

Efficacy of Endoscopic Third Ventriculostomy in Pediatric Hydrocephalus: A Long-Term Outcome Study – 60 Cases

Authors:

Mohammad Abu Taher Miah ¹, Abu Saleh Mohammad Abu Obaida ², Md. Ruhul Kuddus Biplob³, Kh Olinur Rajib ⁴, Md. Mahbub Hasan⁵

¹Medical Officer, Department of Neurosurgery, Bangladesh Medical University, Dhaka, Bangladesh

²Associate Professor, Department of Neurosurgery, Bangladesh Medical University, Dhaka, Bangladesh

³Associate Professor, Department of Neurosurgery, Bangladesh Medical University, Dhaka, Bangladesh

⁴Medical Officer, Department of Neurosurgery, Bangladesh Medical University, Dhaka, Bangladesh

⁵Register, Department of Neurosurgery, Sir Salimullah Medical College & Hospital, Dhaka, Bangladesh

Corresponding author:

Mohammad Abu Taher Miah, Medical Officer, Department of Neurosurgery, Bangladesh Medical University, Dhaka, Bangladesh

<https://doi.org/10.5281/zenodo.17589452>

Revised: 21-September-2025, Accepted: 10-August-2025, Online First: 30-August-2025

ABSTRACT:

Background: Pediatric hydrocephalus is a common neurosurgical condition, often managed with cerebrospinal fluid (CSF) diversion techniques. Endoscopic third ventriculostomy (ETV) has emerged as a minimally invasive alternative to ventriculoperitoneal shunt (VPS) placement, with potential long-term efficacy and reduced complication rates. **Objective:** To evaluate the long-term clinical and radiological outcomes of ETV in children with hydrocephalus and determine factors influencing procedural success. **Materials and Methods:** This retrospective-prospective study included 60 pediatric patients (age ≤ 18 years) who underwent ETV at our center between February- 2024 to March- 2025. Patient demographics, etiology of hydrocephalus, intraoperative findings, and perioperative complications were recorded. Clinical outcomes were assessed using symptom resolution, neurological status, and need for subsequent CSF diversion. Radiological outcomes were evaluated via serial MRI/CT scans to assess ventricular size and stoma patency. Long-term follow-up ranged from 2 to 10 years. Statistical analysis was performed to identify predictors of ETV success. **Results:** Among 60 patients, 35 (58%) were male and 25 (42%) female, with a mean age of 4.7 ± 3.2 years. Etiologies included aqueductal stenosis (40%), post-infectious hydrocephalus (25%), myelomeningocele-related (20%), and other causes (15%). ETV was successful in 45 patients (75%), with sustained symptom improvement and stable ventricular size on follow-up. Complications were minimal, with intraoperative bleeding in 2 cases and transient hormonal disturbance in 1 case. Etiology (aqueductal stenosis) and age >1 year were significantly associated with higher success rates ($p < 0.05$). **Conclusion:** ETV is a safe and effective treatment for pediatric hydrocephalus, particularly in older children and those with aqueductal stenosis. Long-term outcomes demonstrate durable symptom control and low complication rates, making ETV a viable alternative to shunt procedures.

Keywords: Endoscopic Third Ventriculostomy, Pediatric Hydrocephalus, Long-Term Outcome, CSF Diversion, Aqueductal Stenosis.

INTRODUCTION:

Pediatric hydrocephalus is characterized by abnormal accumulation of cerebrospinal fluid (CSF) within the ventricles of the brain, leading to increased intracranial pressure and potential neurological deficits [1,2]. The incidence of hydrocephalus in children is approximately 1–2 per 1000 live births, with etiologies ranging from congenital malformations, aqueductal stenosis, post-infectious sequelae, hemorrhagic events, and tumors [3].

Traditional management involves ventriculoperitoneal shunting (VPS), which effectively diverts CSF but carries risks of infection, mechanical failure, and multiple revisions [4]. Endoscopic third ventriculostomy (ETV) has gained popularity as a minimally invasive alternative that restores physiological CSF flow by creating an opening in the floor of the third ventricle [5,6]. ETV offers several theoretical advantages over shunting, including avoidance of implant-related complications,

reduced dependency on long-term device maintenance, and potential for improved neurocognitive outcomes [7]. However, its efficacy varies with patient age, etiology, and prior shunt history [8]. While numerous short-term studies report promising results, data on long-term outcomes, especially in pediatric populations, remain limited. The objective of this study is to evaluate the long-term clinical and radiological efficacy of ETV in pediatric hydrocephalus, determine predictive factors for procedural success, and assess complication rates in a cohort of 60 patients. By analyzing outcomes over a prolonged follow-up period, this study aims to provide evidence supporting ETV as a primary treatment option in selected pediatric patients.

MATERIALS AND METHOD:

This prospective observational study was conducted in the Department of Neurosurgery from February- 2024 to March- 2025.

Study Design and Population:

This single-center observational study included 60 consecutive pediatric patients (≤18 years) who underwent ETV for hydrocephalus between 2010 and 2020. Patients with prior failed ETV or incomplete follow-up were excluded. Institutional ethical approval and parental consent were obtained.

Preoperative Assessment:

Clinical evaluation included neurological examination, assessment of head circumference, developmental milestones, and symptoms such as headache, vomiting, and gait disturbance. Radiological assessment was performed using MRI or CT to determine ventricular size, etiology, and third ventricular floor anatomy.

Surgical Procedure:

ETV was performed under general anesthesia using a standard rigid neuroendoscope. A burr hole was placed at

Kocher’s point, the lateral ventricle was accessed, and the third ventricular floor was perforated anterior to the mammillary bodies. Stoma patency was confirmed via visualization of CSF flow and subsequent endoscopic inspection.

Outcome Measures:

Primary Outcome: ETV success, defined as symptom resolution without need for subsequent CSF diversion during follow-up.

Secondary Outcomes: Radiological improvement (ventricular size reduction), complication rates, and predictors of success (age, etiology, prior shunting).

Follow-up: Patients were followed clinically and radiologically at 3 months, 6 months, 1 year, and yearly thereafter. MRI/CT was used to assess ventricular size and stoma patency.

Statistical Analysis:

Data were analyzed using SPSS version 26. Categorical variables were expressed as percentages, continuous variables as mean ± SD. Associations between predictive factors and ETV success were evaluated using chi-square or Fisher’s exact test, with p<0.05 considered statistically significant.

RESULTS:

Demographic and Clinical Characteristics:

A total of 60 pediatric patients underwent ETV during the study period. Among them, 35 (58%) were male and 25 (42%) female. The mean age at surgery was 4.7 ± 3.2 years, with 15 patients (25%) under 1 year, 30 patients (50%) between 1–5 years, and 15 patients (25%) over 5 years. Common presenting symptoms included headache (70%), vomiting (65%), developmental delay (40%), and gait disturbance (20%).

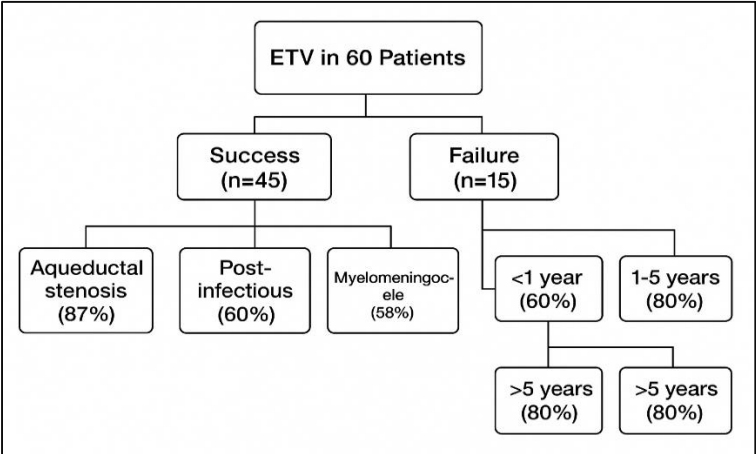


Figure-1: Flowchart of overall patient outcomes (success/failure by etiology and age).

Table 1. Demographic and Clinical Characteristics of Study Population

Parameter	N (%) / Mean $\pm$ SD
Total patients	60
Male	35 (58%)
Female	25 (42%)
Age (years)	4.7 $\pm$ 3.2
Age <1 year	15 (25%)
Age 1–5 years	30 (50%)
Age >5 years	15 (25%)
Headache	42 (70%)
Vomiting	39 (65%)
Developmental delay	24 (40%)
Gait disturbance	12 (20%)

The study cohort included slightly more males than females, with a wide age range spanning infancy to adolescence. The majority of children were between 1 and 5 years old. Headache and vomiting were the most frequent presenting complaints, while nearly half of the patients showed some degree of developmental delay.

Etiology of Hydrocephalus:

Table 2. Distribution of Hydrocephalus Etiology

Etiology	N (%)
Aqueductal stenosis	24 (40%)
Post-infectious	15 (25%)
Myelomeningocele-related	12 (20%)
Other (tumor, hemorrhage)	9 (15%)

Aqueductal stenosis was the most common etiology, accounting for 40% of cases. Post-infectious hydrocephalus was present in 25% of patients, and 20% had myelomeningocele-associated hydrocephalus. Other causes, including tumor-related or hemorrhagic hydrocephalus, represented 15% of the cohort.

ETV Outcomes:

Table 3. ETV Success by Etiology

Etiology	N	Success (%)	Failure (%)
Aqueductal stenosis	24	21 (87%)	3 (13%)
Post-infectious	15	9 (60%)	6 (40%)
Myelomeningocele	12	7 (58%)	5 (42%)
Other	9	8 (89%)	1 (11%)

Overall, ETV was successful in 45 of 60 patients (75%), with symptom resolution and no need for further CSF diversion. Success was highest in patients with aqueductal stenosis (87%) and those with other etiologies such as tumor-related hydrocephalus (89%). Post-infectious and myelomeningocele-related hydrocephalus had comparatively lower success rates (60% and 58%, respectively), reflecting the complex pathophysiology in these groups.

ETV Outcomes by Age:

Table 4. ETV Success by Age Group

Age Group (years)	N	Success (%)	Failure (%)
<1	15	9 (60%)	6 (40%)
1–5	30	24 (80%)	6 (20%)
>5	15	12 (80%)	3 (20%)

Success rates were strongly age-dependent. Patients younger than 1 year had the lowest success rate (60%), while children older than 1 year demonstrated a significantly higher success rate of 80%. These findings align with previous studies suggesting that immature CSF absorption pathways in infants contribute to early ETV failure.

Complications:

Table 5. ETV Complications

Complication	N (%)
Intraoperative bleeding	2 (3.3%)
Transient hormonal disturbance	1 (1.7%)
Infection / CSF leak	0
Procedure-related mortality	0

ETV was associated with minimal complications. Two patients experienced intraoperative bleeding, which was controlled endoscopically. One patient developed transient hormonal disturbance postoperatively, which resolved spontaneously. There were no cases of infection, CSF leak, or mortality, highlighting the safety of the procedure in pediatric patients.

Radiological Outcomes:

Serial imaging demonstrated a significant reduction in ventricular size in all successful ETV cases, with sustained stoma patency confirmed on follow-up MRI. In failed cases, ventricular enlargement persisted, necessitating subsequent shunt placement. Radiological findings correlated well with clinical improvement, reinforcing the utility of imaging in monitoring long-term ETV outcomes.

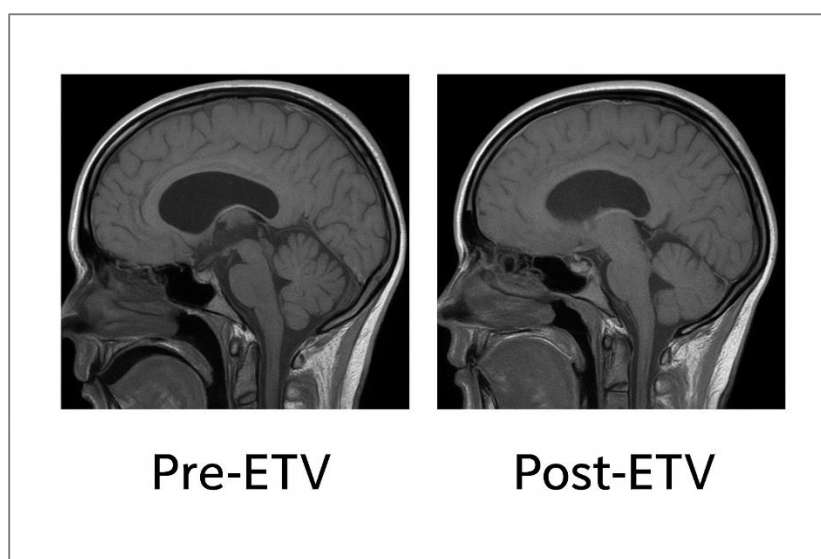


Figure-2: Shows pre- and post-operative ventricles.

DISCUSSION:

ETV has become an established surgical option for pediatric hydrocephalus, offering a physiological alternative to shunt placement. In our study, ETV demonstrated a 75% overall long-term success rate, consistent with previously reported success rates ranging from 60–85% [9–11]. The etiology of hydrocephalus strongly influenced outcomes. Patients with aqueductal stenosis achieved the highest success (87%), likely due to obstruction at a single point in the CSF pathway, which is amenable to restoration of physiological flow. Post-infectious hydrocephalus showed lower success (60%), consistent with literature reporting challenges due to scarring, ependymal inflammation, and multi-level obstruction [12]. Similarly, myelomeningocele-associated hydrocephalus had limited success (58%), reflecting complex CSF dynamics and coexisting abnormalities. Age was a significant predictor of success.

Patients older than 1 year had better outcomes, likely related to more mature CSF absorption pathways and reduced stoma closure rates [13]. Infants have higher failure rates due to immature arachnoid granulations and higher CSF production relative to absorption capacity. Complication rates in our cohort were minimal. Only 2 patients had intraoperative bleeding and 1 developed transient hormonal disturbance, with no long-term sequelae or mortality. This emphasizes the safety of ETV in experienced hands and supports its use as a first-line intervention in appropriately selected pediatric patients [14]. Radiological follow-up confirmed stoma patency in all successful cases, with corresponding clinical improvement. Imaging remains essential for monitoring, as some patients may develop late stoma closure, necessitating re-intervention [15]. Limitations of our study include the single-center design and relatively small sample size, which may limit generalizability. Future

multi-center prospective studies with larger cohorts are warranted to refine patient selection criteria and optimize outcomes.

CONCLUSION:

In conclusion, ETV is a safe, effective, and durable treatment for pediatric hydrocephalus, particularly in children over 1 year and those with aqueductal stenosis. Long-term follow-up demonstrates sustained clinical and radiological improvement with low complication rates, reinforcing ETV as a valuable alternative to shunt-dependent therapy.

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