, 8 patients had leptomeningeal spread of tumor and distal metastasis in the spine. All of these patients had open basilar cisterns; therefore, an ETV was attempted. Out of these eight patients, only three had a shunt placed after failed ETV.

### Historical control group

The mean age at the time of surgery for the control group was 6.81 years (range 0.11–15.97) with an average follow-up

period of 2.2 years. Twenty-three (64%) were male (Table 1). Overall, 11 out of 36 (31%) patients were unable to be weaned from the ventriculostomy postoperatively and ultimately required a VPS to manage hydrocephalus (Table 3). Two of the three patients with ependymomas (67%) required VPS on postoperative days 8 and 13. The patient that required VPS 8 days postoperatively underwent near total resection of their tumor secondary to the tumor being adherent to the floor of the 4th ventricle while the other two patients underwent gross total resection. All three patients with high-grade cerebellar astrocytomas underwent gross total resection and did not require VPS postoperatively. Three of the 11 (27%) patients with a brainstem or cerebellar low-grade astrocytoma subsequently required a VPS on postoperative days 12, 28, and 32. Five of the 18 (28%) patients with a medulloblastoma underwent VPS on postoperative days 3, 6, 12, 20, and 47. The patient that required a VPS on postoperative day 6 underwent subtotal resection; however, the remaining patients had gross total resection of their tumor. The one patient with a 4th ventricle ATRT required a VPS 18 days after undergoing gross total resection.

In this group, there were no complications observed in the placement of an external ventricular drain. Of the 11 patients that required VPS, 3 patients required one or greater shunt revisions. All 3 of these patients had a low-grade brainstem or cerebellar astrocytoma.

### ETV group

For the ETV group, the mean age at the time of surgery was 5.64 years (range 0.20–13.8). Twenty-five (66%) patients were male (Table 1). The average follow-up period was 5.02 years. All patients who had an ETV prior to tumor resection also had an external ventricular drain placed at the same time that was weaned in the ICU over the next 1–11 days. The mean duration of EVD placement was 3 days. Overall, 6 out of 38 (16%) patients were unable to be weaned from the ventriculostomy postoperatively and ultimately required a VPS (Table 3). Fifteen patients had a low-grade cerebellar or brainstem astrocytoma and three (20%) of these patients required a VPS postoperatively. Two of the three patients that needed shunts in this category of an astrocytoma had leptomeningeal spread of tumor and metastasis in the spine. The success rate of preoperative ETV for low-grade cerebellar

tumors was 80%. Seventeen patients had a 4th ventricular medulloblastoma and only one (6%) patient required a VPS 13 days post-preoperative ETV and gross total resection. This patient did not have leptomeningeal spread or metastases. The success rate of preoperative ETV for 4th ventricular medulloblastomas was 94%. One of the three patients (33%) with a 4th ventricular ependymoma required a VPS 21 days after their initial ETV and gross total resection of their tumor. There were two patients that underwent gross total resection of a 4th ventricular ATRT tumor and one of these patients required a VPS 23 days post-initial surgery (Tables 2 and 3).

There were no complications from the ETV procedure. Specifically, no patients experienced vascular injury, endocrine abnormalities, or vision deficits. There were no complications observed in the placement of the external ventricular drain in this group either. One patient did however develop gram-positive cocci and gram-negative rod ventriculitis while the EVD was still in place. The EVD was later removed and the patient was treated with the appropriate antibiotics. Of the six patients that required VPS, one patient later underwent six shunt revisions while the remaining patients did not require any shunt revisions.

### Literature review

Ten case series examining the role of pre-resection ETV for the management of hydrocephalus in patients with posterior fossa tumors have been reported in the literature between 2001 and 2017 (Table 4). All but one [13] restricted their population to only pediatric patients. The rate of ETV success defined as patients not requiring further CSF-diverting procedures (VPS or repeat ETV) ranged from 65 to 100%. Only one series [10] directly examined the effect of tumor histology on the success of ETV and found that patients harboring low-grade astrocytomas had the greatest success rate (100%) while patients with medulloblastomas only had a 47% success rate. Similarly, Morelli et al. series found that patients with medulloblastomas had a statistically higher rate of persistent hydrocephalus after early subtotal or total resection and preoperative EVD with medulloblastomas. Fournier et al. series included only patients with posterior fossa medulloblastomas and ependymomas with either distant metastasis, diffuse leptomeningeal spread, or the presence of metastatic cell in the CSF. In this series, the success rate for preoperative ETV prior to biopsy or resection was only 55% and the authors of the study concluded that preoperative ETV should not be recommended in patients with medulloblastomas and ependymomas with evidence of metastases. In Kobayashi et al.'s series which included only brainstem gliomas [18], all six patients did not require a VPS including the one patient with a high-grade astrocytoma after undergoing a ETV for the treatment of their hydrocephalus.

**Table 1** Patient characteristics

Characteristic	Control (2005–2009)	ETV (2010–2016)
No. of patients	36	38
Mean age (years)	6.81	5.64
Age range (years)	0.11–15.97	0.20–13.8
% Males	64	66

**Table 2** Tumor histology and location

Characteristic	Control	ETV
Tumor type, number (%)		
Ependymoma	3 (8.3)	3 (7.9)
High-grade astrocytoma	3 (8.3)	0 (0)
Low-grade astrocytoma	11 (30.6)	15 (39.5)
Medulloblastoma	18 (50)	18 (44.7)
ATRT	1 (2.8)	2 (5.3)
Tumor location, number (%)		
4th ventricular	17 (47.2)	23 (57.9)
Brainstem/CP angle	1 (2.8)	2 (7.9)
Cerebellar hemisphere	18 (50)	13 (34.2)

## Discussion

Our results show a trend that ETV is decreasing the shunt rate particularly in patients with posterior fossa low-grade astrocytomas and medulloblastomas. Even though not statistically significant, our findings suggest that ETV can be used successfully to manage hydrocephalus in patients with posterior fossa lesions with a 15% decrease in shunt rate. Complications occur more commonly with VPS than with ETV noting the postoperative complication rate of ventriculoperitoneal shunting for posterior fossa tumors with hydrocephalus is reported to be 31% which is significantly higher compared to the 17% postoperative complication rate of an ETV in a similar cohort of patients [7].

Upwards of 70–80% of patients with posterior fossa tumor present with obstructive hydrocephalus [29]. Currently, a number of surgical options exist including immediate tumor resection, internal CSF diversion via ventriculoperitoneal shunt (VPS), external ventricular drainage (EVD), and endoscopic third ventriculostomy (ETV) [1, 10, 23]. One study reported an 87% cure rate of hydrocephalus with surgical resection alone in children with posterior fossa astrocytomas [9]. This percentage was significantly lower in patients with medulloblastomas and ependymomas (47 and 54%, respectively) [9]. Other studies reported the rate of persistent hydrocephalus

**Table 3** Rates of VPS in control versus ETV patients with subgroup analysis

	Control # of shunts (% of shunt rate)	ETV # of shunts (% of shunt rate)	P value
Ependymoma	2 (66%)	1 (33%)	
High-grade astrocytoma	0 (0%)	0 (0%)	
Low-grade astrocytoma	3 (27%)	3 (20%)	
Medulloblastoma	5 (28%)	1 (6%)	
ATRT	1 (100%)	1 (50%)	
Total	11 (31%)	6 (16%)	0.131

**Table 4** Literature review (and comparison to this study): pre-resection ETV on posterior fossa tumors for obstructive hydrocephalus

Author/year	No. of patients (with ETV)	Length of follow-up (mean in years)	Success rate
Sainte-Rose et al. 2001	67	2.15	94%
Frisoli et al. (this study)	38	5.02	84%
LG astrocytoma	15		80%
Medulloblastoma	17		94%
Other	6		
Ruggiero et al. 2004	20	1.75	80%
Klimo et al. 2006	13	0.78	92%
Gangemi et al. 2007	12	8.4	83%
El Beltagy et al. 2010	40	1.08	65%
Astrocytoma	13		100%
Medulloblastoma	11		47%
El-Ghandour. 2011	32	2.28	94%
Morelli et al. 2005	14	2	78%
Azab et al. 2013	17	1.15	88%
Kobayashi et al. 2016		1.025	100%
Pontine glioma	6		
Foumer et al. 2017	18	2.25	45%

after immediate resection ranging from 11.5 to 39% [5, 8, 12, 19]. However, these rates are largely driven by success with resection of cerebellar pilocytic astrocytomas and may mask the increased rate of persistent hydrocephalus in patients with more malignant tumors. In our study, the rate for not requiring VPS in our control patients' medulloblastomas was 72% vs. 94% in the ETV group.

ETV has been increasingly used as an alternative to EVD and VPS in the management of hydrocephalus secondary to intracranial tumors. Its efficacy has been convincingly demonstrated in patients with tectal and pineal regions tumors [16, 21, 24, 26, 32]. A review of the literature generally supports the use of the pre-resection ETV for this patient population as the success rates ranged from 65 to 94%. Numerous studies have shown that tumor histology differentially affects the rate of persistent hydrocephalus [6, 15, 20]. Specifically, medulloblastomas and ependymomas tend to have higher rates of persistent hydrocephalus than low-grade cerebellar astrocytomas. In Azab et al.'s review [2], 2 of the 17 patients that underwent a preoperative ETV later developed recurrent hydrocephalus requiring a VPS. In this study, 7 patients had an ependymoma, 6 patients had a cerebellar astrocytoma, 3 patients had a medulloblastoma, and 1 patient had a diffuse pontine glioma, while the 2 patients that failed preoperative ETV had an ependymoma and a medulloblastoma. In Beltagy

et al.'s series [10], the success rate for preoperative ETV for low-grade cerebellar astrocytomas was 100% compared to 47% for medulloblastomas. Our results differ from these findings. Our preoperative ETV success rate (no VPS) for low-grade posterior fossa cerebellar astrocytomas and fourth ventricle medulloblastomas were 80 and 94%, respectively, which did not meet a statistically significant decrease in VPS rate compared to the control group ( $p = 0.189$ ,  $p = 0.086$ ). Similarly, patients with fourth ventricular ependymomas/ATRT and posterior fossa high-grade astrocytomas who underwent preoperative ETV did not have a lower VPS rate compared to our controls although this may be limited by the small sample size.

Tamburrini et al. evaluated the use of an ETV post-tumor resection in patients with persistent hydrocephalus instead of either a pre-resection ETV or postoperative VPS [30, 31]. However, there are two significant benefits in performing an ETV pre-resection compared to post-resection. One is the decreased number of anesthesia events as we perform our ETV, EVD, and tumor resection in 1 day under one anesthesia event. In their series, 28.8 and 40% of the patients had persistent hydrocephalus post-posterior fossa tumor resection requiring a second surgery for performing an ETV compared to our study in which only 16% of our pre-resection ETV patients had persistent hydrocephalus and requiring a second operation [30, 31]. Unlike post-resection ETV, pre-resection ETV also has the potential to decrease the duration of EVD postoperatively and thus the length of stay in the ICU. In Tamburrini et al.'s review, the mean duration of EVD placement was 14 days (range 11–25 days) compared to our study in which the mean duration of EVD placement was only 3 days in the patients that underwent a pre-resection ETV [31].

The majority of patients with preoperative ETV failure presented within 30 days postoperatively with a pseudomeningocele and/or CSF leakage from their incision. We frequently use navigation-assisted image guidance for our ETVs. Our rate of technical failure is similar to that reported in the literature, which is 6–14% [4, 28]. Importantly, we did not encounter any significant complications such as infection, hematomas, and vascular injury.

## Conclusions

Our study, which is one of the largest case series to date, shows there to be a clinical significance of decreasing the shunt rate with preoperative ETVs for pediatric posterior fossa tumors. Given our lack of complications and the substantial benefit to any patient who avoids a VPS, ETV is a safe and quick procedure that can be done immediately prior to tumor resection.

## Compliance with ethical standards

**Conflict of interest** On behalf of all authors, the corresponding author states that there is no conflict of interest.

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