# Endoscopic third ventriculostomy for hydrocephalus in paediatrics

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**Significance:** There was an inverse relationship between the extent of postoperative decrease in ventricular size and the duration and magnitude of preoperative symptoms. However, a decrease in the size of ventricles after ETV may or may not indicate a successful process, as it has been established to lessen marginally in both settings. The clinical findings of patients who underwent endoscopic third ventriculostomy (ETV) for hydrocephalus were studied and compared to make decisions clearer.

## Abstract

### Background
Abnormal CSF accumulation within the ventricles of the brain, leading to increased intracranial pressure, is a potentially life-threatening state that is commonly observed in neurosurgical patients. This study aimed to assess the efficacy of endoscopic third ventriculostomy (ETV) in the treatment of hydrocephalus in pediatric patients.

### Materials and Methods
Sixty-two patients were included in this prospective study. Postoperative follow-up- Patients were generally discharged from the hospital on the 2nd or 3rd postoperative day unless some complications arose. All the information was recorded in a pre-structured proforma, and data were analyzed by statistical significance defined as a P value less than or equal to 0.05.

### Results
At follow-up, clinical improvement and radiological findings did not necessarily correlate with each other, as ventricular size was reduced in only 42 (67.7%) of 62 patients. The remaining 20 (32.3%) patients showed no change in ventricular size. The differences were not statistically significant. However, as observed on cine PC MRI, CSF flow was observed in all patients.

**Conclusion:** ETV is a simple, safe, and effective treatment for non-communicating hydrocephalus if performed correctly by an expert surgeon. It is a reasonable alternative to the VPS owing to its simplicity and effectiveness.

## Introduction
A urologist named Mixter first successfully executed endoscopic third ventriculostomy (ETV) in Chicago in 1923 (1). In hydrocephalus cases, the most widespread procedure is the ventriculoperitoneal shunt (VPS). There is 80% long-term- shunt failure in patients over a period of 20 years, from childhood to adulthood (2). In contrast, the best alternative technique to cerebrospinal fluid (CSF) shunt systems for treating Tri ventricular hydrocephalus is endoscopic third ventriculostomy (ETV). ETV is intended for communication between the third ventricle and the interpeduncular cistern to create a CSF flow that bypasses an obstruction to allow circulation of CSF (3).
Abnormal CSF accumulation within the ventricles of the brain, leading to increased intracranial pressure, is a potentially life-threatening state that is commonly observed in neurosurgical patients. Based on the presence or absence of CSF outflow obstruction, it is divided into communicating and non-communicating hydrocephalus (4). A ventriculoperitoneal shunt is an economical and easily available device that remains the mainstay of treatment. However, shunt failure is common, and repetitions in use may not yield outcomes (5). For this reason, endoscopic procedures such as endoscopic third ventriculostomy, endoscopic aqueductoplasty, and endoscopic aqueductal stenting are gaining recognition compared with VP shunts. ETV success is defined on the basis of clinical and radiological conditions. Clinical criteria include resolution of signs of increased intracranial pressure, such as improved consciousness, ocular movement abnormalities, headache, and reduction in the circumference of the head and fontanelle tension in infants. Radiological criteria comprise a 25% and 15% decrease in the size of the third ventricle within 3 months of follow-up, and the size of the third ventricle within 1 month, respectively, is considered a reliable indication of favorable outcome (6, 7). There is an inverse relationship between the extent of postoperative decrease in ventricular size and the duration and magnitude of preoperative symptoms; on the other hand, a decrease in the size of ventricles after ETV may or may not indicate a successful process, as it has been established to lessen marginally in both settings (8). The clinical findings of patients who underwent endoscopic third ventriculostomy (ETV) for hydrocephalus were studied and compared. This study aimed to assess the efficacy of ETV in the treatment of pediatric hydrocephalus.

## Materials and Methods
This was a prospective study conducted over three years from June 2017 to May 2020 in Nishtar Hospital Multan in the Department of Neurosurgery. Ethical approval was obtained from the hospital's ethical board. The sample size was calculated using the reference study by Sarmast et al. (9). A non-probability consecutive sampling technique was used. Patients' personal data including age, sex, and other factors such as causes, signs, and symptoms of the disease as well as previous use of any device or shunt, imaging findings including Evans ratio, and intraoperative and postoperative complications were recorded for this study. The participants of this study included only those patients aged between 6 months and 18 years with symptoms of intracranial hypertension and radiographic evidence indicating non-communicating hydrocephalus. In this study, the Burr hole was placed anterior to the coronal suture in the right prefrontal area of the mid-pupillary- line. The burr hole is used to achieve

the optimal trajectory into the 3rd ventricle via the foramen of Monro and the interpeduncular cistern. Through video guidance, a 0° rigid endoscope with a double irrigating sheath (4.6 mm) was introduced into the lateral ventricle following the catheter. In the supine position, the burr hole was the highest when the head was flexed and ETV was performed. The foramen of Monro can be identified by joining the thalamostriate vein, septal vein, and choroid plexuses. For irrigation, Ringer's lactate was used at 90 °F. A negotiating endoscope via the foramen Monro was used for perforation in 3rd ventricle and a cautery probe between the mammillary bodies and infundibular recess was used for puncturing at the most transparent site. An inflating Fogarty catheter was used to dilate the initial fenestrations. At the end of the procedure Gelfoam plug was introduced into the cortical tract.

Postoperative follow-up- Patients were generally discharged from the hospital on the 2nd or 3rd postoperative day unless some complications arose. All information was recorded in a pre-structured proforma, and data were analyzed by statistical significance defined as a P value less than or equal to 0.05.

If no complications occurred, patients were discharged from the hospital within 2–3 days after surgery. Follow-up was performed postoperatively, after a duration of 2 weeks, and at 1, 3, and 6 months, and every 6 months thereafter. Imaging via magnetic resonance imaging (MRI) or computed tomography (CT) was performed in patients if the aspects showed failed ETV performed before 3 months. On the other hand, 3 months follow up for MRI or CT scan of the brain was performed to determine ventricular size postoperatively. The patency of the stoma was determined by cine phase contrast- MRI, which was performed in all patients. Flow across the stoma was not considered to be a sign of stoma closure. If there was no shunt insertion and a decrease in symptoms of intracranial pressure (irritability and vomiting, resolution of eye findings such as sixth cranial nerve palsy, and a reduction in ventriculomegaly as determined by ultrasonography or MRI/CT scanning using Evans index or fronto-occipital horn ratio and also demonstration of CSF flow on cine PC MR), the procedure was considered to be successful. Pre-structured Performa was used to record information, and Statistical Package for Social Sciences (SPSS) version 23 was used for statistical analysis. Statistical significance was set at $P \leq 0.05$.

**Results:**

<u>Clinical Presentation</u>

Of the 62 patients, the clinical presentation was headache in 29 patients, increased head circumference in 10 patients, gait disturbance in 7 patients, hemiparesis in 4 patients, bulging fontanelle in 3 patients, nausea and vomiting, altered mental status, urinary incontinence, and Parinaud's syndrome in 2 patients each, and locomotor ataxia in one patient. Table-I

<u>Outcomes and Complications</u>

Posterior fossa mass was present in 13 patients, and successful ETV was performed in all, with stomal block observed as a complication in one patient. Primary aqueduct stenosis was present in 11 patients, and successful ETV was performed in all, with CSF leak observed as a complication in one patient. Myelomeningocele associated hydrocephalus was present in 12 patients and successful ETV was performed in 11 patients, out of which one patient presented with stomal block. Hydrocephalus due to previous VPS failure was present in nine patients, and ETV was successful in eight patients, of which two patients later presented with stomal block. Posterior third ventricular mass was the cause of hydrocephalus in 6 patients, all of whom underwent successful ETV and one patient developed CSF leak. Dandy-Walker syndrome was the etiology in 11 patients, successful ETV was performed in all patients, and no patient developed any complications. Six patients developed any type of complications. Table-II

<u>Effectiveness</u>

At follow-up, clinical improvement and radiological findings did not necessarily correlate with each other, as ventricular size was reduced in only 42 (67.7%) of 62 patients. The remaining 20 (32.3%) patients showed no change in ventricular size. The differences were not statistically significant. However, as observed on cine PC MRI, CSF flow was observed in all patients. Table-III.

**Table-I Clinical presentation of the patients**

| Clinical presentation | Number |
|---|---|
| Headache | 29 |
| Increased head circumference | 10 |
| Gait disturbance | 7 |
| Hemiparesis | 4 |
| Bulging fontanelle | 3 |
| Nausea and vomiting | 2 |
| Altered mental status | 2 |
| Urinary incontinence | 2 |
| Parinaud's syndrome | 2 |
| Locomotor ataxia | 1 |

**Table-II Etiology, procedure success, outcome and complications**

| Etiology | Procedure success | Outcome | Complications |
|---|---|---|---|
| Posterior fossa mass (13) | 13/13 | 12/13 | 1, stomal block |
| Primary aqueduct stenosis (11) | 11/11 | 10/11 | 1, CSF leak |
| Myelomeningocele associated (12) | 11/12 | 10/11 | 1, stomal block |
| Previous VPS failure (9) | 8/9 | 6/8 | 2, stomal block |
| Posterior third ventricular mass (6) | 6/6 | 5/6 | 1, CSF leak |
| Dandy-Walker syndrome (11) | 11/11 | 11/11 | - |
| Total | 60/62 | 54/60 | 6 complications |

**Table-III Effectiveness of ETV in non-communicating hydrocephalus**

| Etiology | Reduced ventricular diameter | Unchanged ventricular diameter | P value |
|---|---|---|---|
| Posterior fossa mass (13) | 6 | 7 | 0.284 |
| Primary aqueduct stenosis (11) | 10 | 1 | |
| Myelomeningocele associated (12) | 8 | 4 | |
| Previous VPS failure (9) | 6 | 3 | |
| Posterior third ventricular mass (6) | 5 | 1 | |
| Dandy-Walker syndrome (11) | 7 | 4 | |
| Total (62) | 42 (67.7%) | 20 (32.3%) | |

**Discussion**

The common practice of ETV is due to its success in terms of avoidance of dependency on VPS for life and a guaranteed shunt-free period. In cases where VPS or VASs are not successful, ETV is a reasonable alternative. In a comparison between VPS/VAS and ETV, the safety and better treatment approach for pediatric patients is the main issue related to the use of ETV in hydrocephalus (10). However, there are a variety of views on ETV as an effective approach in children aged less than 1 year [11], and the question of ETV treatment failure risks in infants and young children than older children is still under discussion by many authors. Along with the patient's age, the causes of hydrocephalus are also considered evidence of ETV success (12). In a study by Cinalli et al. (13), it was reported that patients aged less than 6 months, in which ETV was considered to be a contraindication, are now successfully treated.

In another study by Gorayeb et al. (14), the success rate for ETV performed in young children with age less than 1 year of age with obstructive hydrocephalus was 64%, and it was concluded that ETV can be used whenever required, regardless of the age of children younger than 1 year. As in previous studies, failure in the use of ETV was reported in patients younger than six months (15), and our study included patients aged > 6 months. There was a success rate of 71% for ETV treatment in patients with obstructive hydrocephalus along with VPS obstruction, and only 25% showed no recurrence after two years of follow-up, according to a study of Woodworth et al. (16). The age of patients younger than 1 year, already present shunt infection, and infection occurring after shunt placement have been attributed to factors leading to failure of this procedure (17). However, in our study, there was no statistically significant correlation between the age of the patients and causes of hydrocephalus with ETV failure ($P > 0.05$). The reason for these findings may be related to the limited sample size and the lower rate of complications in our study.

Damage in the pituitary stalk and hypothalamus, which mainly occurs in the diabetes insipidus, were the complications not encountered in our study and were described by other authors (18). Other complications included cardiac arrhythmias and respiratory arrest due to hypothalamic irritation and manipulation, (19) damage to vascular structures (the most feared complication of all) such as the basilar artery due to the proximity in the perforation field. Any fenestration in the floor of the 3rd ventricle made with potassium titanyl phosphate laser, even slight perforations due to endoscope or Fogarty balloon, may cause basilar artery injury. If the floor is not transparent, intravenous ICG dye to visualize the basilar artery through the opaque third ventricular floor (20) and microvascular Doppler probes have been used for the identification of arteries to avoid this complication.

**Conclusion**

In non-communicating hydrocephalus, ETV is a simple, safe, and effective treatment, if performed correctly by an expert surgeon. It is a reasonable alternative to the VPS owing to its simplicity and effectiveness. In comparison to post-shunt, the radiological improvements after the ETV approach are less because the size of ventricles does not decrease and the fluid is maintained in the same physiological space, which occurs in patients with shunt placement. The results of ETV in patients with shunt malfunction are encouraging and, proves that patients can stay. The rates of complications and side effects associated with ETV are generally limited.

**Conflict of interest:** Authors do not have any conflict of interest to declare.

**Disclosure:** None

**Human/Animal Rights:** No human or animal rights were violated during this study.

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