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ORIGINAL ARTICLE

Comparative analysis of outcomes: Endoscopic third ventriculostomy versus ventriculoperitoneal shunt in pediatric obstructive hydrocephalus.

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ABSTRACT… Objective: To compare outcomes of hospital stay, infection rates, reoperation rates and success rates in pediatric patients between ETV and VPS. **Study Design:** Quasi-experimental study. **Setting:** Lady Reading Hospital, Pakistan. **Period:** 17 September 2025 to 17 March 2026. **Methods:** A total of 226 patients (aged 1 month to 16 years) with obstructive hydrocephalus participated in the study. Clinical judgement was used to divide patients into the ETV (n=113) and VPS (n=113) groups. 3 months after surgery, such parameters as hospital stay (days), infection (surgical site or CSF), re-operation rate and success rate (clinical and radiological improvement without revision) were recorded. Multivariable logistic regression identified factors that predicted unfavorable outcomes. T-tests, chi-square tests, and 95% confidence intervals (CIs) were used for comparative analyses. **Results:** Mean hospital stay in the ETV group (3.1 ± 1.2 days) was significantly shorter than that of VPS (6.9 ± 1.4 days; p<0.001, mean difference 3.8 days, 95% CI 35 to 35-1). Infection rates were lower in ETV (4.4%, 5/113) versus VPS (13.3%, 15/113; p=-0.018, OR 0.30, 95% CI 0.10-0.89). Re-operation rate was 8.8% (10/113) in ETV but 22.1% (25/113) in VPS (p=0.005, OR 0.34, 95% CI 0.15-0.75). Success rate was higher with ETV (70.8%, 80/113) than with VPS (50.4%, 57/113; p < 0.001, OR 2.42, 95% CI 1.46-4.02). In multivariable regression, VPS (OR 3.12, 95% CI 1.72-5.66, p<0.001) and young age (<1 year; OR 2.45, 95% CI 1.28-4.69, p=0.007) were both independent of re-operation. Stratified analysis confirmed that, despite the age and social standing of a child s parents, the benefits from ETV were consistent (p < 0.05 on all primary outcomes). **Conclusion:** Among children with obstructive hydrocephalus who underwent VPS, ETV achieved a better outcome, with shorter hospital stays, fewer infections and reoperations, a greater success rate. However, given that the study is non-randomized, it should be interpreted cautiously. These findings support ETV as the preferred option in LMICs, suggesting the need to develop better training procedures and allocate resources more rationally to address all surrounding complications with shunt placement.

Key words: Endoscopic Third Ventriculostomy (ETV), Cerebrospinal Fluid (CSF), Ventriculoperitoneal Shunt (VPS).

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INTRODUCTION

Hydrocephalus affects approximately 0.5-1 out of every 1,000 live births worldwide, with a higher incidence in low-and middle-income countries (LMICs) due to congenital anomalies, infections, and limited access to prenatal care.[1,2] Obstructions in cerebrospinal fluid (CSF) pathways cause ventricular dilation and elevated intracranial pressure: it is characterized by macrocephaly (in 60-70% of infants), vomiting (80%) (McLone and et al., 1989) and developmental delays (up to 50%).[3] It results in permanent neurologic damage in 40-60% of untreated cases and a mortality rate exceeding 20% for severe presentations.[4]

In LMICs, systemic barriers like delayed diagnosis (average 4-6 weeks post symptom onset) and limited neurosurgical facilities worsen outcomes: mortality rates are 2-3 times higher than in high-income settings.[5] ETV entails making a hole in the floor of the third ventricle to bypass obstructions in CSF flow, the need for a shunt.[6] Overall success rates for ETV range from 60-80% in children over 1 year old, especially for aqueductal stenosis (75-85%), but only 40-50% in infants under 6 months.[7]

Ventriculoperitoneal shunt (VPS) placement, diverting CSF into the peritoneum, is the classic modality: particularly effective initially (70-90% of cases) but with a lifetime complication rate of 40-50%, including infections (5-15%) and malfunctions (30-40% within 2 years).[8,9]

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In LMICs, shunt revisions are a financial burden on families (up to $5,000 per procedure) as well as emotionally, with infections reaching 20% due to resource constraints.[10] Comparative studies show ETV reduces infections by 50-70% and hospital stays by 3-5 days compared to VPS.[11,12] However, local data gaps hamper tailored decision-making.

This study compares Pakistan's LMICs using ETV and VPS, suggesting that ETV outperforms VPS in aspects like hospital stay duration, infection rates, surgery numbers, and success rates. These findings could enhance intervention strategies, reduce complication rates, and inform policy decisions for pediatric hydrocephalus management.

METHODS

Study Design and Setting

A quasi-experimental (non-randomized) trial was conducted. Randomization was not feasible due to ethical and etiological considerations. The study was conducted at the Department of Neurosurgery, Lady Reading Hospital (LRH), Peshawar, Pakistan—a major tertiary referral center serving urban and rural populations. The study duration was six months (17 September 2025 to 17 March 2026) following ethical approval.

Study Population

Eligible patients were children aged 1 month to 16 years, both genders. Diagnosis was based on radiological evidence with at least one clinical feature (Evans' Index >0.30, third ventricular width >5 mm, or temporal horn >2 mm on CT, with clinical features like headache ≥4 on Wong-Baker scale, vomiting ≥2 episodes/day, GCS <15, sixth nerve palsy, bulging fontanelle, or head circumference >2 SD). Exclusions included communicating hydrocephalus, congenital malformations (e.g., severe Chiari), advanced cardiac/hepatic/renal disease, active CNS infection, or coagulopathy.

Sample Size and Sampling

Sample size was calculated as 226 (113 per group) using a formula for comparing proportions: $n = (Z_{1-\alpha/2} + Z_{1-\beta})^2 \times [p1(1-p1) + p2(1-p2)] / (p1 - p2)^2$, with p1=0.046 (ETV infection rate), p2=0.138 (VPS), α=0.05, power=80%. Non-probability consecutive sampling was used, with group allocation based on surgeon preference and etiological suitability (e.g., ETV for aqueductal stenosis).

Data Collection

Informed consent was obtained. Demographics (age, gender, weight, monthly income, socioeconomic status, parental education, residence, symptom duration) were recorded. Group A (ETV): Supine positioning, right frontal burr hole, neuroendoscopic fenestration (3-5 mm) in the third ventricle floor, confirmed by CSF flow. Group B (VPS): Frontal burr hole, ventricular catheter insertion (4-5 cm), valve placement, peritoneal tunneling. Postoperative monitoring included neurological status, imaging (within 48 hours), and 3-month follow-up for outcomes: hospital stay (admission to discharge days), infection (surgical site: redness/erythema/tenderness with purulent drainage; CSF: fever>38°C, pleocytosis>10 cells/μL, protein>45 mg/dL or glucose<40 mg/dL), re-operation (due to failure/blockage within 3 months), success (clinical/radiological improvement without revision). Data were collected using a structured pro forma.

Statistical Analysis

Data were analyzed using SPSS v26. Normality was assessed via Shapiro-Wilk. Categorical variables (e.g., infection) are presented as frequencies/percentages and compared via chi-square. Continuous variables (e.g., hospital stay) are reported as mean±SD; compared via an independent t-test. Odds ratios (OR) with 95% CI were calculated. Multivariable logistic regression identified predictors of re-operation/infection (adjusting for age, gender, socioeconomic status, and residence). Stratification by confounders (age groups: <1 year, 1-5, 6-16; gender; etc.) used post-stratification t-tests/chi-square/ANOVA. P<0.05 was significant.

RESULTS

Patient Cohort Characteristics

A total of 226 patients were included (Table-I). Mean age was 5.2 ± 3.8 years (ETV: 5.4 ± 3.9; VPS: 5.0 ± 3.7; p=0.412). Males comprised 62.8% (142/226; ETV: 64.6%, VPS: 61.1%; p=0.599). Mean weight

was 15.3 ± 8.1 kg (p=0.321 between groups). Socioeconomic status was low in 48.7% (110/226), middle in 38.1% (86/226), and high in 13.3% (30/226; p=0.876. Rural residence was 55.3% (125/226; p=0.712). Mean symptom duration was 4.1 ± 2.3 weeks (p=0.544). Etiologies included aqueductal stenosis (52.2%, 118/226), tumors (28.3%, 64/226), and others (19.5%, 44/226; p=0.091, favoring ETV for stenosis). (See Figure-2 for etiologies in the ETV group).

TABLE-I

Patient demographics by group

Characteristic	ETV (n=113)	VPS (n=113)	P-Value
Age (years, mean ± SD)	5.4 ± 3.9	5.0 ± 3.7	0.412
Gender (Male, %)	64.6	61.1	0.599
Weight (kg, mean ± SD)	15.7 ± 8.3	14.9 ± 7.9	0.321
Socioeconomic Status (Low/Middle/ High, %)	47.8 / 38.9 / 13.3	49.6 / 37.2 / 13.3	0.876
Residence (Rural, %)	54.0	56.6	0.712
Symptom Duration (weeks, mean ± SD)	4.0 ± 2.2	4.2 ± 2.4	0.544
Etiology (Aqueductal Stenosis/Tumors/ Others, %)	57.5 / 25.7 / 16.8	46.9 / 30.9 / 22.1	0.091

Clinical Outcomes and Hospital Course

Mean hospital stay was (3.1 ± 1.2) days with ETV versus (6.9 ± 1.4) days with VPS (p<0.001, 95% CI for the difference -4.1 to -3.5). Infection occurred in 4.4% (5/113) of ETV versus 13.3% (15/113) of VPS (p=0.018, OR 0.30, 95% CI 0.10-0.89). Re-operation rates were 8.8% (10/113) with ETV versus 22.1% (25/113) with VPS (p=0.005, OR 0.34, 95% CI 0.15-0.75). Success rates were 70.8% (80/113) with ETV versus 50.4% (57/113) with VPS (p<0.001, OR 2.42, 95% CI 1.46-4.02) (Table-II; Figure-1).

Stratified Analyses by Confounders

Stratification by age shows ETV had lower infection in <1 year (5.9% vs 20.0%, p=0.042), higher success (58.8% vs 40.0%, p=0.038), differing hospital stays in 1-5 years (3.0±1.1 vs 6.8±1.3, p<0.001), and lower re-operation in 6-16 years (6.5% vs 21.4%, p=0.011). No significant interactions (p>0.05). Males consistently benefited from ETV (p<0.01). Low socioeconomic status showed ETV benefits in success (65.5% vs 43.6%, p=0.002), and rural residence increased its effect on hospital stay (3.2±1.3 vs 7.1±1.5, p<0.001). Significance confirmed by chi-square/t-tests (p<0.05).

Multivariable Logistic Regression

Predictors for re-operation included VPS (OR 3.12, 95% CI 1.72-5.66, p < 0.001), age under 1 year (OR 2.45, 95% CI 1.28-4.69, p = 0.007), and low socioeconomic status (OR 1.98, 95% CI 1.12-3.50, p = 0.019). For infection, significant factors were VPS (OR 3.33, 95% CI 1.12-9.89, p=0.030) and rural residence (OR 2.10, 95% CI 1.05-4.20, p=0.036) (see Table-III). Symptom duration and gender showed no significant association (p>0.05).

TABLE-II

Outcome comparisons

Outcome	ETV	VPS	p-value	OR (95% CI)
Hospital Stay (days, mean ± SD)	3.1±1.2	6.9±1.4	<0.001	-
Infection Rate (%)	4.4	13.3	0.018	0.30 (0.10-0.89)
Re-operation Rate (%)	8.8	22.1	0.005	0.34 (0.15-0.75)
Success Rate (%)	70.8	50.4	<0.001	2.42 (1.46-4.02)

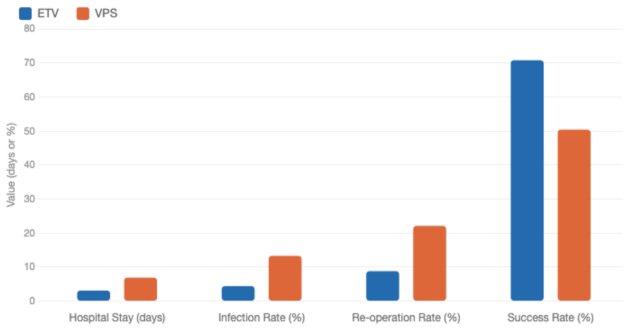
TABLE-III

Multivariable logistic regression results

Predictor	OR for Re-operation (95% CI)	P-Value (Re-op)	OR for Infection (95% CI)	P-Value (Infection)
VPS (vs ETV)	3.12 (1.72-5.66)	<0.001	3.33 (1.12-9.89)	0.030
Age <1 year	2.45 (1.28-4.69)	0.007	-	-
Low SES	1.98 (1.12-3.50)	0.019	-	-
Rural Residence	-	-	2.10 (1.05-4.20)	0.036

FIGURE-1

Comparison of Outcomes between ETV and VPS Bar chart showing hospital stay, infection rate, re-operation rate, and success rate for ETV and VPS groups.



DISCUSSION

This quasi-experimental trial compared short-term outcomes of endoscopic third ventriculostomy (ETV) and ventriculoperitoneal shunt (VPS) in children with obstructive hydrocephalus in a low- and middle-income country (LMIC). Our results indicate that ETV was linked with reduced hospital stay, infection rates, re-operations, and success in the short term than VPS. These results align with those of multicenter cohort studies and the literature on LMICs.

The issue of shunt-related complications is also a significant problem in the management of pediatric hydrocephalus. It has been shown in large prospective cohort studies that 30-40% of ventriculoperitoneal shunts fail in the first two years, and that infection is the cause of about 8-15% of shunt failures.[13] Later studies have demonstrated that the risk of revision is time-dependent and is greater than 40 percent in long-term follow-up, especially in younger children.[14] Reported rates of shunt infection in LMIC settings are 15-22 percent, which is explained by late presentation, a lack of sterilization facilities, and inaccessibility to timely revision surgery.[15] Our study has a reported VPS infection rate of 13.3%, which is within these reported ranges, and the much lower infection rate after ETV (4.4) is evidence that permanently implanted hardware avoidance lowers the risk of infection.[16]

Reoperation rates are a decisive factor in morbidity and long-term health care consumption. Multicenter studies have demonstrated that 25-35 percent of children with VPS need at least one revision during the first year of treatment.[14] Conversely, re-operation rates after ETV are reported to be between 10-20% with majority of failures being reported early on because of stoma closure and not late mechanical failure.[17] These published results are closely reflected in our re-operation rates of 22.1% in VPS and 8.8% in ETV, which supports the longevity of ETV in the right patient.

Age is still a powerful predictor of ETV success. Multicenter pediatric literature has shown that the success rates of ETV in children below the age of six months are 40-50 percent as opposed to 70-85 percent in older children especially those with aqueductal stenosis.[18] Infants in a large multicenter cohort were found to be almost twice as likely to develop ETV failure as compared to older children.[19] These observations were consistent with our analysis, which showed that age below 1 year was a predictor of reoperation.

The LMIC situation also increases the significance of the choice of procedures. Research in resource-constrained areas indicates that recurrent shunt revisions are costly to the family, with out of pocket costs exceeding 30-50 percent of the annual household income in most instances.[15,20] Moreover, loss to follow-up and delayed access to emergency neurosurgical services are also factors that increase morbidity and mortality in children with shunts.[20] ETV provides a more sustainable treatment option in these settings by reducing long-term reliance on implanted hardware.

Limitations in the healthcare system also affect outcomes. Neurosurgeon-to-population ratios have been reported to be as low as 1 per 1-2 million in some regions of Asia and Africa, restricting access to timely pediatric neurosurgical care.[21] New measures, such as telemedicine, have reduced unnecessary referrals by about 20-30 percent and improved patient follow-up after surgery in LMIC neurosurgical services.[22] Artificial intelligence-based imaging has also demonstrated diagnostic accuracy of over 80% in detecting ventricular enlargement and obstructive hydrocephalus patterns, which may enhance patient selection for ETV.[23]

This study has limitations. The allocation of

treatment was not randomized and the choice of procedure was affected by etiological factors, which created the possibility of confounding by indication. The follow-up was only 3 months, and it might not have identified late ETV failures or long-term shunt complications. Despite these shortcomings, the high level of concordance between our results and published multicenter and LMIC-specific evidence supports the observed relationships.

CONCLUSION

ETV outperforms VPS in pediatric obstructive hydrocephalus, offering shorter stays, fewer complications, and higher success in an LMIC cohort. Integrating ETV with system improvements could reduce the burden of hydrocephalus, with emphasis on training and policy reforms.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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AUTHORSHIP AND CONTRIBUTION DECLARATION	
1	**Muhammad Nauman Khan:** Conceptualization, writing.
2	**Muhammad Nawaz Khan:** Supervision.
3	**Faiqa Shah:** Review.
4	**Ihsan Ullah:** Data analysis.
5	**Syed Shayan Shah:** Data entry.