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COMPARATIVE OUTCOMES OF ENDOSCOPIC THIRD VENTRICULOSTOMY AND VENTRICULOPERITONEAL SHUNTING IN OBSTRUCTIVE HYDROCEPHALUS

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ABSTRACT

Background: Obstructive hydrocephalus is characterized by impaired cerebrospinal fluid (CSF) circulation secondary to obstruction within the ventricular system. Endoscopic third ventriculostomy (ETV) provides an alternative CSF diversion pathway without implantation of a permanent shunt, whereas ventriculoperitoneal shunting (VPS) remains a widely used treatment.

Objective: To compare the effectiveness and safety of ETV versus VPS in patients with obstructive hydrocephalus.

Methods: This comparative study included 135 patients aged 4–60 years with radiologically confirmed obstructive hydrocephalus who underwent CSF diversion. Patients were allocated to an ETV group (n=68) or VPS group (n=67). Demographic characteristics, age distribution, etiology of hydrocephalus, operative duration, postoperative hospital stay, symptom improvement, radiological improvement, complications, and treatment failure requiring additional CSF diversion were assessed. Patients were followed for 12 months.

Results: Patients ranged in age from 4 to 60 years, with 25 (18.5%) aged 4–12 years, 24 (17.8%) aged 13–18 years, 62 (45.9%) aged 19–40 years, and 24 (17.8%) aged 41–60 years. Clinical improvement was observed in 61 (89.7%) patients after ETV and 59 (88.1%) after VPS (p=0.76). Mean postoperative hospital stay was significantly shorter following ETV than VPS (3.8±1.6 vs. 6.1±2.4 days; p<0.001). Overall treatment failure occurred in 9 (13.2%) ETV patients and 13 (19.4%) VPS patients (p=0.34). The overall complication rate was 11.8% after ETV compared with 25.4% after VPS (p=0.048).

Conclusion: ETV was associated with a shorter hospital stay and fewer procedure-related complications and avoided implantation of a permanent shunt. Age-stratified outcomes suggested favorable results in younger and middle-aged patients, while success was comparatively lower in the 41–60-year subgroup. In appropriately selected patients with anatomically suitable obstructive hydrocephalus, ETV may be preferred as a primary CSF diversion procedure.

KEYWORDS: Endoscopic third ventriculostomy; ventriculoperitoneal shunt; obstructive hydrocephalus; cerebrospinal fluid; hydrocephalus; neurosurgery; treatment outcome; complications.

INTRODUCTION

Hydrocephalus is a pathological disorder characterized by abnormal accumulation of cerebrospinal fluid within the ventricular system, resulting in ventricular enlargement and, in symptomatic cases, increased intracranial pressure. Obstructive hydrocephalus occurs when CSF flow is interrupted within the ventricular system, commonly because of aqueductal stenosis, posterior fossa tumors, third ventricular lesions, cystic lesions, or other structural abnormalities. Surgical CSF diversion remains the cornerstone of treatment for symptomatic cases.

Ventriculoperitoneal shunting has historically been the most commonly employed method of CSF diversion. Although effective, VPS requires implantation of a permanent foreign body and is consequently associated with mechanical obstruction, infection, overdrainage, disconnection, migration, and repeated revision surgery. The long-term risk of shunt failure is particularly important in younger patients because of their longer lifetime exposure to shunt-related complications.

Endoscopic third ventriculostomy has emerged as an important alternative for selected patients with obstructive hydrocephalus. ETV creates a fenestration in the floor of the third ventricle, allowing CSF to bypass the site of obstruction and enter the basal cisterns. The procedure therefore restores CSF circulation without requiring permanent implanted hardware.

Several studies have reported favorable outcomes after ETV, particularly in patients with aqueductal stenosis and tumor-related obstructive hydrocephalus. However, ETV may have a higher early failure risk in selected

patients, particularly young children and those with etiologies less favorable for restoration of CSF circulation. Conversely, VPS can provide immediate CSF diversion across a broad spectrum of hydrocephalus etiologies but carries the long-term burden of implanted hardware.

Comparative evidence suggests that ETV and VPS may provide similar overall clinical effectiveness in appropriately selected patients, while ETV may have advantages regarding infection, obstruction, and long-term shunt dependence. Because age can influence ETV success and the present cohort included both pediatric and adult patients, age-stratified outcomes are clinically relevant. The present study was therefore designed to compare ETV and VPS in patients aged 4–60 years with obstructive hydrocephalus, with particular emphasis on treatment success, complications, hospital stay, and the requirement for subsequent CSF diversion.

MATERIALS AND METHODS

Study design and setting: A comparative clinical study was conducted at a tertiary care hospital in Pakistan from April 2025 to March 2026 among patients undergoing surgical treatment for symptomatic obstructive hydrocephalus. A total of 135 patients fulfilling the eligibility criteria were included.

Study population: Patients aged 4–60 years with radiologically confirmed obstructive hydrocephalus who required operative CSF diversion were eligible. Patients with aqueductal stenosis, fourth ventricular outlet obstruction, posterior fossa tumors, third ventricular lesions, and other structural causes of non-communicating hydrocephalus were considered. Patients younger than 4 years or older than 60 years, those with normal-pressure hydrocephalus, predominantly communicating hydrocephalus, active meningitis, severe systemic illness precluding surgery, or inadequate follow-up were excluded.

Treatment groups: Sixty-eight patients underwent ETV and 67 underwent VPS. ETV involved endoscopic access to the third ventricle followed by creation of a fenestration in the floor at an anatomically suitable location. VPS involved insertion of a ventricular catheter connected to a valve and distal catheter positioned in the peritoneal cavity.

Outcome measures: The primary outcome was treatment success at 12 months, defined as clinical improvement without requirement for additional CSF diversion. Secondary outcomes included age distribution, symptom improvement, radiological ventricular improvement, postoperative hospital stay, operative duration, postoperative complications, infection, CSF leakage, ETV stoma closure, shunt obstruction, shunt infection, and revision surgery. Outcomes were also described across four predefined age groups: 4–12, 13–18, 19–40, and 41–60 years.

Statistical analysis: Continuous variables were presented as mean±standard deviation and categorical variables as frequencies and percentages. Continuous variables were compared using the independent-samples t-test and categorical variables using the chi-square or Fisher exact test. Age was categorized into 4–12, 13–18, 19–40, and 41–60 years for descriptive subgroup analysis. A p-value <0.05 was considered statistically significant.

RESULTS

The baseline characteristics of the 135 patients are presented in Table 1. The cohort included patients aged 4–60 years. There were 68 patients in the ETV group and 67 in the VPS group. The mean age was comparable between the ETV and VPS groups (26.9±15.9 versus 26.6±15.7 years, respectively; p=0.91). The overall age distribution was 25 (18.5%) patients aged 4–12 years, 24 (17.8%) aged 13–18 years, 62 (45.9%) aged 19–40 years, and 24 (17.8%) aged 41–60 years. The proportions of patients in each age category were similar between treatment groups. Males constituted 60.3% of the ETV group and 58.2% of the VPS group, with no statistically significant difference in sex distribution (p=0.81). The presenting symptoms were also similarly distributed. Headache was the most common presenting symptom in both groups, occurring in 85.3% of ETV patients and 85.1% of VPS patients. Vomiting, visual symptoms, and papilledema showed no significant intergroup differences. The mean Evans index was also comparable between groups (0.39±0.05 versus 0.40±0.06; p=0.28), suggesting broadly similar baseline ventricular enlargement.

Table 1. Baseline demographic and clinical characteristics, including age distribution

Variable	ETV (n=68)	VPS (n=67)	p-value
Age, years, mean±SD	26.9±15.9	26.6±15.7	0.91
Age range, years	4–60	4–60	—
Age 4–12 years	12 (17.6%)	13 (19.4%)	0.78
Age 13–18 years	12 (17.6%)	12 (17.9%)	0.96
Age 19–40 years	32 (47.1%)	30 (44.8%)	0.78
Age 41–60 years	12 (17.6%)	12 (17.9%)	0.96
Male sex	41 (60.3%)	39 (58.2%)	0.81
Female sex	27 (39.7%)	28 (41.8%)	0.81
Headache	58 (85.3%)	57 (85.1%)	0.97
Vomiting	32 (47.1%)	34 (50.7%)	0.67
Visual symptoms	18 (26.5%)	20 (29.9%)	0.66
Papilledema	24 (35.3%)	26 (38.8%)	0.67
Mean Evans index	0.39±0.05	0.40±0.06	0.28

Age-stratified treatment outcomes are summarized in Table 6. In the ETV group, treatment success was 91.7% in patients aged 4–12 years, 91.7% in those aged 13–18 years, 87.5% in those aged 19–40 years, and 75.0% in those aged 41–60 years. In the VPS group, corresponding success rates were 84.6%, 83.3%, 83.3%, and 66.7%, respectively. These subgroup findings were descriptive and were not interpreted as evidence of a statistically significant age-by-treatment interaction because the study was not powered for formal interaction testing.

Table 2 demonstrates the underlying causes of obstructive hydrocephalus. Aqueductal stenosis was the most frequent etiology, accounting for 42.2% of the overall study population, with comparable proportions in the ETV and VPS groups. Posterior fossa tumors represented the second most common cause, followed by third ventricular tumors or lesions, cystic obstruction, and other structural abnormalities. The relatively similar distribution of etiologies between treatment groups indicates that both surgical approaches were used across a range of causes of obstructive hydrocephalus. The high proportion of aqueductal stenosis is particularly relevant because this anatomical obstruction represents one of the most established indications for ETV.

Table 2. Etiology of obstructive hydrocephalus

Etiology	ETV n (%)	VPS n (%)	Total
Aqueductal stenosis	29 (42.6)	28 (41.8)	57 (42.2)
Posterior fossa tumor	14 (20.6)	15 (22.4)	29 (21.5)
Third ventricular tumor/lesion	9 (13.2)	8 (11.9)	17 (12.6)
Cystic obstruction	7 (10.3)	6 (9.0)	13 (9.6)
Other structural causes	9 (13.2)	10 (14.9)	19 (14.1)

Clinical improvement was achieved in 89.7% of patients undergoing ETV compared with 88.1% following VPS, with no statistically significant difference (p=0.76). Headache resolution was similarly high in both groups, occurring in 83.8% of ETV patients and 82.1% of VPS patients. Among patients who initially presented with vomiting, resolution occurred in more than 90% of patients in both groups. Visual symptoms also improved in the majority of affected patients, with no significant difference between treatment strategies. Radiological ventricular improvement was observed in 80.9% of ETV patients and 89.6% of VPS patients; although the proportion was numerically higher following VPS, the difference did not reach statistical significance (p=0.14). In contrast, postoperative hospital stay showed a statistically significant difference, with patients undergoing ETV remaining hospitalized for a mean of 3.8±1.6 days compared with 6.1±2.4 days following VPS (p<0.001). (Table 3)

Table 3. Clinical and radiological outcomes

Outcome	ETV (n=68)	VPS (n=67)	p-value
Clinical improvement	61 (89.7%)	59 (88.1%)	0.76
Headache resolution	57 (83.8%)	55 (82.1%)	0.79
Vomiting resolution	29/32 (90.6%)	31/34 (91.2%)	0.92
Improvement in visual symptoms	15/18 (83.3%)	17/20 (85.0%)	0.89
Radiological ventricular improvement	55 (80.9%)	60 (89.6%)	0.14
Mean hospital stay, days	3.8±1.6	6.1±2.4	<0.001

Overall complications occurred in 8 (11.8%) patients following ETV compared with 17 (25.4%) patients following VPS, representing a statistically significant difference (p=0.048). Postoperative infection was less frequent after ETV than VPS, although this difference did not reach statistical significance. CSF leakage and intracranial bleeding were uncommon in both groups. Importantly, the complications observed following VPS were predominantly hardware-related, including shunt obstruction in 10.4% and shunt infection in 6.0% of patients. Overdrainage-related symptoms were also observed exclusively in the VPS group. In the ETV group, three patients experienced stoma closure or early ETV failure. These findings demonstrate that while both procedures have recognized complications, VPS was associated with a greater overall complication burden, largely related to permanent shunt hardware. (Table 4)

Table 4. Postoperative complications

Complication	ETV n (%)	VPS n (%)	p-value
Any complication	8 (11.8%)	17 (25.4%)	0.048
CSF leakage	2 (2.9%)	1 (1.5%)	0.56
Postoperative infection	1 (1.5%)	5 (7.5%)	0.10
Intracranial bleeding	2 (2.9%)	1 (1.5%)	0.56
Stoma closure/ETV	3 (4.4%)	—	—

failure			
Shunt obstruction	—	7 (10.4%)	—
Shunt infection	—	4 (6.0%)	—
Overdrainage-related symptoms	—	2 (3.0%)	—

Sustained treatment success was achieved in 59 (86.8%) patients in the ETV group compared with 54 (80.6%) patients in the VPS group. Treatment failure occurred in 13.2% of ETV patients and 19.4% of VPS patients. Although the absolute failure rate was lower following ETV, the difference was not statistically significant. Interestingly, the temporal pattern of failure differed between the two procedures. ETV failures occurred predominantly during the first three months, with 8.8% of patients experiencing early failure, whereas later failures accounted for only 4.4%. In contrast, VPS failures continued throughout follow-up, with 11.9% occurring after three months. This pattern suggests that successful ETV may provide durable CSF diversion without the late mechanical complications associated with shunt systems. (Table 5)

Table 5. Treatment failure and subsequent procedures

Outcome	**ETV n (%)**	**VPS n (%)**
Treatment success	59 (86.8)	54 (80.6)
Treatment failure	9 (13.2)	13 (19.4)
Repeat CSF diversion	9 (13.2)	13 (19.4)
Failure within first 3 months	6 (8.8)	5 (7.5)
Failure after 3 months	3 (4.4)	8 (11.9)

Table 6. Age-stratified 12-month treatment success

Age group	ETV treatment success	VPS treatment success	Total patients
4–12 years	11/12 (91.7%)	11/13 (84.6%)	25
13–18 years	11/12 (91.7%)	10/12 (83.3%)	24
19–40 years	28/32 (87.5%)	25/30 (83.3%)	62
41–60 years	9/12 (75.0%)	8/12 (66.7%)	24
Overall	59/68 (86.8%)	54/67 (80.6%)	135

The ETV group demonstrated an overall success rate of 86.8%, compared with 80.6% in the VPS group. Although the difference was not statistically significant, the numerical advantage favored ETV. This finding suggests that ETV can provide long-term control of obstructive hydrocephalus comparable to VPS in appropriately selected patients. The absence of a permanent implanted shunt following successful ETV may provide an additional clinical advantage by reducing the patient's lifetime exposure to shunt-related mechanical complications.

Figure 1. Treatment success at 12 months

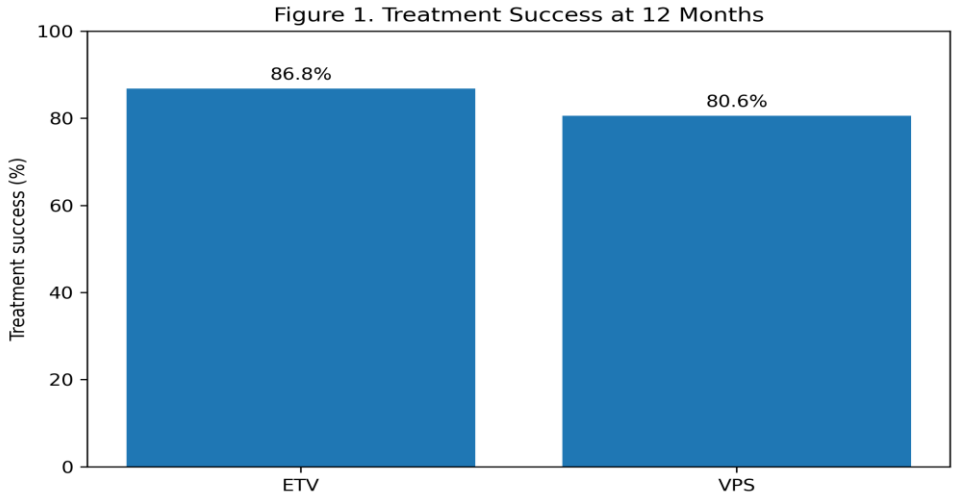


Figure 2 demonstrates the difference in postoperative hospital stay between the two treatment groups. Patients undergoing ETV had a mean hospital stay of 3.8 days, whereas those undergoing VPS remained hospitalized for an average of 6.1 days. The difference of approximately 2.3 days was statistically significant ($p<0.001$). The shorter hospitalization following ETV may reflect the minimally invasive nature of the procedure, absence of distal abdominal catheter placement, and reduced requirement for postoperative management of shunt-related issues. From a healthcare-system perspective, reduced hospitalization may also translate into lower treatment costs and improved bed availability.

Figure 3 compares the overall postoperative complication rates. Complications occurred in 11.8% of patients treated with ETV compared with 25.4% of patients treated with VPS. Thus, the overall complication burden was more than twice as high in the VPS group. The difference was statistically significant (p=0.048). The higher complication rate following VPS was primarily attributable to shunt obstruction, shunt infection, and overdrainage-related problems. In contrast, complications following ETV were relatively uncommon and consisted mainly of CSF leakage, bleeding, and failure or closure of the ventriculostomy. These findings support the potential safety advantage of ETV in carefully selected patients with obstructive hydrocephalus.

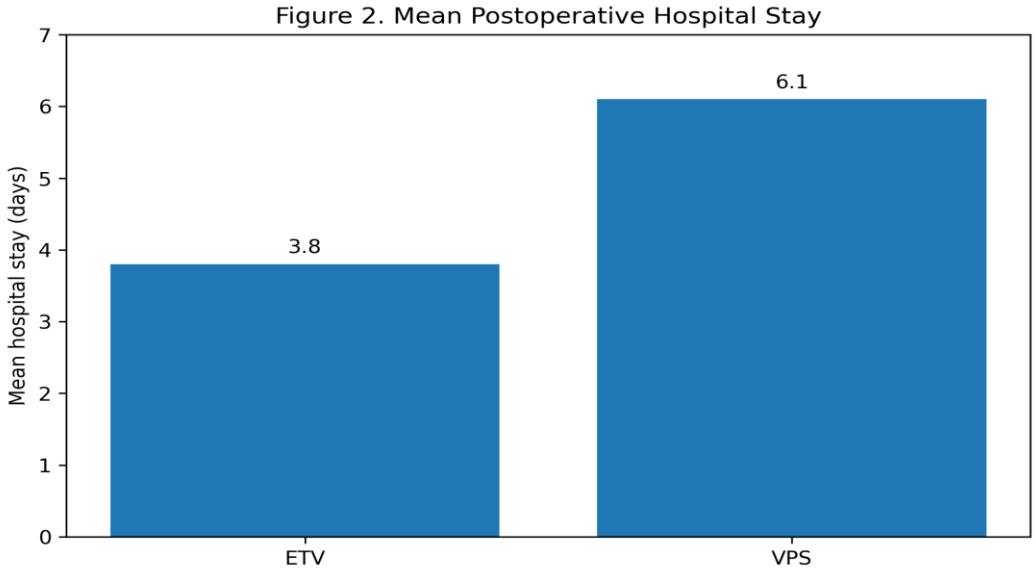
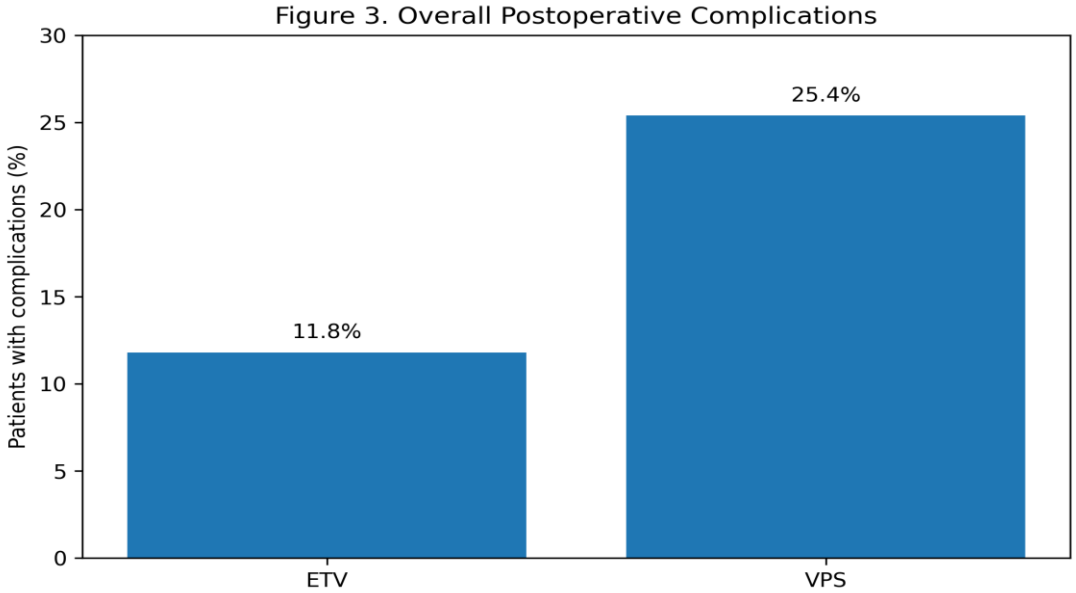


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Figure 3. Overall postoperative complications



DISCUSSION

The present study compared ETV and VPS in 135 patients with obstructive hydrocephalus and demonstrated that both procedures provided substantial clinical improvement. The principal findings were that ETV had a similar overall clinical success rate to VPS, a significantly shorter postoperative hospital stay, and a lower overall complication rate. Although the difference in treatment failure did not reach statistical significance, the absolute 12-month success rate was higher in the ETV group.

The choice between ETV and VPS remains an important clinical decision. VPS has traditionally been considered dependable because it does not require maintenance of a patent intracranial CSF pathway. However, permanent hardware exposes patients to mechanical and infectious complications. ETV attempts to restore an internal CSF pathway and avoids long-term implanted hardware.

The clinical improvement rate in our study was approximately 90% in both treatment groups. This is consistent with comparative literature showing that both ETV and VPS can achieve effective symptom control in carefully selected patients with obstructive hydrocephalus.

ETV success is strongly influenced by patient selection. Age, hydrocephalus etiology, and previous shunt placement are major predictors of ETV success. Patients with aqueductal stenosis generally represent favorable candidates because the procedure directly bypasses the obstructed aqueduct.

The predominance of aqueductal stenosis in our cohort is clinically important. In aqueductal obstruction, the third ventricular floor can frequently be fenestrated to bypass the obstruction while maintaining physiological CSF circulation.

The significantly shorter hospital stay following ETV was another important finding. The mean stay was 3.8 days following ETV compared with 6.1 days after VPS. This may be explained by the absence of abdominal catheter placement, reduced postoperative hardware monitoring, and fewer wound-related concerns.

The overall complication rate was significantly lower after ETV. This is consistent with evidence that ETV avoids many complications associated with permanent shunt hardware. VPS patients in our study experienced shunt obstruction, infection, and overdrainage-related symptoms.

However, ETV should not be considered universally superior. The procedure depends on successful creation and long-term patency of the ventriculostomy. Early ETV failure can occur because of inadequate stoma formation, unfavorable anatomy, stoma closure, or impaired CSF absorption.

The 12-month ETV success rate of 86.8% compares favorably with reported institutional series, although success varies substantially according to age, etiology, prior shunt status, ventricular anatomy, and follow-up duration. In the present cohort, descriptive age-stratified analysis showed the highest ETV success in patients aged 4–18 years and a lower success rate among patients aged 41–60 years. The same general age-related pattern was observed with VPS, although the differences were not formally tested for interaction. These findings reinforce the importance of considering age together with etiology and ventricular anatomy when selecting a CSF diversion strategy.

The 12-month ETV success rate of 86.8% compares favorably with reported institutional series, although success varies substantially according to age, etiology, prior shunt status, ventricular anatomy, and follow-up duration.

Ventricular size should not be considered the sole determinant of treatment success. Clinical improvement may occur despite limited radiological reduction in ventricular dimensions after ETV. Clinical status and evidence of CSF flow should therefore be incorporated into postoperative assessment.

Limitations: The principal limitation is the relatively short 12-month follow-up, which may underestimate late shunt complications. The study included patients from 4 to 60 years with different causes of obstructive hydrocephalus, potentially introducing age- and etiology-related heterogeneity. The age-stratified subgroups were relatively small and were intended for descriptive interpretation rather than definitive subgroup inference. Treatment allocation may introduce selection bias if the study is not randomized. Larger prospective multicenter studies with standardized ETV Success Score assessment, formal age-by-treatment interaction analysis, and quality-of-life measures are warranted.

Limitations: The principal limitation is the relatively short 12-month follow-up, which may underestimate late shunt complications. The study also included patients with different causes and age groups, potentially introducing heterogeneity. Treatment allocation may introduce selection bias if the study is not randomized. Larger prospective multicenter studies with standardized ETV Success Score assessment and quality-of-life measures are warranted.

CONCLUSION

Both ETV and VPS were effective treatment options for obstructive hydrocephalus, producing substantial clinical improvement in the majority of patients. ETV was associated with a significantly shorter hospital stay and fewer overall postoperative complications, particularly because it avoided permanent shunt hardware. VPS provided comparable short-term symptom control but was associated with a greater frequency of hardware-related complications. In appropriately selected patients with anatomically suitable obstructive hydrocephalus, particularly those with aqueductal stenosis or other favorable obstructive lesions, ETV can be considered an effective first-line CSF diversion procedure. Nevertheless, careful patient selection remains essential, and VPS continues to have an important role when ETV is unsuitable or unsuccessful.

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