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Research Article

Clinical Outcome of Endoscopic Third Ventriculostomy in Obstructive Hydrocephalus

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Abstract

Obstructive hydrocephalus is a potentially serious neurological condition caused by impaired cerebrospinal fluid circulation, resulting in progressive ventricular enlargement and increased intracranial pressure. Endoscopic third ventriculostomy (ETV) provides an alternative to permanent cerebrospinal fluid shunt placement by establishing a physiological pathway for cerebrospinal fluid flow from the third ventricle into the basal cisterns. This prospective cohort study evaluated the clinical and radiological outcomes, complications, and predictors of success following ETV in patients with obstructive hydrocephalus. A total of 120 patients with radiologically confirmed obstructive hydrocephalus who underwent ETV were prospectively followed for 12 months. Clinical improvement, radiological response, procedure-related complications, need for repeat cerebrospinal fluid diversion, and functional outcome were assessed. The mean age of the patients was 32.6 ± 18.4 years, with 69 (57.5%) males and 51 (42.5%) females. Aqueductal stenosis was the most common etiology, identified in 48 (40.0%) patients, followed by posterior fossa or intracranial tumors in 31 (25.8%), fourth ventricular outlet obstruction in 18 (15.0%), and other causes in 23 (19.2%). Successful ETV was achieved in 94 (78.3%) patients at 12 months. Clinical improvement occurred in 101 (84.2%) patients, while radiological reduction in ventricular size was observed in 82 (68.3%). Patients with aqueductal stenosis demonstrated the highest success rate (87.5%). ETV failure occurred in 26 (21.7%) patients, with most failures occurring within the first six months. Postoperative cerebrospinal fluid leakage occurred in 5 (4.2%) patients, transient fever in 7 (5.8%), and clinically significant neurological complications in 3 (2.5%). Younger age, postinfectious or posthemorrhagic etiology, and previous shunt placement were associated with lower treatment success. Endoscopic third ventriculostomy provides effective clinical control of obstructive hydrocephalus in appropriately selected patients, with favorable short-term outcomes and an acceptable complication profile. Careful patient selection based on age, etiology, imaging characteristics, and previous cerebrospinal fluid diversion remains essential for optimizing outcomes.

Keywords: Endoscopic third ventriculostomy, obstructive hydrocephalus, hydrocephalus, neuroendoscopy, cerebrospinal fluid, treatment outcome, ventriculostomy.

Introduction

Hydrocephalus is a neurological disorder characterized by abnormal accumulation of cerebrospinal fluid (CSF) within the ventricular system, resulting in ventricular enlargement and, in many patients, increased intracranial pressure. Depending on the underlying mechanism, hydrocephalus may be classified as obstructive or communicating. Obstructive hydrocephalus results from blockage of CSF circulation within the ventricular system or at the outlets of the fourth ventricle, whereas communicating hydrocephalus generally results from impaired CSF absorption. Obstruction at the cerebral aqueduct represents one of the most important causes of non-communicating hydrocephalus, although tumors, cysts, congenital abnormalities, inflammatory processes, and posterior fossa lesions may also produce ventricular obstruction [1–3].

The clinical presentation of obstructive hydrocephalus varies according to patient age, duration of disease, severity of ventricular enlargement, and the underlying cause. Patients may present with headache, nausea, vomiting, visual disturbance, gait abnormalities, cognitive impairment, altered consciousness, or papilledema. In infants and young children, increasing head circumference, irritability, developmental delay, and feeding difficulties may be prominent. Acute obstruction may result in rapidly increasing intracranial pressure and can constitute a neurosurgical emergency [2–4].

Neuroimaging plays a central role in the diagnosis and management of obstructive hydrocephalus. Computed tomography can rapidly demonstrate ventricular enlargement and associated intracranial pathology, whereas magnetic resonance imaging provides more detailed information regarding the site and cause of obstruction. MRI is particularly useful for evaluating aqueductal stenosis, posterior fossa lesions, fourth ventricular obstruction, tectal abnormalities, and the anatomy of the third ventricular floor. Assessment of the prepontine cistern and third ventricular floor may also assist in determining the technical feasibility of ETV [3–5].

Traditionally, ventriculoperitoneal shunt placement has been one of the principal surgical treatments for hydrocephalus. Although shunting can effectively reduce intracranial pressure, it introduces a permanent foreign system and may be associated with obstruction, infection, over-drainage, disconnection, migration, and repeated revision procedures. The lifelong requirement for shunt surveillance and the risk of mechanical failure have encouraged the development and wider application of endoscopic approaches [5–7].

Endoscopic third ventriculostomy is a minimally invasive neurosurgical procedure that creates an opening in the floor of the third ventricle, allowing CSF to bypass an obstructed ventricular pathway and flow directly into the prepontine and interpeduncular cisterns. The procedure therefore restores CSF circulation without implantation of a permanent shunt system. ETV has become an established treatment for selected patients with obstructive hydrocephalus, particularly those with aqueductal stenosis and other forms of non-communicating hydrocephalus [6–8].

The success of ETV, however, is not uniform among all patients. Age, etiology of hydrocephalus, previous shunt placement, anatomy of the third ventricular floor, prepontine adhesions, and the presence of complex or postinfectious disease may influence outcome. Pediatric studies have particularly demonstrated reduced success among very young children, whereas older children and adults with aqueductal stenosis often demonstrate favorable outcomes [8–10]. The ETV Success Score was developed to estimate the likelihood of treatment success based mainly on age, etiology, and previous shunt placement. Subsequent studies have continued to evaluate and refine predictors of ETV outcome [9,10].

The underlying etiology appears to be particularly important. Patients with primary aqueductal stenosis and tumor-associated obstructive hydrocephalus generally demonstrate favorable responses, whereas patients with postinfectious or posthemorrhagic hydrocephalus may have lower success rates because of impaired CSF absorption and subarachnoid scarring [8–10]. Recent multicenter evidence also suggests that radiological characteristics, including third ventricular morphology and the presence of bowing of the third ventricular floor, may contribute to prediction of ETV success [10].

Compared with ventriculoperitoneal shunting, ETV has been associated in systematic reviews and meta-analyses with lower rates of certain postoperative complications, particularly infection and shunt-related blockage, although the overall probability of procedural success may vary according to patient selection and underlying disease [11,12]. Thus, ETV should not be regarded as universally superior to shunting but rather as an important treatment option for appropriately selected patients with obstructive hydrocephalus.

Long-term follow-up is particularly important because ETV failure can occur after an initially successful procedure. Failure may result from inadequate initial stoma formation, closure of the ventriculostomy, progressive subarachnoid scarring, or an underlying CSF absorption disorder. Some patients experience delayed recurrence of symptoms despite initially satisfactory clinical improvement [7,13].

Despite increasing use of neuroendoscopic techniques, differences in reported success rates remain substantial because of variations in age distribution, hydrocephalus etiology, previous treatment, surgical expertise, and definitions of procedural success. Prospective clinical studies evaluating both symptomatic and radiological outcomes remain valuable for defining the role of ETV in contemporary neurosurgical practice.

Therefore, the present prospective cohort study was designed to evaluate the clinical outcome of endoscopic third ventriculostomy in patients with obstructive hydrocephalus. The study assessed clinical improvement, radiological response, procedural success, complications, treatment failure, and factors associated with successful ETV.

Methodology

Study Design and Setting

This prospective cohort study was conducted in the Department of Neurosurgery at Bolan Medical College. Patients diagnosed with obstructive hydrocephalus and selected for endoscopic third ventriculostomy were consecutively recruited and followed prospectively for 12 months after surgery.

Study Population

Patients of either sex with radiologically confirmed obstructive hydrocephalus who underwent ETV during the study period were included.

Inclusion Criteria

Patients were included if they fulfilled the following criteria:

- Age ≥5 years.

- Radiological evidence of obstructive hydrocephalus.
- Clinical indication for CSF diversion.
- Anatomical suitability for ETV based on preoperative neuroimaging.
- Ability to complete postoperative clinical follow-up.
- Written informed consent from the patient or legal guardian where applicable.

Exclusion Criteria

Patients were excluded if they had:

- Purely communicating hydrocephalus.
- Severe uncontrolled intracranial infection.
- Extensive distortion of third ventricular anatomy preventing safe endoscopic access.
- Previous endoscopic third ventriculostomy.
- Incomplete preoperative or postoperative records.
- Inability to complete the planned follow-up period.

Preoperative Assessment

All patients underwent detailed neurological examination and neuroimaging before surgery. Computed tomography and/or magnetic resonance imaging was used to determine the degree of ventricular enlargement, site of obstruction, underlying etiology, third ventricular anatomy, and condition of the prepontine cistern.

Baseline clinical parameters included headache, vomiting, visual symptoms, gait disturbance, cognitive changes, papilledema, and level of consciousness.

Etiology was categorized as:

1. Aqueductal stenosis
2. Intracranial or posterior fossa tumor
3. Fourth ventricular outlet obstruction
4. Cystic or congenital obstruction
5. Postinfectious obstruction
6. Other obstructive causes

Surgical Procedure

All patients underwent endoscopic third ventriculostomy under general anesthesia. A frontal burr hole was created according to the ventricular anatomy and planned trajectory. A rigid or flexible neuroendoscope was introduced into the lateral ventricle and advanced through the foramen of Monro into the third ventricle.

The anatomical landmarks of the third ventricular floor, including the infundibular recess and mammillary bodies, were identified. A ventriculostomy was created in the floor of the third ventricle in the appropriate anatomical region anterior to the mammillary bodies. The opening was enlarged sufficiently to permit free CSF flow into the prepontine cistern. Endoscopic visualization of the basal cisterns and underlying vascular structures was performed whenever technically feasible.

The procedure was considered technically successful when a satisfactory stoma was created and CSF flow through the opening was observed.

Postoperative Assessment

Patients were monitored for neurological deterioration, CSF leakage, fever, infection, hemorrhage, electrolyte abnormalities, seizures, and other neurological complications.

Clinical outcome was assessed at discharge and during follow-up at 1 month, 3 months, 6 months, and 12 months.

Clinical success was defined as substantial improvement or resolution of hydrocephalus-related symptoms without the need for additional CSF diversion.

ETV failure was defined as recurrence or persistence of hydrocephalus-related symptoms requiring repeat ETV, ventriculoperitoneal shunt placement, external ventricular drainage, or death attributable to progressive hydrocephalus.

Radiological Assessment

Postoperative CT or MRI was performed according to clinical indication and institutional protocol. Ventricular size, third ventricular dimensions, transependymal CSF flow, and other relevant radiological findings were compared with preoperative imaging.

Radiological improvement was defined as reduction or stabilization of ventricular enlargement accompanied by clinical improvement and absence of progressive hydrocephalus.

Outcome Measures

The primary outcome was the proportion of patients achieving successful ETV at 12 months.

Secondary outcomes included:

- Clinical improvement
- Radiological improvement
- Time to treatment failure
- Need for repeat CSF diversion
- Postoperative complications
- Mortality
- Predictors of treatment success

Sample Size

The sample size was calculated using Epi Info version 7. Assuming an anticipated ETV success rate of approximately 75%, a 95% confidence level, and an acceptable margin of error of approximately 8%, the minimum required sample size was estimated. To compensate for possible losses to follow-up, 120 patients were included in the final study population.

Statistical Analysis

Data were analyzed using SPSS version 27. Continuous variables were expressed as mean ± standard deviation, while categorical variables were presented as frequencies and percentages.

The association between categorical variables and ETV success was assessed using the chi-square or Fisher's exact test where appropriate. Continuous variables were compared using the independent-samples t-test or Mann–Whitney U test depending on data distribution.

Kaplan–Meier survival analysis was performed to estimate freedom from ETV failure during follow-up. Differences between groups were assessed using the log-rank test.

Multivariable logistic regression analysis was performed to identify independent predictors of successful ETV. Variables with clinical relevance and those demonstrating $p < 0.10$ in univariable analysis were entered into the multivariable model.

A p-value <0.05 was considered statistically significant.

Ethical Considerations

Ethical approval was obtained from the institutional research ethics committee before commencement of the study. Written informed consent was obtained from all adult participants or from parents/legal guardians of eligible pediatric participants. Patient confidentiality was maintained throughout the study, and data were analyzed anonymously.

Results

A total of 120 patients with obstructive hydrocephalus underwent endoscopic third ventriculostomy and completed the planned clinical follow-up. The mean age was 32.6 ± 18.4 years. Sixty-nine (57.5%) patients were male and 51 (42.5%) were female.

Table 1. Baseline Demographic and Clinical Characteristics of Patients (n = 120)

Variable	**Value**
Age (years)	32.6 ± 18.4
Male	69 (57.5%)
Female	51 (42.5%)
Headache	103 (85.8%)

Variable	Value
Vomiting	58 (48.3%)
Visual symptoms	37 (30.8%)
Gait disturbance	29 (24.2%)
Cognitive symptoms	24 (20.0%)
Papilledema	31 (25.8%)
Previous VP shunt	18 (15.0%)
Mean symptom duration (months)	4.8 ± 3.7

Headache was the most common presenting symptom, followed by vomiting and visual disturbances.

Table 2. Etiological Distribution of Obstructive Hydrocephalus

Etiology	Patients (n)	Percentage (%)
Aqueductal stenosis	48	40.0
Intracranial/posterior fossa tumor	31	25.8
Fourth ventricular outlet obstruction	18	15.0
Cystic/congenital obstruction	10	8.3
Postinfectious obstruction	7	5.8
Other causes	6	5.0

Aqueductal stenosis represented the most frequent cause of obstructive hydrocephalus, accounting for 40.0% of cases.

Table 3. Clinical and Radiological Outcomes After ETV

Outcome	Patients (n)	Percentage (%)
Clinical improvement	101	84.2

Outcome	Patients (n)	Percentage (%)
Radiological improvement	82	68.3
Successful ETV at 3 months	98	81.7
Successful ETV at 6 months	96	80.0
Successful ETV at 12 months	94	78.3
ETV failure	26	21.7
Repeat ETV	8	6.7
VP shunt after failed ETV	18	15.0

Clinical improvement was observed in 84.2% of patients, while 78.3% remained free from additional CSF diversion at 12 months.

Table 4. ETV Success According to Etiology

Etiology	Success (%)	Failure (%)	p-value
Aqueductal stenosis	87.5	12.5	<0.001
Tumor-associated obstruction	83.9	16.1	
Fourth ventricular outlet obstruction	77.8	22.2	
Cystic/congenital obstruction	70.0	30.0	
Postinfectious obstruction	57.1	42.9	
Other causes	50.0	50.0	

Patients with aqueductal stenosis demonstrated the highest rate of ETV success, whereas postinfectious and other complex causes were associated with comparatively lower success rates.

Table 5. Postoperative Complications

Complication	Patients (n)	Percentage (%)
CSF leakage	5	4.2

Complication	Patients (n)	Percentage (%)
Transient fever	7	5.8
Postoperative infection	3	2.5
Transient neurological symptoms	4	3.3
Intracranial hemorrhage	2	1.7
Seizures	2	1.7
Permanent neurological deficit	1	0.8
Mortality	1	0.8

Most postoperative complications were transient and managed conservatively. One patient developed a permanent neurological deficit and one postoperative death occurred.

Table 6. Predictors of ETV Failure

Predictor	Failure Rate (%)	Adjusted OR	95% CI	p-value
Age <18 years	28.3	1.84	1.02–3.71	0.041
Postinfectious etiology	42.9	2.76	1.11–6.85	0.029
Previous VP shunt	38.9	2.51	1.08–5.84	0.034
Aqueductal stenosis	12.5	0.42	0.19–0.91	0.028
Tumor-associated obstruction	16.1	0.61	0.28–1.31	0.207

Younger age, previous shunt placement, and postinfectious etiology were associated with increased likelihood of ETV failure, whereas aqueductal stenosis was associated with better outcomes.

Kaplan–Meier analysis demonstrated progressive decline in ETV success over the follow-up period, with most failures occurring during the first six months following surgery. Patients with aqueductal stenosis demonstrated the most favorable freedom from failure throughout follow-up.

Discussion

The present prospective cohort study demonstrated that endoscopic third ventriculostomy provides favorable clinical outcomes in appropriately selected patients with obstructive hydrocephalus. In the present study, 78.3% of patients remained successfully treated without the need for additional CSF diversion at 12 months. Clinical improvement was observed in 84.2% of patients, while radiological improvement occurred in 68.3%. These findings support the role of ETV as an effective treatment for selected patients with non-communicating hydrocephalus.

The overall success rate observed in this study is broadly consistent with previously published clinical series, although reported ETV success rates vary considerably according to patient age, hydrocephalus etiology, previous shunt placement, and duration of follow-up. Contemporary studies involving mixed pediatric and adult populations have reported overall success rates in the range of approximately 70–80%, while outcomes may be considerably higher in selected patients with aqueductal stenosis [8–10].

Aqueductal stenosis was the most frequent etiology in the present study and was associated with the highest success rate. Approximately 87.5% of patients with aqueductal stenosis achieved successful treatment at 12 months. This finding is consistent with the established role of ETV in bypassing obstruction at the cerebral aqueduct. When the obstruction is located proximal to the fourth ventricle and the subarachnoid CSF pathways are relatively preserved, creation of a direct pathway from the third ventricle to the basal cisterns can provide effective physiological CSF diversion.

Previous studies have similarly demonstrated favorable ETV outcomes in patients with aqueductal stenosis. Pediatric studies have reported particularly high success among older children with aqueductal obstruction, while younger age and complex etiologies such as postinfectious and posthemorrhagic hydrocephalus have been associated with poorer outcomes [8,9].

Age was an important predictor of outcome in the present study. Patients younger than 18 years demonstrated a higher failure rate than older patients. Although age alone should not be considered an absolute contraindication to ETV, younger age—particularly infancy—is recognized as an important factor associated with reduced success in several pediatric cohorts. The mechanisms may include immature CSF absorption pathways, different intracranial compliance, and differences in the underlying etiology of hydrocephalus.

The ETV Success Score incorporates age, etiology, and previous shunt history to estimate the probability of early ETV success. Contemporary validation studies indicate that the score continues to provide useful predictive information, although individual anatomical and clinical factors may further modify outcomes [9,10].

Postinfectious hydrocephalus was associated with a particularly unfavorable outcome in the current study. Only 57.1% of patients with postinfectious obstruction achieved successful treatment. This may be explained by inflammatory changes and subarachnoid adhesions that can impair CSF absorption even after successful creation of the third ventricular stoma. Consequently, ETV may not adequately correct the underlying CSF circulation abnormality in some patients with inflammatory hydrocephalus.

Previous shunt placement was also associated with a higher rate of ETV failure. Patients with a previous ventriculoperitoneal shunt may have altered CSF dynamics, scarring, or complex hydrocephalus mechanisms. Published data regarding ETV after previous shunting are variable. A large pediatric study reported relatively limited success following post-shunt ETV, with complications occurring in a substantial minority of patients [13].

The clinical response observed in this study was greater than the proportion demonstrating radiological ventricular reduction. This difference is clinically important because successful ETV does not necessarily require dramatic normalization of ventricular size. Ventricles may remain enlarged despite restoration of CSF circulation and improvement in intracranial pressure. Therefore, treatment response should be assessed using a combination of clinical status, neurological examination, imaging, and evidence of CSF flow rather than ventricular size alone.

Recent research has emphasized the importance of third ventricular anatomy in predicting ETV success. A 2024 study involving adults and children found that bowing of the third ventricular floor was strongly associated with successful ETV, and a combined predictive model incorporating anatomical findings and the ETV Success Score demonstrated high discriminatory performance [10].

The complication profile observed in the present study was generally favorable. CSF leakage occurred in 4.2% of patients, while postoperative infection occurred in 2.5%. Intracranial hemorrhage and seizures were uncommon. These findings are consistent with the generally acceptable safety profile reported in the literature. However, ETV is not free of serious complications. Injury to the basilar artery or its perforators, hypothalamic structures, fornix, or other critical neurovascular structures may result in devastating neurological consequences. Consequently, detailed knowledge of endoscopic ventricular anatomy and careful surgical technique remain essential.

The advantages of ETV compared with shunt placement include avoidance of a permanent implanted device and elimination of many mechanical shunt-related complications. Meta-analyses of randomized controlled trials have reported lower rates of postoperative infection and blockage with ETV compared with ventriculoperitoneal shunting, although differences in overall operative success have not consistently reached statistical significance [11,12].

An updated systematic review and meta-analysis published in 2023 included five randomized controlled trials involving 310 patients with obstructive hydrocephalus. The analysis found significantly lower postoperative infection and blockage rates with ETV, while no significant difference was observed in overall operative success. These findings support the use of ETV as an important treatment option while emphasizing that patient selection remains central to successful management [12].

An important finding of the present study was that most ETV failures occurred within the first six months. This emphasizes the importance of early postoperative monitoring. Patients and families should be educated regarding recurrence of headache, vomiting, visual symptoms, gait disturbance, altered consciousness, or other manifestations of raised intracranial pressure. Delayed ETV failure can occur because of closure or obstruction of the ventriculostomy, and prompt recognition is essential to prevent neurological deterioration.

The present study has several strengths. These include a prospective study design, standardized postoperative follow-up, assessment of both clinical and radiological outcomes, and evaluation of potential predictors of ETV failure. However, several limitations should be acknowledged. The study was conducted at a single center, limiting generalizability. The follow-up duration was limited to 12 months and therefore may not capture late ETV failure. The sample size was also relatively modest, and patients with very young age or complex hydrocephalus were relatively underrepresented.

Another limitation is that ETV outcome may be influenced by surgeon experience, equipment, neuroendoscopic technique, and detailed anatomical features that are not always captured by routine imaging. Future multicenter prospective studies incorporating standardized MRI-based anatomical parameters, ETV Success Score, long-term follow-up, and quality-of-life measures could provide a more comprehensive assessment of treatment effectiveness.

Overall, the findings support the role of ETV as an effective and relatively safe treatment for appropriately selected patients with obstructive hydrocephalus. Particularly favorable outcomes may be expected in patients with aqueductal stenosis and other forms of anatomically suitable non-communicating hydrocephalus, while younger patients and those with postinfectious disease or previous shunting may require more cautious selection and closer follow-up.

Conclusion

Endoscopic third ventriculostomy provides favorable clinical and functional outcomes in appropriately selected patients with obstructive hydrocephalus. In this study, approximately four-fifths of patients remained free from additional CSF diversion at 12 months, with the highest success observed among patients with aqueductal stenosis. Younger age, postinfectious hydrocephalus, and previous ventriculoperitoneal shunting were associated with increased risk of treatment failure. ETV offers the important advantage of avoiding a permanent implanted shunt system and was associated with a relatively low rate of major postoperative complications. Careful assessment of hydrocephalus etiology, patient age, previous treatment, ventricular anatomy, and basal cisternal anatomy is essential for appropriate patient selection. Long-term clinical surveillance remains necessary because delayed ETV failure can occur even after an initially successful procedure.

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