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Surgical outcome of endoscopic third ventriculostomy compared to ventriculoperitoneal shunt in non-communicating or obstructive hydrocephalus: A study from tertiary care centre of a low-middle-income country

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ABSTRACT

Objectives: To assess and compare the effectiveness of Endoscopic Third Ventriculostomy over Ventriculoperitoneal shunt in terms of rate of revision in non-communicating or obstructive hydrocephalus at a tertiary care centre in a low-middle-income country.

Materials and methods: A Prospective Cohort Study was conducted from January 2019 to December 2020 at PIMS/SZABMU, Islamabad, Pakistan. A total of 104 patients of either gender under the age of 12 years diagnosed with non-communicating/obstructive hydrocephalus were enrolled in this study. They were allocated into two equal groups of 52 by the lottery method. One group underwent Ventriculoperitoneal Shunt (Group I) and another group underwent Endoscopic Third Ventriculostomy (Group II). They received routine treatment of one-week postoperative prophylactic broad-spectrum antibiotics. They were discharged on the third postoperative day and were instructed for follow-up on the 4th, 12th and 24th postoperative week. Clinically, successful outcomes were defined as no event occurring during or after the surgery that could result in reoperation or any significant postoperative complication.

Results: 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. During the procedure, the overall complication rate was 0% in group I and 4.1% in group II. In the 4th postoperative week, the overall complication rate was 5.9% in group I and 4.1% in group II. At the 12th postoperative

Keywords
hydrocephalus, endoscopic third ventriculostomy, ventriculoperitoneal shunt, low-middle-income country

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week, the overall complication rate was 17.6% in group I and 2.0% in group II. On the 24th postoperative week, the overall complication rate was 9.8% in group I and none in group II. During the procedure, reoperation was needed in 0% in group I and 4.1% in group II. In the 4th postoperative week, reoperation was needed in 5.9% of patients in group I and 2.0% in group II. In the 12th postoperative week, reoperation was needed in 17.6% of patients in group I and 2.0% in group II. At the 24th postoperative week, reoperation was needed in 9.8% of patients in group I and none in group II. The overall mortality rate was 5.9% in group I and 4.1% in group II.

Conclusion: Endoscopic Third Ventriculostomy procedure was found to be better than the Ventriculoperitoneal shunt in terms of reoperation and complication rate at the 4th, 12th and 24th week after the procedure in infants and children with non-communicating/obstructive hydrocephalus.

INTRODUCTION

Hydrocephalus is an abnormal ventricular dilatation secondary to excessive buildup of cerebrospinal fluid (CSF) in the cranial cavity. Normal CSF production is mostly by choroid plexus and to a lesser extent by interstitial space and ependymal lining of the ventricles and the nerve sleeve dura. It is absorbed into the venous circulation by arachnoid granulations.[1] Causes of hydrocephalus are congenital or acquired. Congenital causes include neural tube defects and those causing aqueductal stenosis. Post-traumatic, Post-hemorrhagic and posterior fossa tumors (Fig. 1) are some of the acquired causes.[1,2]

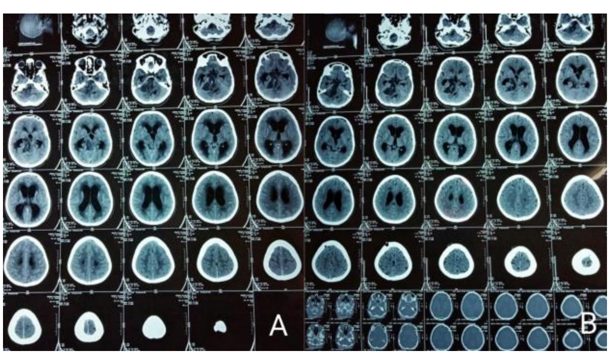

Figure 1. A: Preoperative CT Brain Plain of an 11-year-old boy with Hydrocephalus secondary to Posterior Fossa Tumor. B: Postoperative CT Brain Plain following ETV.

There are four types of hydrocephalus including Communicating, Non-communicating, Ex vacuo and Normal pressure hydrocephalus. Impedance of CSF flow after it exits the ventricles causes communicating hydrocephalus. Obstruction of CSF flow within the ventricular chain causes non-communicating also called Obstructive hydrocephalus. Hydrocephalus Ex vacuo occurs after stroke or traumatic brain injury. Normal pressure hydrocephalus is a chronic type usually present in adults and is mostly idiopathic.[1]

Usual presentations of hydrocephalus in children include progressively enlarging head size, drowsiness, vomiting, seizures and sunsetting of eyes. In adults, it may present with headache, visual impairment, poor balance, urinary incontinence, personality changes or mental impairments. Diagnosis is by clinical examination and neuroimaging techniques like; Ultrasonography, Computed Tomography (CT), Magnetic Resonance Imaging (MRI) and intracranial pressure monitoring techniques.[1,3] 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.[4] 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. Shunt involves placement of a ventricular catheter into the cerebral ventricles in order to bypass flow obstruction/malfunctioning arachnoid granulations and drain the excess fluid into other body cavities where it is absorbed. Most shunts drain fluid into peritoneal cavity therefore called ventriculoperitoneal shunts.[4,5]

Shunts generally work well but they have inherent complications such as disconnection, blockade, infection, overdrainage or underdrainage. All these complications lead to multiple shunt revisions in a patient's lifetime. It is of particular importance that shunt systems are generally very expensive and cost about all of a month's income of a family in a developing country like ours.[6-10] Alternative treatment for obstructive hydrocephalus is ETV. Surgeon makes a burr hole just anterior to the coronal suture about three centimeters lateral to midline and inserts an endoscope through it inside the ventricles. Endoscope assisted opening is made in the floor of third ventricle, which allows the CSF to flow directly to basal cisterns thereby shortcutting any obstruction as in aqueductal stenosis.[6-10,11,12]

Complications of ETV include hemorrhage, injury to neural structures and late sudden deterioration. Infection, hematoma and CSF leak may present in the postoperative period. Failure of ETV may occur due to occlusion of Ventriculostomy that may need revision.[12,13] 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. Multiple studies have shown that ETV treated patients have better neurological outcome.[2,3,6-13] In this study, we compared the surgical outcome of ETV to VP shunt in terms of rate of reoperation and the complications of primary procedure.

MATERIALS AND METHODS

Study design: Descriptive Observational Study

Setting: Department of Neurosurgery, Pakistan Institute of Medical Sciences (PIMS)/Shaheed Zulfiqar Ali Bhutto Medical University (SZABMU), Islamabad, Pakistan.

Duration of Study: 2 years (January, 2019 to December, 2020).

Sample size: A sample size of 104 patients was included in this study according to WHO sample size calculator, using the following parameters:

- Level of significance: 5%
- Power of test: 80%
- Anticipated population proportion of unfavorable outcome with ETV, p1: 4%
- Anticipated population proportion of unfavorable outcome with VP shunt, p2: 18%

Sampling Technique: Non-probability based consecutive sampling.

Sample Selection:

A. Inclusion Criteria:

- All the patients of any gender under the age of 12 diagnosed with non-communicating/obstructive hydrocephalus by radiology (CT/MRI), clinical correlation and advised for surgical treatment were included.

B. Exclusion Criteria:

- Patients already treated (VP shunt or ETV)
- Active intracranial infection
- Patients with communicating hydrocephalus

Data Collection Procedure: Permission from ethical review board was taken for this study. After obtaining informed consent, patients of any gender under the age of 12 years diagnosed with non-communicating/obstructive hydrocephalus on CT/MRI brain, with clinical correlation and advised for surgical treatment were included in this study. The sample size for this study was 104 patients. 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 52 by lottery method. Group I patients underwent Ventriculoperitoneal shunt while Group II patients underwent Endoscopic Third Ventriculostomy. All included patients had their history taken and relevant physical examination done preoperatively. They also had routine baseline investigations done preoperatively 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 one-week postoperative prophylactic broad-spectrum antibiotics to avoid infection and analgesia according to WHO pain ladder for pain control. They were discharged on the third postoperative day or later depending on their clinical condition and recovery. Trainee residents recorded data on proforma as Per-op, at 4th, 12th and 24th postoperative week of follow-up. CT/MRI Brain was done preoperatively 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 postoperative 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 Analysis Procedure: Data was analyzed using SPSS version 23. Mean and standard deviation was calculated for quantitative variables like age. Frequency and percentages were presented for qualitative variables like gender, presenting complaints, need for reoperation and complications. Chi-square test was applied to compare outcome and complications between both the groups. P-value < 0.05 was considered significant.

Results

Demography of the selected population:

There were 55.8% (n=29/52) males and 44.2% (n=23/52) females in group I while 50.0% (n=26/52) males and 50.0% (n=26/52) females in group II (Table 1). Age distribution was also comparable in both groups. Mean age of Group I patients was 0.89 years ± 1.5 SD while it was 2.3 years ± 2.8 SD in group II patients (Table 2).

Table 1. Gender distribution in both the study groups

Gender	Groups		Total
	VP Shunt	ETV	
Males	29 (55.8%)	26 (50%)	55 (52.9%)
Females	23 (44.2%)	26 (50%)	49 (47.1%)
Total	52 (100%)	52 (100%)	104 (100)

Table 2. Age distribution in both the study groups

Groups	n	Mean Age (years)	± SD (years)
VP Shunt	52	0.89	1.5
ETV	52	2.3	2.8

Excluded patients:

We enrolled 104 patients and a total of four patients were excluded from the study (3 from ETV group and 1 from VP shunt group). Two patients from ETV and one patient from VP shunt group were excluded as lost to follow up. One patient from the ETV group was excluded as procedure aborted due to opaque 3rd ventricular floor.

Figure 2. A: Surgical site swelling in a child with shunt blockade. B: CT Brain Plain of the same child with shunt blockade.

Outcome analysis of treatment in both groups:

Complications:

During the procedure, overall complication rate was 0% (n=0/51) in group I and 4.1% (n=2/49) in group II (P=0.145, Table 3). At 4th postoperative week, the overall complication rate was 5.9% (n=3/51) in group I and 4.1% (n=2/49) in group II (P=0.680, Table 3). At 12th postoperative week, overall complication rate was 17.6% (n=9/51) in group I and 2.0% (n=1/49) in group II (P=0.009, Table 3). At 24th postoperative week, overall complication rate was 9.8% (n=5/51) in group I and none in group II (P=0.025, Table 3). Overall complication rate was higher in patients who underwent VP shunt procedure as compared to those who underwent Endoscopic Third Ventriculostomy at 4th, 12th and 24th week after the procedure. The difference was not significant at 4th week (P>0.05), however, it was significant at 12th (P=0.009) and at 24th postoperative week (P=0.025).

Table 3. Complications rate Per-op, at Week 4, 12 and 24 in both study groups

Complications		Groups		Total	P-Value
		VP Shunt	ETV		Chi-square
Per-op	Present	0 (0%)	2 (4.1%)	2 (2%)	0.145
	Absent	51 (100%)	47 (95.9%)	98 (98%)	
Week 4	Present	3 (5.9%)	2 (4.1%)	5 (5%)	0.680
	Absent	48 (94.1%)	47 (95.9%)	95 (95%)	
	Present	9 (17.6%)	1 (2%)	10 (10%)	0.009

Week 12	Absent	42 (82.4%)	48 (98%)	90 (90%)	
Week 24	Present	5 (9.8%)	0 (0%)	5 (5%)	0.025
	Absent	46 (90.2%)	49 (100%)	95 (95%)	

Table 4. Reoperation rate Per-op, at Week 4, 12 and 24 in both study groups

Reoperation		Groups		Total	P-Value
		VP Shunt	ETV		Chi-square
Per-op	Present	0 (0%)	2 (4.1%)	2 (2%)	0.145
	Absent	51 (100%)	47 (95.9 %)	98 (98%)	
Week 4	Present	3 (5.9%)	1 (2%)	4 (4%)	0.327
	Absent	48 (94.1%)	48 (98%)	96 (96%)	
Week 12	Present	9 (17.6%)	1 (2%)	10 (10%)	0.009
	Absent	42 (82.4)	48 (98%)	90 (90%)	
Week 24	Present	5 (9.8%)	0 (0%)	5 (5%)	0.025
	Absent	46 (90.2%)	49 (100%)	95 (95%)	

Reoperation:

During the procedure, reoperation was needed in 0% (n=0/51) patients in group I and 4.1% (n=2/49) in group II (P=0.145, Table 4). At 4th postoperative week, reoperation was needed in 5.9% (n=3/51) patients in group I and 2.0% (n=1/49) in group II (P=0.327, Table 4). At 12th postoperative week, reoperation was needed in 17.6% (n=9/51) patients in group I and 2.0% (n=1/49) in group II (P=0.009, Table 4). At 24th postoperative week, reoperation was needed in 9.8% (n=5/51) patients in group I and none in group II (P=0.025, Table 4). Reoperation rate was higher in patients who underwent VP shunt procedure as compared to those who underwent Endoscopic Third Ventriculostomy at 4th, 12th and 24th week after the procedure. The difference was not significant at 4th week (P>0.05), however, it was significant at 12th (P=0.009) and at 24th postoperative week (P=0.025).

Figure 3. Ventriculoperitoneal shunt hardware exposure.

Details of complications and reoperations:

Details of complications and reoperations are mentioned in Table 5.

- Hardware exposure (Fig. 3) was the most frequent complication noted in VP shunt group followed by shunt blockage/breakage/malposition (Fig. 2), meningitis and intestinal obstruction. VP shunt revision was the most frequent reoperation procedure followed by shunt removal and External Ventricular Drain (EVD) placement (Table 5).
- In the ETV group, intraventricular hemorrhage was the most frequent complication followed by CSF leak and subdural hygroma. EVD placement was the most frequent reoperation procedure (Table 5).

Table 5. Complications and Reoperation details Per-op, at Week 4, 12 and 24 in both study groups

Time	Complications and Reoperation details				
		VP Shunt		ETV	
Per-op	Intraventricular hemorrhage	0	-	2	EVD placement
Week 4	Increased head size	1	Shunt revision	0	-
	Shunt malposition	1	Shunt revision	0	-

	CSF leak	1	Shunt distal end revision	1	Conservative management
	CSF hygroma	0	-	1	B/L subdural shunt placement
Week 12	CSF leak	0	-	1	VP Shunt
	Hardware exposure	4	Shunt removal	0	-
	Meningitis	3	Shunt removal + EVD	0	-
	Intestinal obstruction	2	Distal end of shunt exteriorized	0	-
Week 24	Shunt blockade	3	Shunt revision	0	-
	Shunt breakage	1	Shunt revision	0	-
	Meningitis	1	Shunt removal + EVD	0	-

Mortality:
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 (P=0.680, Table 6). In the VP shunt group, two patients died due to meningitis and one patient died of a burst abdomen due to intestinal obstruction. In the ETV group, one patient died due to intraventricular hemorrhage and one due to subdural hygroma.

Table 6. Overall mortality rate in both the study groups

Mortality	Groups		Total	P-Value
	VP Shunt	ETV		Chi-square
Present	3 (5.9%)	2 (4.1%)	5 (5%)	0.680
Absent	48 (94.1%)	47 (95.9%)	95 (95%)	
Total	51(100%)	49 (100%)	100 (100%)	

Discussion

CSF shunts have long been the standard treatment for hydrocephalus in children.[14,15,16] ETV is an alternative approach that has several advantages over CSF shunting in that it is relatively low-cost, durable, and potentially avoids the long-term complications that frequently occur with VP shunts.[17] In the present study, we aimed to compare both the techniques in terms of rate of reoperation and the complications of primary procedure. In our study, the overall complication rate was higher in patients who underwent VP shunt procedure as compared to those who underwent Endoscopic Third Ventriculostomy. Hardware exposure was the most frequent complication noted in the VP shunt group followed by shunt blockage/breakage/malposition, meningitis and intestinal obstruction. Delayed presentation of hydrocephalus in low-middle-income countries like Pakistan is a reason that patients present with very large head size and thin scalp, which may be the cause of hardware exposure. We suggest that paediatric shunts with small reservoirs should be used in such patients.

Hardware exposure leads to CSF leak from cranial end. If present, CSF leak can become a drastic complication. Increased operative time or contact of shunt hardware with skin of patient is the most common cause of shunt infection.[18,19] In ETV group, intraventricular hemorrhage was the most frequent complication followed by CSF leak and subdural hygroma. Intraoperative hemorrhage is the most dreadful and major complication of ETV. Although severe hemorrhages are rare, the neurosurgeon needs to be aware of them and has to establish strategies for their management. Most hemorrhages can be stopped by constant irrigation and coagulation. In the other rare cases, the dry field technique is a safe and reliable technique and can be easily incorporated into endoscopic surgery. A 2° basilar artery hemorrhage will inevitably lead to EVD placement per-operatively and later death. And to avoid it beforehand MRI brain sagittal cuts are done to know the thickness of third ventricular floor and relation of basilar artery.[20] Patients having thin cortical mantle who underwent ETV had poor outcome (chances of subdural hygroma formation). Kamel et al proposed that the prolonged ventricular dilatation leads to the compression of the thin cortical mantle, causing an alteration in the cerebral viscoelastic properties. Thus, there would not be adequate spacing in the cortical mantle following the ETV, favoring the collection formation in the increased subdural space.[21,22] After piercing floor of third ventricle, membrane of liliequist needs to be cut effectively in order to establish a pathway between ventricle and basal cisterns. It is known that its fenestration in microsurgeries for ruptured cerebral aneurysm clipping reduces the risk of the occurrence of postoperative hydrocephalus, however, it increases the formation of subdural collections. Cartimill and Vloeberghs attributed the occurrence of spinal subdural hematoma in a 9-year-old child to the very same mechanism.[23,24]

Our findings are comparable with other similar studies cited in the literature. Lu L 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 postoperative infection (risk ratio [RR] 0.09, 95% confidence interval [CI]: 0.02-0.32, P=0.0002); postoperative 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.[25] Jiang L 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). They further highlighted that patients who received ETV had shorter duration of surgery (SMD: -1.71; 95% CI: -3.16 to -0.27; P=0.020) and hospital stay (SMD: -0.91; 95% CI: -1.45 to -0.38; P=0.001).[23] In our study, we did not take into account duration of procedure and hospital stay as our outcome variables.

Complications of ETV were described in a 2012 systematic review of 24 case series reporting outcomes of >2500 ETV procedures in children and adults with hydrocephalus due to a variety of etiologies. The overall complication rate was 8.8 percent, including intraoperative hemorrhage (3.9%), infection (1.8%), CSF leak (1.7%), and other surgical complications.[26] The analysis was on ETV only and no comparison with VP shunting was performed. Jiang L et al compared ETV and VP Shunting for patients with non-communicating hydrocephalus in 10 observational studies. Their pooled analysis revealed that ETV was associated with lower incidence of major complications when compared with VPS (RR: 0.31; 95% CI: 0.17-0.56; P<.001). ETV was also associated with lower incidence of infection (RR: 0.20; 95% CI: 0.06-0.69; P=0.010).[27]

Our results further showed that reoperation rate was higher in patients who underwent VP shunt as compared to those who underwent ETV. During operation (0% vs 3.8%, P=0.145), at 4th week (5.9% vs 2.0%, P=0.327), 12th week (17.6% vs 2.0%; P=0.009) and 24th week (9.8% vs 0%, P=0.025). The difference was statistically significant at 12th and 24th postoperative week. VP shunt revision was the most frequent reoperation in VP shunt group followed by shunt removal and EVD placement. EVD placement was the most frequent reoperation procedure in the ETV group. Kulkarni AV et al compared ETV and shunt in infants (<24 months old) with symptomatic triventricular hydrocephalus from aqueductal stenosis. They reported that actual success rates for ETV vs shunt at 3, 6, and 12 months were: 68 vs 95 %, 66 vs 88 %, and 66 vs 83.[6] The trend appeared in both studies is comparable with higher success rate for ETV at 6 months (24 weeks). We, however, did not follow our patients till 12 months. 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.[28]

Some authors advocate that the ETV success score can be used to estimate the likelihood of early success. The score was developed and validated using a dataset of 618 consecutive ETV procedures performed at 12 international institutions.[8] Older age at the time of the procedure (i.e, >1 year old) is the strongest predictor of success; other important predictors include non-infectious hydrocephalus etiology (e.g, aqueductal stenosis, tectal tumor, myelomeningocele, intraventricular hemorrhage), and lack of previous shunt.[29] In one study, investigators compared outcomes of ETV and shunting using ETV scoring in a cohort of children with newly diagnosed hydrocephalus.[30] Among patients with high predicted ETV success (i.e, ETV success score ≥80), cumulative reoperation-free survival at 36 months was greater with ETV compared with shunting (72% vs 54%). However, among patients with moderate and low ETV success scores, outcomes were similar with the two procedures. For patients with moderate ETV success scores (i.e, 50 to 70), reoperation-free survival at 36 months was approximately 50% in both groups; and for those with low ETV success scores (i.e, ≤40), reoperation-free survival at 36 months was approximately 38% in both groups. In the present study, we did not use such scores.

Other studies compared ETV and VP shunting in other causes of hydrocephalus. Aranha A et al compared ETV and VP shunt in the treatment of hydrocephalus in tuberculous meningitis and reported the success rate for ETV 65.4% compared to the 61.54% success rate in VP shunt group.[31] Gonda DD et al treated patients with hydrocephalus related to cerebral metastases by either ETV or VP shunting and analyzed the clinical outcomes. The overall efficacy of symptomatic palliation was comparable in the ETV and VPS patients (ETV=69%, VPS=75%). The overall complication rate for the two groups was comparable (ETV=12.6%, VPS=19.4%), although the spectrum of complications differed.[32] The results of both studies are comparable to our study results. There are some ongoing clinical trials as well, which are evaluating outcomes with ETV compared with shunting in children with communicating[33] and non-communicating hydrocephalus[7]. Long term follow-up results are awaited.

In summary, both ETV and VP shunting are practical treatment options for non-communicating/obstructive hydrocephalus. Criteria for selection of patients for ETV versus shunting are not standardized and practice varies considerably. The 2014 evidence-based guidelines of AANS and the CNS concluded that outcomes of the two procedures are generally equivalent and they did not advocate for one approach over the other. ETV is generally not performed for treatment of obstructive hydrocephalus in infants <3 months old due to low success rates in this age group. For children in whom ETV is unsuccessful, a shunting procedure is generally performed, because repeating the ETV acutely is not likely to be successful. Present study results and several other studies cited in the literature showed that ETV when performed in a carefully selected group of patients is more effective and associated with lesser complication rates. ETV technique is cost effective and if made with correct surgical expertise it does not need revisions and overall patient morbidity is lower than that caused by multiple shunt issues. Our study design is the major strength of the study as we used stringent inclusion and exclusion criteria, though this study has some limitations as well. Firstly, the sample was relatively smaller, yet sufficient enough for interpretation. Secondly, our duration of follow up was relatively shorter and we did not follow the patients beyond 6 months, while studies in the literature showed longer duration of follow up even up to 5 years after the procedure. Thirdly, we didn't do ETV success scoring, which is an established score predicting the success of ETV and finally we did not take into account the duration of procedure, length of hospital stay and neurological outcome as our outcome measures.

Conclusion

Endoscopic Third Ventriculostomy was found to be better than Ventriculoperitoneal shunt in terms of reoperation and complication rate at 4th, 12th and 24th week after the procedure in infants and children with non-communicating or obstructive hydrocephalus. We suggest future studies taking larger sample sizes, with longer duration of follow up and taking into account other outcome variables like duration of procedure, length of hospital stay and neurological outcome.

List of Abbreviations

CSF: Cerebrospinal fluid
CT: Computed Tomography
EVD: External Ventricular Drain
ETV: Endoscopic Third Ventriculostomy
MRI: Magnetic Resonance Imaging
VP: Ventriculoperitoneal
VPS: Ventriculoperitoneal shunt
SD: Standard Deviation
RR: Risk Ratio
CI: Conference Interval
SMD: Standardized Mean Difference
P: P-value

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