

## CLINICAL FACTORS INFLUENCING OUTCOMES AFTER ETV IN HYDROCEPHALUS

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### ABSTRACT

**Background:** Endoscopic third ventriculostomy (ETV) is an established treatment modality for hydrocephalus, particularly in obstructive forms. However, prediction of postoperative ETV success remains challenging, especially during the early postoperative period. Clinical and radiological parameters often fail to reliably identify early ETV failure. Postoperative intracranial pressure (ICP) monitoring may provide useful information regarding ETV function and outcome prediction. **Objectives:** To analyze clinico-demographic and etiological predictors influencing ETV outcome, compare outcomes between obstructive and communicating hydrocephalus, evaluate the effect of cerebrospinal fluid (CSF) characteristics and age on ETV success, and assess postoperative complications and ICP trends in relation to ETV outcome. **Materials and Methods:** This prospective observational study was conducted in the Department of Neurosurgery, King George's Medical University, Lucknow, from January 2016 to July 2016. Forty-five patients undergoing ETV for hydrocephalus were enrolled, of whom 41 completed follow-up. Postoperative ICP monitoring was performed for 3 days using an external ventricular drain connected to a pressure transducer. Daily average ICP values were used to derive ICP trends. Patients were followed for 3 months, and ETV outcome was classified as successful or failed based on clinical improvement and requirement of repeat CSF diversion procedure. **Results:** Successful ETV outcome was observed in 24 patients (58.5%), while 17 patients (41.5%) had ETV failure. Obstructive hydrocephalus demonstrated higher success rates compared with communicating hydrocephalus (65.5% vs. 41.7%), although the difference was not statistically significant ( $p=0.158$ ). Age, gender, etiology, and CSF characteristics were not significantly associated with ETV outcome. Progressive decrease and stable ICP trends were significantly associated with successful ETV outcome, whereas progressive increase trend strongly correlated with ETV failure ( $p<0.001$ ). Absolute ICP values did not significantly correlate with outcome. Common postoperative complications included CSF leak (24.4%) and meningitis (22.0%). **Conclusion:** Postoperative ICP trends correlate significantly with ETV outcome and may serve as a useful adjunct for early prediction of ETV success or failure. ICP trend monitoring may aid in identifying patients at risk of ETV failure during the early postoperative period.

## INTRODUCTION

Endoscopic third ventriculostomy (ETV) has become an established surgical modality for the treatment of hydrocephalus, particularly in obstructive forms, by restoring physiological cerebrospinal fluid (CSF) circulation without dependence on shunt hardware.<sup>[1]</sup>

<sup>4]</sup> Compared with ventriculoperitoneal shunting, ETV avoids long-term shunt-related complications such as infection, obstruction, over drainage, and repeated revisions.<sup>[4]</sup> Consequently, ETV is increasingly preferred in both pediatric and adult patients with hydrocephalus.

Despite widespread acceptance, the success rate of ETV remains variable, ranging from 50% to 90%, depending on patient age, etiology, prior shunt status, and CSF pathway dynamics.<sup>[1-5]</sup> Obstructive hydrocephalus, particularly aqueductal stenosis, has consistently demonstrated favorable outcomes following ETV.<sup>[3,6]</sup> In contrast, communicating hydrocephalus, postinfectious hydrocephalus, and hemorrhagic CSF states have been associated with poorer outcomes due to impaired CSF absorption and arachnoidal scarring.<sup>[7,8]</sup> Age has also been considered an important predictor of ETV outcome, with younger infants traditionally reported to have lower success rates owing to immature CSF absorptive pathways and increased tendency for stoma closure.<sup>[5,9]</sup> However, more recent studies suggest that age alone may not independently predict ETV failure.<sup>[10]</sup>

Prediction of postoperative ETV function remains challenging. Clinical improvement may be delayed, and reduction in ventricular size is frequently minimal or absent during the early postoperative period.<sup>[11,12]</sup> Conventional imaging modalities such as computed tomography and magnetic resonance imaging therefore have limited utility in accurately predicting early ETV success.<sup>[11]</sup> Various methods including cine phase-contrast magnetic resonance imaging and ETV Success Score systems have been proposed to predict ETV outcomes; however, their predictive accuracy remains inconsistent.<sup>[13]</sup>

Postoperative intracranial pressure (ICP) monitoring has recently gained attention as a potential method for assessing ETV function and identifying early treatment failure.<sup>[14-18]</sup> Previous studies have demonstrated that ICP trends following ETV may correlate with restoration of CSF pathways and long-term clinical outcomes.<sup>[15-18]</sup> Progressive reduction or stabilization of ICP has been associated with successful ETV, whereas persistently elevated ICP may indicate treatment failure.<sup>[15,16]</sup>

The present study was conducted to analyze clinico-demographic and etiological predictors influencing ETV outcome, compare outcomes between obstructive and communicating hydrocephalus, evaluate the effect of CSF characteristics and age on ETV success, and assess the relationship between postoperative ICP trends and final clinical outcome following ETV.

## MATERIALS AND METHODS

This prospective observational study was conducted in the Department of Neurosurgery, King George's Medical University, Lucknow, between January 2016 and July 2016. The study included all patients undergoing endoscopic third ventriculostomy (ETV) for hydrocephalus of various etiologies during the study period. Patients older than 70 years of age, those unwilling to participate in the study, and patients in whom ETV could not be completed successfully were excluded. A total of 45 patients

fulfilled the inclusion criteria and were enrolled in the study.

Detailed clinical evaluation and radiological assessment were performed in all patients before surgery. The demographic profile, etiology of hydrocephalus, type of hydrocephalus, and cerebrospinal fluid (CSF) characteristics were recorded. Hydrocephalus was categorized as obstructive or communicating based on clinical and radiological findings.

ETV was performed using standard endoscopic neurosurgical techniques under general anesthesia. At the end of the procedure, an external ventricular drain (EVD) was placed through the same burr hole into the ventricle under strict aseptic precautions for postoperative intracranial pressure (ICP) monitoring. The EVD was connected to a pressure transducer and bedside monitor (PHILIPS IntelliVue MP40). ICP values were recorded every 30 minutes for the first 3 postoperative days.

For analysis, 48 ICP recordings obtained each day were averaged to calculate the daily average value (DAV). To assess fluctuations in ICP more reliably, the averages of the five highest and five lowest ICP values recorded each day were also calculated and designated as high daily average value (HDAV) and low daily average value (LDAV), respectively.

Based on the daily average ICP values from postoperative day 1 to day 3, five ICP trends were identified: progressive increase, progressive decrease, stable trend, increase followed by decrease, and decrease followed by increase. Progressive increase was defined as continuously increasing DAV from day 1 to day 3, whereas progressive decrease represented continuously decreasing DAV during the same period. Stable trend was defined as variation within 1 mmHg between the daily averages. Increase followed by decrease and decrease followed by increase trends were defined according to the sequential change in DAV over the three postoperative days.

Computed tomography (CT) of the head was performed at discharge and whenever patients developed features suggestive of raised ICP or clinical deterioration. Lumbar puncture or CSF drainage through the EVD was performed in selected symptomatic patients at the discretion of the operating surgeon. The ICP monitoring system was removed after 3 days or earlier if additional CSF diversion procedures were required.

Patients were followed for 3 months after surgery with clinical assessment at 15 days and at 3 months. Follow-up evaluation included assessment of symptoms and signs of raised intracranial pressure and radiological imaging with CT head at the final follow-up visit. ETV failure was defined as persistence or recurrence of symptoms requiring repeat CSF diversion procedure, including repeat ETV or ventriculoperitoneal shunt placement.

Data were entered into Microsoft Excel and analyzed using SPSS version 22.0 (IBM SPSS Statistics, Somers, NY, USA). variables were expressed as

mean  $\pm$  standard deviation, whereas categorical variables were expressed as frequency and percentage. Associations between categorical variables were analyzed using the Chi-square test. Comparison of continuous variables between groups was performed using independent samples t-test. A p value of less than 0.05 was considered statistically significant.

## RESULTS

A total of 45 patients underwent endoscopic third ventriculostomy (ETV) during the study period. Four patients were lost to follow-up and excluded from the final outcome analysis. Therefore, 41 patients were included in the final analysis. Successful ETV outcome was observed in 24 patients (58.5%), while 17 patients (41.5%) were classified as ETV failures. The majority of patients belonged to the pediatric age group, with 21 patients (51.2%) aged less than 1 year. ETV success was observed in 11/21 (52.4%) infants, 9/14 (64.3%) patients aged 1–18 years, and 4/6 (66.7%) adults. However, age group did not show a statistically significant association with ETV outcome ( $p=0.711$ ). Similarly, no significant association was observed between gender and ETV outcome ( $p=0.288$ ). Male patients constituted 25/41 (61.0%) of the study population, among whom 13 (52.0%) had successful outcomes, whereas 11/16 (68.8%) female patients had successful outcomes. [Table 1]

Obstructive hydrocephalus was present in 29 patients (70.7%), while 12 patients (29.3%) had communicating hydrocephalus. Successful ETV outcome was achieved in 19/29 (65.5%) patients with obstructive hydrocephalus compared to 5/12 (41.7%) patients with communicating hydrocephalus; however, this difference did not reach statistical significance ( $p=0.158$ ). Etiologically, aqueductal stenosis (31.7%) and tubercular meningitis-related hydrocephalus (19.5%) were the most common diagnoses. No statistically significant association was

found between etiology and ETV outcome ( $p=0.413$ ). [Table 1]

CSF characteristics were also analyzed in relation to ETV outcome. Clear CSF was observed in 34 patients, of whom 21 (61.8%) had successful outcomes. Hemorrhagic/xanthochromic CSF was present in 7 patients, among whom 3 (42.9%) had successful outcomes. Although success rates were higher in patients with clear CSF, the association was not statistically significant ( $p=0.735$ ). [Table 2]

Five postoperative intracranial pressure (ICP) trends were identified during the first 3 postoperative days: progressive decrease, stable, progressive increase, increase followed by decrease, and decrease followed by increase. Progressive decrease trend was observed in 14 patients, of whom 12 (85.7%) had successful outcomes. Stable trend was noted in 11 patients, with successful outcomes in 9 (81.8%). In contrast, progressive increase trend was observed in 12 patients, of whom 11 (91.7%) were ETV failures. There was a statistically significant association between ICP trend and final ETV outcome ( $p<0.001$ ). [Table 3]

Combined progressive decrease/stable ICP trends demonstrated a sensitivity of 84.0%, specificity of 81.3%, positive predictive value of 87.5%, and negative predictive value of 76.5% for predicting successful ETV outcome. Progressive increase trend demonstrated a sensitivity of 91.7%, specificity of 79.3%, positive predictive value of 64.7%, and negative predictive value of 95.8% for predicting ETV failure. [Table 3]

Analysis of absolute ICP measurements, including daily average values (DAV), high daily average values (HDAV), and low daily average values (LDAV), did not demonstrate any statistically significant association with final ETV outcome.

Postoperative complications included CSF leak in 10 patients (24.4%), meningitis in 9 patients (22.0%), subdural hygroma in 3 patients (7.3%), and wound infection in 1 patient (2.4%). Three patients (7.3%) died during follow-up, and all deaths were associated with CSF leak and meningitis requiring prolonged external ventricular drainage. [Table 4]

**Table 1: Baseline clinico-demographic and etiological factors associated with ETV outcome**

Variable	Total (n=41)	Successful ETV (n=24)	Failed ETV (n=17)	p value
<b>Age group</b>				0.711
<1 year	21	11 (52.4%)	10 (47.6%)	
1–18 years	14	9 (64.3%)	5 (35.7%)	
>18 years	6	4 (66.7%)	2 (33.3%)	
<b>Gender</b>				0.288
Male	25	13 (52.0%)	12 (48.0%)	
Female	16	11 (68.8%)	5 (31.2%)	
<b>Hydrocephalus type</b>				0.158
Obstructive	29	19 (65.5%)	10 (34.5%)	
Communicating	12	5 (41.7%)	7 (58.3%)	
<b>Etiology</b>				0.413
Aqueductal stenosis	13	6 (46.2%)	7 (53.8%)	
Tubercular meningitis	8	2 (25.0%)	6 (75.0%)	
Shunt malfunction	5	3 (60.0%)	2 (40.0%)	
Third ventricular lesions	3	3 (100%)	0	
Other etiologies	12	10 (83.3%)	2 (16.7%)	

Chi-square test.

**Table 2: CSF characteristics and hydrocephalus subtype in relation to ETV outcome**

	Variable	Successful ETV (n=24)	Failed ETV (n=17)	p value
CSF characteristics	Clear CSF	21 (61.8%)	13 (38.2%)	0.735
	Hemorrhagic/xanthochromic CSF	3 (42.9%)	4 (57.1%)	
Hydrocephalus subtype	Obstructive hydrocephalus	19 (65.5%)	10 (34.5%)	0.158
	Communicating hydrocephalus	5 (41.7%)	7 (58.3%)	

Chi-square test.

**Table 3: Association of postoperative ICP trends with ETV outcome and diagnostic performance****A. ICP trends and ETV outcome**

ICP trend	Total (n=41)	Successful ETV (n=24)	Failed ETV (n=17)	p value
Progressive decrease	14	12 (85.7%)	2 (14.3%)	<0.001*
Stable	11	9 (81.8%)	2 (18.2%)	
Progressive increase	12	1 (8.3%)	11 (91.7%)	
Increase followed by decrease	3	1 (33.3%)	2 (66.7%)	
Decrease followed by increase	1	1 (100%)	0	

Chi-square test.

**B. Diagnostic performance of ICP trends for prediction of ETV outcome**

Predictor	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
Progressive decrease/stable trend predicting ETV success	84	81.25	87.5	76.47
Progressive increase trend predicting ETV failure	91.67	79.31	64.71	95.83

**PPV: Positive predictive value; NPV: Negative predictive value.**

**Table 4: Postoperative complications following ETV**

Complication	Number of patients (%)
CSF leak	10 (24.4%)
Meningitis	9 (22.0%)
Subdural hygroma	3 (7.3%)
Wound infection	1 (2.4%)
Mortality	3 (7.3%)

## DISCUSSION

Endoscopic third ventriculostomy has become an important treatment option for hydrocephalus because it restores near-physiological CSF circulation while avoiding shunt dependency and its associated complications.<sup>[1-4]</sup> However, predicting postoperative ETV success remains difficult, particularly during the early postoperative period.<sup>[11,12]</sup> The present study evaluated clinical, etiological, and postoperative ICP-related factors influencing ETV outcomes in patients with hydrocephalus.

The overall ETV success rate in the present study was 58.5%, which is comparable to previously reported success rates ranging between 50% and 90%.<sup>[1-5]</sup> Variability in reported outcomes across studies may be attributable to differences in patient age, etiology, prior shunt status, and proportion of communicating hydrocephalus cases included in different series.

Age has traditionally been considered an important predictor of ETV outcome, with lower success rates reported in infants.<sup>[5,9]</sup> Koch and Wagner<sup>5</sup> and Beems and Grotenhuis,<sup>[9]</sup> reported higher ETV failure rates in children younger than 1 year, attributing this to immature CSF absorptive pathways and increased gliotic stoma closure. In the present study, although infants demonstrated comparatively lower success rates than older age groups (52.4% vs. 64.3% and 66.7%), the difference did not reach statistical

significance. Similar findings have been reported by Gorayeb et al,<sup>[10]</sup> suggesting that age alone may not independently predict ETV outcome.

Hydrocephalus subtype has also been recognized as an important determinant of ETV success.<sup>[3,6,7]</sup> In the present study, obstructive hydrocephalus demonstrated higher success rates than communicating hydrocephalus (65.5% vs. 41.7%), although this association did not achieve statistical significance. Previous studies have similarly demonstrated superior outcomes in obstructive hydrocephalus, particularly aqueductal stenosis.<sup>[3,6]</sup> The lower success observed in communicating hydrocephalus may be related to impaired CSF absorption resulting from arachnoidal scarring and altered CSF dynamics.<sup>[7,8]</sup>

Among etiologies, aqueductal stenosis and tubercular meningitis-associated hydrocephalus constituted the majority of cases. Patients with tubercular meningitis-related hydrocephalus had comparatively poorer outcomes, consistent with previous reports demonstrating lower ETV success in postinfectious hydrocephalus due to cisternal fibrosis and impaired CSF absorption.<sup>[7,8]</sup> However, etiological factors did not show statistically significant association with outcome in the present study, likely because of the relatively small sample size and heterogeneity of diagnostic categories.

CSF characteristics have also been proposed as predictors of ETV success.<sup>[8]</sup> In the present study,

patients with clear CSF demonstrated higher success rates than those with hemorrhagic or xanthochromic CSF, although the association was not statistically significant. Siomin et al,<sup>[8]</sup> similarly reported lower ETV success rates in patients with hemorrhagic or infected CSF due to inflammatory changes, arachnoidal adhesions, and impaired CSF absorptive capacity.

The most important finding of the present study was the significant association between postoperative ICP trends and final ETV outcome. Progressive decrease and stable ICP trends were strongly associated with successful ETV, whereas progressive increase trend was significantly associated with ETV failure. Furthermore, combined progressive decrease/stable trends demonstrated good sensitivity and specificity for predicting successful outcome, while progressive increase trend showed high sensitivity and negative predictive value for detecting ETV failure.

These findings are consistent with previous studies evaluating postoperative ICP monitoring after ETV.<sup>[14-18]</sup> Cinalli et al,<sup>[15]</sup> demonstrated that patients with successful ETV commonly exhibited progressive decrease or stable ICP patterns, whereas progressive increase patterns were associated with failure. Rapana et al,<sup>[16]</sup> and Roytowski et al,<sup>[18]</sup> similarly reported that postoperative ICP monitoring could help identify patients at risk of early ETV failure and postoperative intracranial hypertension.

Interestingly, absolute ICP measurements themselves did not correlate significantly with final outcome in the present study. This suggests that dynamic ICP behavior may be more clinically relevant than isolated ICP values, emphasizing the importance of trend analysis rather than individual readings.

Postoperative complications in the present series included CSF leak, meningitis, subdural hygroma, and mortality. CSF leak and meningitis were the most frequent complications and accounted for all mortalities observed during follow-up. Similar postoperative complications have been described in previous ETV series.<sup>[2,4]</sup> Prompt recognition and management of CSF leak and infection remain essential to minimize morbidity and mortality following ETV.

The present study has certain limitations, including relatively small sample size, heterogeneity of etiologies, and short follow-up duration. Nevertheless, the study demonstrates that postoperative ICP trends may serve as a useful adjunct for early prediction of ETV outcome and may help guide postoperative management strategies.

## CONCLUSION

Endoscopic third ventriculostomy is an effective treatment modality for hydrocephalus, with favorable outcomes particularly in obstructive hydrocephalus. In the present study, clinico-demographic factors, hydrocephalus subtype, and CSF characteristics did

not show statistically significant association with ETV outcome. However, postoperative intracranial pressure trends demonstrated significant correlation with final clinical outcome. Progressive decrease and stable ICP trends were associated with successful ETV, whereas progressive increase trend strongly predicted ETV failure. Absolute ICP values alone were not predictive of outcome. Postoperative ICP trend monitoring may therefore serve as a useful adjunct for early identification of ETV success or failure.

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