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Endoscopic third ventriculostomy versus ventriculoperitoneal shunt in patients of hydrocephalus in eastern India: A prospective observational study

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ABSTRACT

Background: Hydrocephalus is a disorder of cerebrospinal fluid (CSF) physiology, resulting in an abnormal enlargement of the ventricles due to excessive accumulation of CSF. Although neurosurgical treatment has evolved over time with ventriculoperitoneal shunt (VPS) as the standard of care, procedure-related complications and poor long-term cognitive and motor milestone outcomes are still considerable, justifying the need for safer alternatives. Endoscopic third ventriculostomy (ETV) has emerged as a promising prospect especially in non-communicating hydrocephalus (NCH). **Aims and Objectives**: To compare the beneficial effects of ETV versus ventriculoperitoneal shunt in patients of NCH. **Materials and Methods:** The present prospective study was conducted at the Department of Neurosurgery, Bangur Institute of Neurosciences, IPGMER and SSKM Hospital, Kolkata from July 2021 to December 2022 among 60 patients admitted with NCH. Out of 60 patients; 30 patients underwent ETV and the remaining 30 patients VP shunting. All included patients had their history taken and relevant clinical and radiological examination done pre-operatively. They were discharged on the third post-operative day or later depending on their clinical condition and recovery. **Results**: Aqueductal stenosis was the most common etiology for NCH in both the groups. Post-intervention, complications and reoperation rate were reported more in VP group as compared to ETV group. Overall 3 subjects died, out of which 2 belonged to VP group and 1 to ETV group. Success was found in 70% and 86.67% of the subjects in VP and ETV group respectively. **Conclusion**: In patients with non-communicating or obstructive hydrocephalus, ETV was reported to be superior to VPS in terms of reoperation and complication rate at 4th, 12th, and 24th weeks after the treatment.

Key words: Endoscopic third ventriculostomy; VP shunt; Hydrocephalus; Non-communicating hydrocephalus

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INTRODUCTION

Hydrocephalus is one of the most common pediatric neurological diseases.[1] It is estimated that congenital hydrocephalus incidence ranges between 0.5 and 1 case per 1000 births and acquired hydrocephalus is 3–5 cases per 1000 births.[2] Cerebrospinal fluid (CSF) is produced predominantly from choroid plexus located within the lateral, third, and fourth ventricles then travel through subarachnoid spaces to be absorbed through arachnoid granulations into the venous sinuses and systemic circulation.[3] Hydrocephalus is a disorder of CSF physiology, resulting in an abnormal enlargement of the ventricles due to excessive accumulation of CSF. The main causes are disturbance of CSF flow, subnormal resorption or, rarely, overproduction.[4] One of the most common classifications of hydrocephalus is obstructive versus communicating hydrocephalus. In obstructive type there is blockage in CSF flow. One of the commonest

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etiologies is aqueductal stenosis. In communicating type there is an impairment of CSF reabsorption. Other classifications include acquired versus developmental (congenital) and syndromic versus non-syndromic.[5]

Diagnosis is by clinical examination and neuroimaging techniques like; ultrasonography, computed tomography (CT), magnetic resonance imaging (MRI) and intracranial pressure monitoring techniques.[6]

Various treatments for this condition include surgical and non-surgical management. Conservative measures work with variable success and often these measures serve only to temporize hydrocephalus until shunt placement. Approaches include head wrapping, pharmacological treatment and intermittent CSF removal.[7] Surgical management includes non-shunting and shunting procedures. Non-shunting procedures include endoscopic third ventriculostomy (ETV), resection of obstructing lesions when possible and choroid plexus coagulation.[8]

Although neurosurgical treatment has evolved over time with ventriculoperitoneal shunt (VPS) as the standard of care, procedure-related complications and poor long-term cognitive and motor milestone outcomes are still considerable, justifying the need for safer alternatives.[9,10] ETV has emerged as a promising prospect especially in non-communicating hydrocephalus (NCH) (Figures 1 and 2).[11]

In ETV; Surgeon makes a burr hole just (2 cm) anterior to the coronal suture about three centimeters lateral to midline and inserts an endoscope through it inside the ventricles. Continuous irrigation is done with isotonic fluids to clear any minute bleeding which may cloud the vision. Endoscope assisted opening is made in the floor of third ventricle, confirmed by pulsatile egress of CSF which allows the CSF to flow directly to basal cisterns (pre-pontine) thereby bypassing any obstruction as in aqueductal stenosis (Figures 3 and 4).[12]

Complications of ETV include hemorrhage, injury to neural structures and delayed complications. Infection, hematoma and CSF leak may present in the post-operative period. Failure of ETV may occur due to occlusion of ventriculostomy that may need revision. A huge advantage of ETV over implantation of shunt is the absence of foreign body. This technique is cost effective but if made with correct surgical expertise it does not need revisions and overall patient morbidity is lower than that caused by multiple shunt issues.[13,14]

In the above context the purpose of the study was to assess the beneficial effects the incidence of complications and failures of both modalities of treatment.

Aims and objectives

To compare the beneficial effects of endoscopic third ventriculostomy vs ventriculo-peritoneal shunt in patients of non-communicating hydrocephalus.

MATERIALS AND METHODS

The present prospective study was conducted at the Department of Neurosurgery, Bangur Institute of Neurosciences, IPGMER and SSKM Hospital, Kolkata from July 2021 to December 2022 among 60 patients admitted with NCH. Out of 60 patients 30 patients underwent ETV and the remaining 30 patients VP shunting. Before conducting the study, permission was obtained from the Ethical Committee of the IPGMER and SSKM Hospital, Kolkata.

Inclusion criteria

All patients of NCH requiring intervention.

Exclusion Criteria

1. Patients with NCH
2. Patients on medical management for hydrocephalus
3. Patients with bleeding diathesis
4. Patients unfit for anesthesia
5. Children with NCH below 2 years of age (due to open fontanelles and poorly matured basal cisterns).

Data collection procedure

Permission from ethical review board was taken for this study. After obtaining informed consent, patients of any gender diagnosed with non-communicating/obstructive hydrocephalus on CT/MRI brain, with clinical correlation and advised for surgical treatment were included in this study. Informed consent for surgery and inclusion in the study was taken from the parents or their closest available relative. Patients were randomly allocated into two equal groups of 30 by lottery method.

Group I patients underwent VPS while group II patients underwent ETV. All included patients had their history taken and relevant physical examination done pre-operatively. They also had routine baseline investigations done pre-operatively including Chest X-ray, full blood counts, liver and renal function tests, serum electrolytes, coagulation profiles and hepatitis B and C screening.

Patients received routine treatment of 1-week post-operative prophylactic broad-spectrum antibiotics to avoid infection and analgesia according to WHO pain ladder for pain control. They were discharged on the third post-operative day or later depending on their clinical condition and recovery. Trainee residents recorded data on pro forma as Per-op, at 4th, 12th and 24th post-operative week of follow-up. CT/MRI Brain was done pre-operatively for diagnosis. Follow-up CT/MRI brain scans were done as required.

Clinically, successful outcomes were defined as no event occurring during or after the surgery that would result in an alternate surgical procedure or significant post-operative complication. All complications related to the procedures were analyzed. The time to complication was noted as well as the type of complication (infection, mechanical failure of the shunt or non-functioning ETV). The diagnosis of a non-functioning ETV/shunt was made according to clinical criteria in patients with signs of raised intracranial pressure or growing head circumference and increase in ventricular size on imaging (CT/MRI brain). Complications of surgical treatment and need for re-operations were recorded during the study period.

Data was collected in a pretested and predesigned pro forma.

Statistical analysis

Data so collected was tabulated in an excel sheet, under the guidance of statistician. The means and standard deviations of the measurements per group were used for statistical analysis (SPSS 22.00 for windows; SPSS inc., Chicago, USA). Difference between two groups was determined using t-test as well as Chi-square test and the level of significance was set at $P<0.05$.

RESULTS

In both the groups, males (56.67% and 53.33% in VP and ETV group respectively) were slightly more as compared to females (53.33% and 46.67% in VP and ETV group respectively). Mean age in ETV and VP group was 3.84±4.19 and 4.06±4.01 years respectively. Hence age was comparable among both the groups as $P>0.05$ as shown in Table 1.

Aqueductal stenosis was the most common etiology for NCH in both the groups (76.67% in VP group and 83.34% in ETV group). Dandy-Walker malformation, Arnold-Chiari malformation and intraventricular cyst loculations was found in 7, 3 and 2 subjects respectively.

Post-intervention, complications were reported more in VP group as compared to ETV group. After 12th and 24th week of intervention, complications were revealed in 23.33%, 20% and 6.67%, 3.33% of the subjects in VP and ETV group respectively. When complications were compared between VP and ETV group using Chi square test, statistically significant difference was found as $P<0.05$ (Table 2).

Post-intervention, reoperation rate was reported more in VP group as compared to ETV group. After 12th and 24th week of intervention, reoperation rate was revealed in 20%, 16.67% and 3.33%, 0% of the subjects in VP and ETV group respectively. When reoperation rate was compared between VP and ETV group using Chi-square test, statistically significant difference was found as $P<0.05$ (Table 3).

Mortality was found to be comparable in VP and ETV group as $P>0.05$. Overall 3 subjects died, out of which 2 belonged to VP group and 1 to ETV group (Table 4).

Success was found in 70% and 86.67% of the subjects in VP and ETV group respectively. Hence success rate was more in ETV as compared to VP group, though no significant difference was found as $P>0.05$ (Graph 2).

DISCUSSION

Placement of a shunt as a standard treatment strategy has been in use for numerous years, while the incidence of shunt failure has remained similar to that from 40 years ago.[15-17] Further, the use of advanced neuroimaging systems is associated with earlier diagnosis and opened avenues for minimally invasive process. Therefore, ETV is employed as a renascence for the treatment of NCH. Although both techniques are effective in treating hydrocephalus, there seems to be lack of evidence supporting the rapid evolution of the endoscopic technique and surgeons are usually expected to rely on their experience.[18-20]

In both the groups, males (56.67% and 53.33% in VP and ETV group respectively) were slightly more as compared to females (53.33% and 46.67% in VP and ETV group

Table 1: Gender distribution among the study groups

Gender	VP		ETV		Chi-square	P-value
	n=30	%	n=30	%		
Male	17	56.67	16	53.33	0.24	0.86
Female	13	43.33	14	46.67		
					t test	P-value
Age in years, mean±SD	3.84±4.19		4.06±4.01		0.31	0.72

VP: Ventriculoperitoneal, ETV: Endoscopic third ventriculostomy

Table 2: Comparison of complications distribution among the study groups

Intervals	VP		ETV		Chi square	P-value
	n	%	n	%		
4th Week	2	6.67	1	3.33	0.35	0.55
12th Week	7	23.33	2	6.67	4.28	0.047*
24th Week	6	20	1	3.33	4.02	0.048*

*Statistically significant, VP: Ventriculoperitoneal, ETV: Endoscopic third ventriculostomy

Table 3: Comparison of reoperation rate among the study groups

Intervals	VP		ETV		Chi square	P-value
	n	%	n	%		
4th Week	2	6.67	1	3.33	0.35	0.55
12th Week	6	20	1	3.33	4.02	0.048*
24th Week	5	16.67	0	0	4.59	0.041*

*Statistically significant, VP: Ventriculoperitoneal, ETV: Endoscopic third ventriculostomy

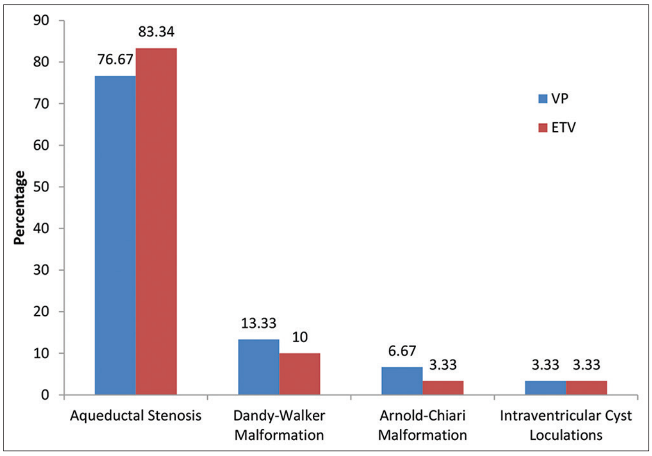
Table 4: Comparison of mortality among the study groups

Mortality	VP		ETV		Chi square	P-value
	n	%	n	%		
Absent	28	93.33	29	96.67	0.87	0.39
Present	2	6.67	1	3.33		

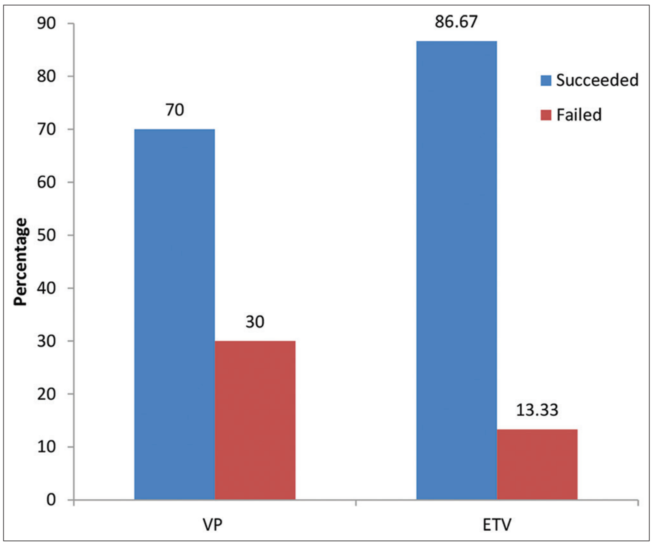
VP: Ventriculoperitoneal, ETV: Endoscopic third ventriculostomy

respectively). Mean age in ETV and VP group was 3.84±4.19 and 4.06±4.01 years respectively. Hence age was comparable among both the groups as P>0.05. Although the true incidence is unknown, the peak age incidence was below 10 years, male are more common than female in a study done by Rubin and Milhorat.[21,22] In a study by Alkhafaji et al.,[23] male to female ratio was 1.14:1. This is in accordance to the present study. The patients age range from 2 weeks to 68 years of both sexes with a mean of 34 years. This might be due to difference in inclusion criteria of the study. Ali et al.,[24] in their study revealed that there were 55.8% males and 44.2% females in group I while 50.0% males and 50.0% females were in group II. The mean age of group I was 0.89 years±1.5 SD while 2.3 years±2.8 SD in group II. These findings are similar to the present study.

In this study; aqueductal stenosis was the most common etiology for NCH in both the groups (76.67% in VP group and 83.34% in ETV group). Dandy-Walker Malformation, Arnold-Chiari Malformation, and Intraventricular Cyst Loculations were found in 7, 3, and 2 subjects, respectively (Graph 1). Similarly Alkhafaji et al.,[23] in their study reported that aqueductal stenosis is the most common cause of congenital obstructive hydrocephalus. Milhort state that



Graph 1: Aetiology among the study groups



Graph 2: Final outcome among the study groups

it was found in approximately 2 out of 3 patients with congenital hydrocephalus.[18]

Post-intervention, complications were reported more in VP group as compared to ETV group. After 12th and 24th week of intervention, complications were revealed in 23.33%, 20% and 6.67%, 3.33% of the subjects in VP and ETV group respectively. When complications were compared between VP and ETV group using Chi-square test, statistically significant difference was found as P<0.05 in this study. Hardware exposure was the most frequent complication noted in VP shunt group followed by shunt blockage/breakage/malposition. In the ETV group, intraventricular hemorrhage was the most frequent complication followed by CSF leak and subdural hygroma. The complications are less in ETV compared to V-P shunt as mentioned by Alkhafaji et al.,[23] which is similar to the present study. According to Ali et al.,[24] in 4th post-operative week, the overall complication rate was 5.9% in group I

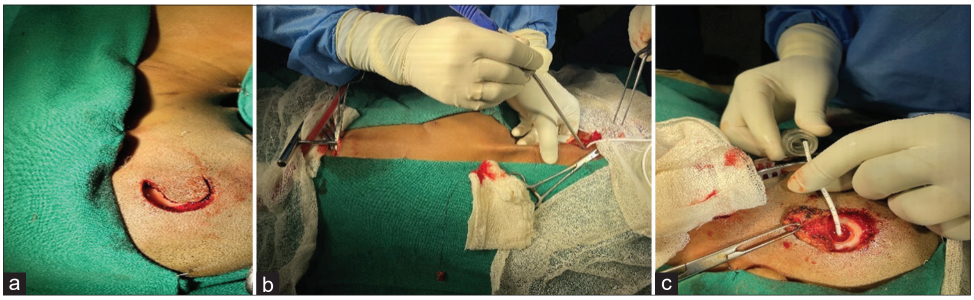


Figure 1: Ventriculo-peritoneal shunt (a) Kochers point (b) Subcutaneous tunneling to connect ventricles with peritoneum (c) Ventricular Access being made

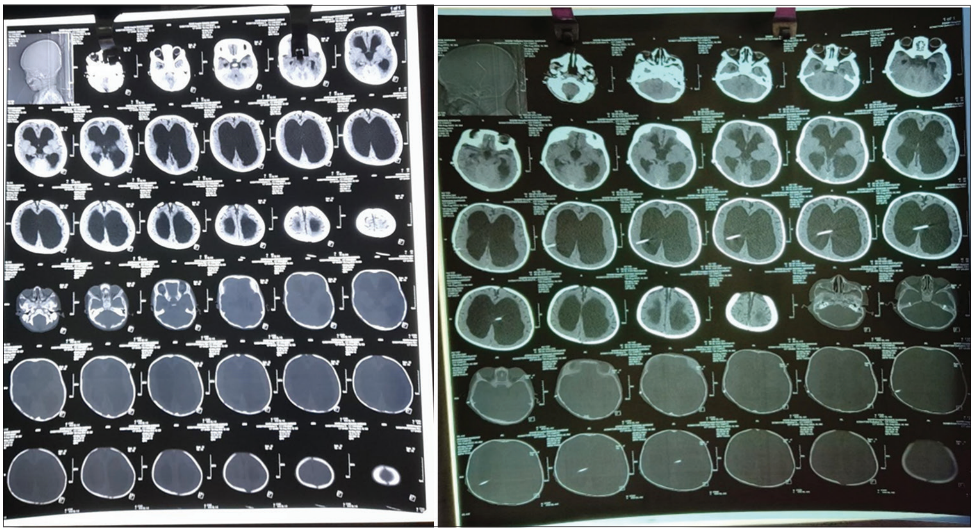


Figure 2: Pre and post-Rt Keens point ventriculoperitoneal shunt in a 10-month-old child with obstructive hydrocephalus

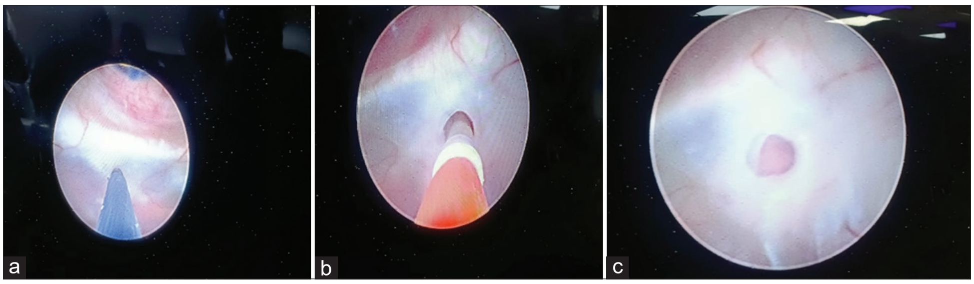


Figure 3: Endoscopic images of third ventriculostomy: (a) Fenestration of floor, (b) Dilatation and (c) Stoma following endoscopic third ventriculostomy

and 4.1% in group II. At the 12th post-operative week, the overall complication rate was 17.6% in group I and 2.0% in group II. On the 24th post-operative week, the overall complication rate was 9.8% in group I and none in group II. These findings are similar to the present study.

Our findings are comparable with other similar studies cited in the literature. Lu conducted a meta-analysis to compare ETV and VPS in patients with obstructive hydrocephalus. They included 4 trials involving 250 patients. Their pooled results showed that ETV was associated with lower incidence of post-operative infection (risk ratio [RR] 0.09, 95% confidence interval [CI]: 0.02–0.32, P=0.0002); post-operative hematoma (RR 0.26, 95% CI: 0.08–0.88, P=0.03); and blockage (RR 0.28, 95% CI: 0.13–0.60, P=0.001) compared with VPS. Cheng et al., in their meta-analysis demonstrated that ETV was associated with lower incidence of infection (RR: 0.20; 95% CI: 0.06–0.69; P=0.010).[25]

Post-intervention, reoperation rate was reported more in VP group as compared to ETV group. After 12th and 24th week of intervention, reoperation rate was revealed in 20%, 16.67% and 3.33%, 0% of the subjects in VP and ETV group respectively with statistically significant

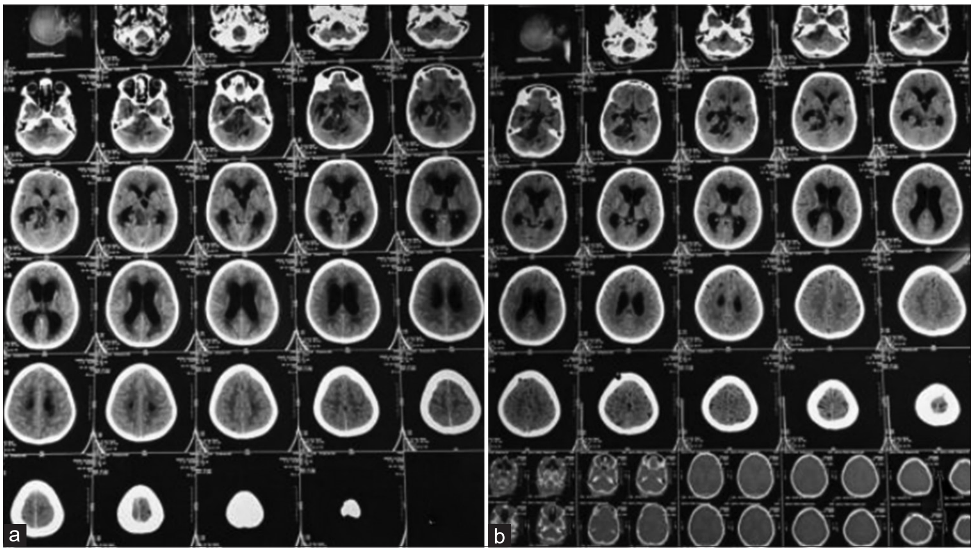


Figure 4: (a) Preoperative computed tomography (CT) brain plain of an 11-year-old boy with hydrocephalus secondary to posterior fossa tumor, (b) Post-operative CT brain plain following endoscopic third ventriculostomy

difference was found as P<0.05. The overall revision rate of V-P shunt in Alkhafaji et al.[23] study was 30.3%, which is lower than the results of Cheng et al.,[25] who perform a retrospective study of 884 patient of hydrocephalus of various etiology, the revision rate for ventriculoperitoneal shunt was 38.5%.

Similarly Ali et al.,[24] in their study showed that in the 4th post-operative week, reoperation was needed in 5.9% of patients in group I and 2.0% in group II. In the 12th post-operative week, reoperation was needed in 17.6% of patients in group I and 2.0% in group II.

Mortality was found to be comparable in VP and ETV group as P>0.05. Overall 3 subjects died, out of which 2 belonged to VP group and 1 to ETV group. In the VP shunt group, one patient died due to meningitis and other patient died of a burst abdomen due to intestinal obstruction. In the ETV group, patient died due to intraventricular hemorrhage. Similarly Ali et al.,[24] in their study found that overall mortality rate was 5.9% (n=3/51) patients in group I and 4.1% (n=2/49) patients in group II. The difference was not statistically significant. These findings are similar to the present study.

Success was found in 70% and 86.67% of the subjects in VP and ETV group respectively. Hence success rate was more in ETV as compared to VP group, though no significant difference was found as P>0.05. According to Alkhafaji et al.,[23] of those treated with ETV; 83.3% were successfully treated as shown by improvement of symptoms in the early post-operative period. Cheng et al., reported an overall success rate of 75% (25), Beem's and Grotenhuis reported 76% an overall success rate in a large series.[26] Kulkarni et al., compared ETV and shunt in infants (<24 months old) with symptomatic triventricular hydrocephalus from aqueductal stenosis. The trend appeared in both studies is comparable with higher success rate for ETV at 6 months (24 weeks).[27]

In our opinion, ETV success is almost always dependent on surgeon expertise with endoscope. We believe for ETV procedure to be successful, the learning curve is steep and good outcome of ETV depends on surgical expertise. Casual attitude of surgeons towards placement of shunt is a factor which leads to increased rates of infection and causes shunt failure.[19,20,6]

All patients with initially successful ETV should receive follow-up care on a regular basis because patients with successful ETV remain at risk of reclosure of the fenestration, which can lead to a fatal outcome if not promptly recognized and treated.[28,29]

Limitations of the study

A longer period of study with a greater study population is required to arrive at more definitive conclusions.

CONCLUSION

In patients with non-communicating or obstructive hydrocephalus, ETV was reported to be superior to VPS in terms of reoperation and complication rate at 4th, 12th, and 24th weeks after the treatment. Future research should include bigger sample sizes, longer follow-up periods, and consideration of additional outcome factors, such as operation time, length of hospital stay, and neurological prognosis.

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Authors' Contributions:
AS- Literature survey, prepared first draft of manuscript, data collection, data analysis, preparation of manuscript and submission of article; **GD**- Concept, design, clinical preparation and manuscript revision; **SIS**- Statistical analysis and interpretation, review manuscript; **SD**- Preparation of figures, co-ordination and manuscript revision.

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