Comparative Outcome Analysis of Endoscopic Third Ventriculostomy and Ventriculoperitoneal Shunt Surgery in Pediatric Hydrocephalus: An Experience of a Tertiary Care Center

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Abstract

Background Endoscopic third ventriculostomy (ETV) and ventriculoperitoneal shunt surgery (VPS) are used for the surgical management of pediatric hydrocephalus. There is controversy regarding the safety and efficacy of these procedures according to age, etiologies, and type of hydrocephalus.

Objective The purpose of this study was to compare the outcomes and complications of ETV and VPS in pediatric hydrocephalus and to evaluate the better procedure.

Material and Methods We retrospectively analyzed the pediatric hydrocephalus cases that were operated by ETV and VPS at our department from June 2016 to June 2019. Data were analyzed with respect to the etiology of hydrocephalus, age, and gender of the patients. We compared the outcomes (success and failure) depending on age at surgery, etiology, and type of hydrocephalus, complications at 12 months of follow-up. Fisher's exact test and chi-square test were applied to test the significance of difference.

Results There were 195 pediatric hydrocephalus cases, which were operated by ETV ($n = 43$; 22.05%) and VPS ($n = 152$; 77.95%). The mean age of the cases was 53.63 ± 60.24 (ranged 0.5–204 months) in the ETV group and 53.44 ± 54.10 (ranged 0.3–210 months) in the VPS group. The male-to-female ratio was 1.41:1 in the ETV group and 1.21: 1 in the VPS group. Overall, ETV had successful outcomes in 30 (69.77%) cases and VPS in 102(67.11%) cases at 12 months of follow-up. The complication rates were found in 7 (16.28%) cases in the ETV group and 38 (25.0%) cases in the VPS group. At initial 0.5 months of follow-up, ETV required revisions in 6 (13.95%) cases and VPS in 15 (9.87%) cases.

Keywords
► Pediatric hydrocephalus
► ETV
► VPS
► Outcomes
► complications

Conclusion   Although the success and failure of both the procedure vary according to the age at surgery, etiology and type of hydrocephalus, and complications, and failure rates on follow-up, there were no statistically significant differences between the two surgical groups in respect to these variables.

Introduction

The term "hydrocephalus" was first described by Hippocrates as early as in 466 to 377 BC.[1] It is defined in pathophysiological terms as an imbalance of cerebrospinal fluid (CSF) formation and absorption of sufficient magnitude to produce a net accumulation of fluid within the ventricles.[2] Hydrocephalus can be classified as communicating and noncommunicating hydrocephalus. Hydrocephalus is the most common problem encountered in neurosurgical practice. It is responsible for 40 to 50% of the neurosurgical interventions and clinic visits.[3]

Ventriculoperitoneal shunt surgeries (VPSs) have been used for long to divert CSF in patients with hydrocephalus whether obstructive or communicating. VPS has several complications such as over- or underdrainage, shunt malfunctions, and infections.[4] The risk of shunt malfunction is relatively high ranging from 25 to 40% following the first year of shunt placement, followed by a 4 to 5% increase every year.[5] Hence, on follow-up, shunt failure is almost inevitable during a patient's life.

Endoscopic third ventriculostomy (ETV) has shown its superiority compared with ventricular shunting, by avoiding shunt-related complications. It has become a routine surgical practice for the past two decades and provides an alternative to the CSF shunt. It is conducted by creating CSF diversion through the basal cistern and subarachnoid spaces (SASs) thus bypassing the cerebral aqueduct and does not require placing hardware in patient's bodies. The effectivity of ETV has been proven for obstructive hydrocephalus. However, for other conditions like communicating hydrocephalus and in children less than 1 year of age, its outcomes are variable. During follow-up after ETV, late failure can occur and may lead to rapid deterioration.[6–9]

VPS is not free of complications, and outcomes of ETV vary according to the age at surgery and the etiology of hydrocephalus. The outcomes of both the procedure vary on follow-up. In this study, we analyzed the comparative outcomes of these two groups, according to age at surgery, etiology and type of hydrocephalus, complications, and failure rates on follow-up.

Material and Methods

All pediatric hydrocephalus patients of less than 18 years of age, who were diagnosed and surgically treated for the first time, at Uttar Pradesh University of Medical Sciences, Saifai, Etawah, India, a tertiary care center, from June 2016 to June 2019, were retrospectively analyzed. There were 43 ETV and 152 VPS cases. Group matching of cases between ETV and VPS was done to avoid selection bias (►Tables 1–3). Data were analyzed with respect to etiology of hydrocephalus, age, and gender of the patients. We compared the outcomes (success and failure) depending on the age at surgery, etiology and type of hydrocephalus, and complications at 12 months of follow-up. We also analyzed the changes in outcomes on follow-up. Following cases were included in our study.

Inclusion Criteria
The inclusion criteria were:

1. Hydrocephalus in infants and other children of less than 18 years of age.
2. Cases with communicating as well as noncommunicating hydrocephalus irrespective of etiology.

Exclusion Criteria
The exclusion criteria were:

1. Cases with incomplete records.
2. Cases with follow-up less than 12 months.

The selection of patients for ETV and VPS was done on the basis of preoperative radiological and intraoperative findings. Hydrocephalus patients with noninfective etiologies (aqueductal stenosis, myelomeningocele, Dandy–Walker malformation, and tumor pathology) and having favorable

Table 1 Demographic characteristics of study subject

Characteristics	ETV n (%)	VPS n (%)	Test value	df	p-Value, LS
Age range (months)	203.50 (0.5–204) mo	209.70 (0.3–210) mo	$t = 0.02$	193	0.984, NS
Mean age (months) $\pm$ SD	53.63 $\pm$ 60.24	53.44 $\pm$ 54.10			
Male	26 (60.47)	86 (56.58)	$\chi^2 = 0.21$	1.0	0.649, NS
Female	17 (39.53)	66 (43.42)			
Total	43 (22.05)	152 (77.95)			

Abbreviations: df, degrees of freedom; ETV, endoscopic third ventriculostomy; LS, level of significance; NS, not significant; VPS, ventriculoperitoneal shunt surgery..

Table 2 Age wise distribution of study subjects

Age	ETV n (%)	VPS n (%)	Test value (χ^2)	df	p Value, LS
≤ 6 mo	7 (16.28)	13 (8.55)	2.45	4.0	0.65, NS
7–12 mo	5 (11.63)	18 (11.82)			
> 1–2 y	10 (23.26)	40 (26.32)			
> 2–5 y	9 (20.93)	30 (19.74)			
5–18 y	12 (27.91)	51 (33.55)			
Total	43	152			

Abbreviations: df, degrees of freedom; ETV, endoscopic third ventriculostomy; LS, level of significance; NS, not significant; VPS, ventriculoperitoneal shunt surgery.
Notes: In both the group, maximum number of cases were found in 5 to 18 years of age group (ETV: $n = 12$, 27.91% and VPS: $n = 51$, 33.55%). Distribution of cases of other age group are given in ►**Table 2**.

Table 3 Etiologies-wise distribution of study subjects

Etiologies	ETV n (%)	VPS n (%)	Test value (χ^2)	df	p-Value, LS
Aqueductal stenosis	14(32.56)	66(43.42)	4.10	4.0	0.392, NS
MMC	9(20.93)	25(16.45)			
DWM	6(13.95)	10(6.58)			
Tumors	7(16.28)	20(13.16)			
TBM	7(16.28)	31(20.39)			
Type of hydrocephalus			0.27	1.0	0.60, NS
Communicating	11(25.58)	45(29.61)			
Noncommunicating	32(74.42)	107(70.39)			
Total	43	152			

Abbreviations: df, degrees of freedom; DWM, Dandy–Walker malformation; ETV, endoscopic third ventriculostomy; LS, level of significance; MMC, myelomeningocele; NS, not significant; TBM, tubercular meningitis; VPS, ventriculoperitoneal shunt surgery.
Notes: Majority of cases were due to aqueductal stenosis in both the groups (ETV: $n = 14$, 32.56% and VPS: $n = 66$, 43.42%). Other etiologies-wise distribution of cases is given in ►**Table 3**.

radiological and intraoperative findings were considered for ETV. All the hydrocephalus cases with noninfective pathologies and having nonfavorable radiological and intraoperative findings were considered for VPS. In the infective pathology, hydrocephalus associated with the chronic phase of tubercular meningitis (TBM) was considered for ETV and VPS was performed in the acute phase of TBM with hydrocephalus.

Favorable preoperative radiological anatomy for ETV:

1. Generous prepontine cisternal space.
2. Absent prepontine cisternal scarring/fibrosis.
3. Adequate size of the foramen of Monro and third ventricle.
4. Patent cranial SAS.

Favorable intraoperative findings for ETV:

1. Intraoperatively third ventricle floor structures should be clearly visualized.

Patients, in which the third ventricle floor was poorly visualized, were considered for VPS.

At our center, postoperative available antibiotics are given intravenously for 5 days and then orally for 3 days in all surgically treated hydrocephalus cases. The surgical failure was defined as the need for a repeat surgical intervention and included shunt revisions, placement of a new shunt, or a new ventriculostomy. Patients who died during the postoperative period were also included in surgical failure.

Statistical Analysis

Statistical analysis was performed with the SPSS, trial version 20 for windows statistical software package (SPSS Inc., Chicago, IL, United States). The demographic data were analyzed at two levels, descriptive and analytical. Frequency, percentage, range, and means were used to describe the characteristics of the study participants. The categorical data were presented as numbers (percentage) and were compared among groups using Fisher's exact test and chi-square test. p-Value less than 0.05 was considered as statistically significant.

Results

The mean age of the cases was 53.63 ± 60.24 months (ranged 0.5–204) in the ETV group and 53.44 ± 54.10 months (ranged 0.3–210) in the VPS group. The male-to-female ratio was 1.41:1 in the ETV group and 1.21: 1 in the VPS group (►**Table 1**).

Table 4 Etiological distribution of cases and their outcomes

S.No.	Etiology	Outcomes	ETV n (%)	VPS n (%)	Test value F with 1 df	p-Value, LS
1.	Aqueductal stenosis	Successful	11 (78.57)	46 (69.69)	0.37	0.50,NS
		Failed	3 (21.43)	20 (30.31)		
2.	MMC	Successful	6 (66.67)	16 (64.0)	0.61	0.88,NS
		Failed	3 (33.33)	9 (36.0)		
3.	DWM	Successful	4 (66.67)	7 (70.0)	0.65	0.88,NS
		Failed	2 (33.33)	3 (30.0)		
4.	Tumors	Successful	5 (71.43)	14 (70.0)	0.66	0.94,NS
		Failed	2 (28.57)	6 (30.0)		
5.	TBM	Successful	4 (57.14)	19 (61.29)	0.54	0.76,NS
		Failed	3 (42.86)	12 (38.71)		
	Total	Successful	30 (69.77)	102 (67.11)	0.44	0.74,NS
		Failed	13 (30.23)	50 (32.89)		
Type of Hydrocephalus						
1.	Communicating	Successful	6 (54.55)	28 (62.22)	0.44	0.64,NS
		Failed	5 (45.55)	17 (37.77)		
2.	Noncommunicating	Successful	24 (75.0)	74 (69.16)	0.34	0.52,NS
		Failed	8 (25.0)	33 (30.84)		

Abbreviations: df, degrees of freedom; DWM, Dandy–Walker malformation; ETV, endoscopic third ventriculostomy; F, Fisher exact test value; LS, level of significance; MMC, myelomeningocele; NS, not significant; S, significant; TBM, tubercular meningitis; VPS, ventriculoperitoneal shunt surgery.

Out of 195 cases, 43 (22.05%) cases were operated by ETV and 152 (77.95%) by VPS surgery. The majority of the cases ($n = 139$, 71.28%) were of the noncommunicating type. Aqueductal stenosis was the most common etiology for hydrocephalus in both the groups. Success and failure rates varied as per etiology in both the groups as given in ►**Table 4**. The overall success rate observed was 30(69.77) in the ETV group and 102(67.11) in the VPS group. In the ETV group, the maximum success rate ($n = 11$; 78.57%) was observed in

hydrocephalus caused by aqueductal stenosis. The maximum failure rate was observed in hydrocephalus caused by TBM in both the groups (►**Table 4**).

There were variations in the success rate with age in both the groups as given in ►**Table 5**. The maximum success rate was observed in more than 2 to 5 years of age in the ETV group and more than 5 to 18 years of age in the VPS group. The maximum failure rate was observed in less than 6 months of age group in both the groups (►**Table 5**).

Table 5 Age-wise distribution and outcomes of individual procedure

Age	Surgical outcomes	ETV n (%)	VPS n (%)	Test value F with 1 df	p-Value, LS
Up to 6 mo	Successful	4 (57.14)	8 (61.53)	0.608	0.84,NS
	Failed	3 (42.86)	5 (38.46)		
7–12 mo	Successful	3 (60.0)	11 (61.11)	0.672	0.964,NS
	Failed	2 (40.0)	7 (38.89)		
> 1–2 y	Successful	7 (70.0)	26 (65.0)	0.53	0.76,NS
	Failed	3 (30.0)	14 (35.0)		
> 2–5 y	Successful	7 (77.78)	21 (70.0)	0.50	0.64,NS
	Failed	2 (22.22)	9 (30.0)		
> 5–18 y	Successful	9 (75.0)	36 (70.59)	0.53	0.76,NS
	Failed	3 (25.0)	15 (29.41)		
Total	Successful	30 (69.77)	102 (67.11)	0.44	0.88,NS
	Failed	13 (30.23)	50 (32.89)		

Abbreviations: df, degrees of freedom; ETV, endoscopic third ventriculostomy; F, Fisher exact test value; LS, level of significance; NS, not significant; S, significant; VPS, ventriculoperitoneal shunt surgery.
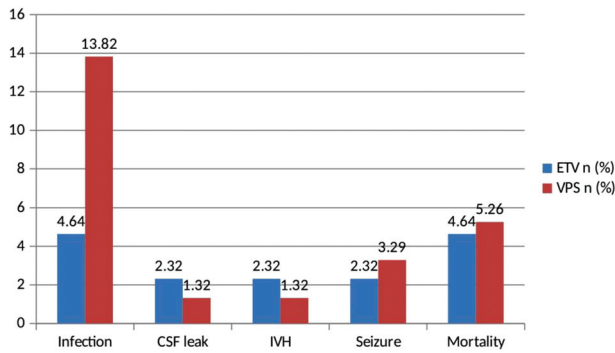
Fig. 1 Comparative distribution of complications in both the procedures. Chi-square test value ($\chi^2 = 2.42$), degree of freedom (df $= 4.0$), probability value ($p = 0.658$, not significant). IVH $=$ Intra ventricular hemorrhage.

Fig. 2 Comparative distribution of cases, which were remaining revision free in both the procedures on 12 months of follow-up. Chi-square test ($\chi^2 = 0.16$), degree of freedom (df $= 4.0$), and probability value ($p = 0.99$, not significant).

The ETV group had lower ($n = 7$, 16.28%) complication rates as compared with the VPS group ($n = 38$, 25.0%). The most common complications were infection in both the groups. Percentage-wise comparison of complications of both procedures is shown in ►**Fig. 1**.

The complication rates were higher in less than 1 years of age group as compared with older than 1 years of age group in both the group. The ETV had a higher complication rate than VPS (4[33.33%] vs. 9[29.03%]) in less than 1 years of age group and had a lower complication rate than VPS (3[9.67%] vs. 29[23.97%]) in less than 1 years of age group. Etiologically, TBM had maximum complications in both the groups. The communicating hydrocephalus had more complications than the noncommunicating type in both the groups (►**Table 6**).

In early postoperative procedure (0.5 months), the ETV group had more number of cases that required revisions as compared with the VPS group (13.05 vs. 9.87%). As time
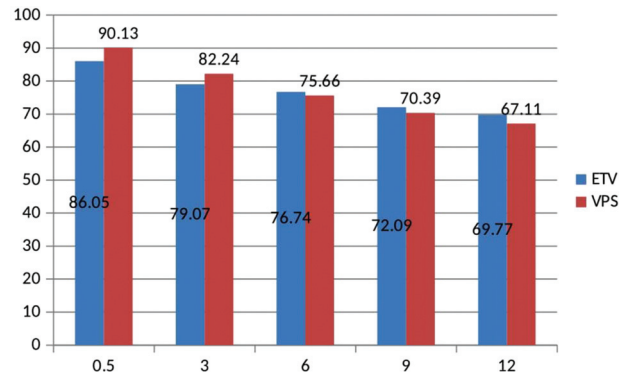
passed after surgery, the ETV group had more numbers of cases that were remained revisions free as compared with the VPS group (69.77 vs. 67.11%) (►**Fig. 2**).

Discussion

Hydrocephalus is one of the most common neurosurgical problems in the pediatric population. There are various methods described in the literature to treat this disease but none of these methods are free of complications. VPS was the most commonly used method to treat the hydrocephalus, but it had a long list of complications and put the patients lifelong on hardware. Recently, ETV has been gaining popularity because it provides the opportunity for the patient to be hardware-free. At first, indications for ETV were restricted to noncommunicating hydrocephalus, but some literature have suggested that it might also be expanded to some cases of

Table 6 Distribution of complication according to age, gender, etiology, and type of hydrocephalus

S. No.	Variables		ETV n (%)	VPS n (%)	Test value df $= 3.0$	p-Value, LS
1.	Age	< 1 y	4 (33.33)	9 (29.03)	F $= 0.093$	0.07,NS
		> 1 y	3 (9.67)	29 (23.97)		
2.	Gender	Male	5 (20.0)	21 (25.30)	F $= 0.35$	0.42,NS
		Female	2 (11.11)	17 (24.64)		
3.	Etiology	Aqueductal stenosis	2 (14.28)	15 (22.73)	$\chi^2 = 0.46$	0.92,NS
		MMC	1 (11.11)	5 (20.0)		
		DWM	1 (16.66)	2 (20.0)		
		Tumors	1 (14.28)	4 (20)		
		TBM	2 (28.57)	10 (32.26)		
4.	Types of hydrocephalus	Communicating	3 (27.27)	16 (35.56)	$\chi^2 = 0.64$	0.970,NS
		Noncommunicating	4 (12.5)	22 (20.56)		
		Total	7 (16.28)	38 (25.0)		

Abbreviations: df, degrees of freedom; DWM, Dandy–Walker malformation; ETV, endoscopic third ventriculostomy; F, Fisher exact test value; LS, level of significance; MMC, myelomeningocele; NS, not significant; S, significant; TBM, tubercular meningitis; VPS, ventriculoperitoneal shunt surgery.

communicating hydrocephalus.[10,11] However, the hope of being cured should not be confused with being shunt-free. Progressively, ETV has been replacing VPS as a treatment for obstructive hydrocephalus, with the belief that no shunt is better than the best shunt.

The success and failure rates of both the group are highly variable in the literature and described as 8 to 69% in the ETV group[12,13] and 27 to 70% in the VPS group.[14,15] There were several factors that are thought to affect outcomes in both the groups, including the patients' age at surgery, etiology and type of hydrocephalus, and duration of follow-up.

The majority of the cases in this study were of the noncommunicating hydrocephalus type ($n = 139$; 71.28%), and aqueductal stenosis was the commonest etiology in both the groups. Similar trends were noticed in the study done by Milhort et al.[2] ETV had a higher success rate ($n = 24$; 75%) than VPS ($n = 74$; 69.16%) in noncommunicating hydrocephalus. ETV had lower ($n = 6$; 54.55%) but comparable ($p = 0.52$, not significant) success rate to VPS ($n = 28$; 62.22%) in communicating hydrocephalus. Most of the previous studies had reported that outcomes of both the procedure vary with etiology, but there were statistically no significant differences between the two groups.[13,16,17] ETV was associated with a lower incidence of infection; this could be the possible reason that VPS was associated with a higher failure rate.

Although ETV had a lower success rate ($n = 4$; 57.14%) than VPS ($n = 19$; 61.29%) in TBM with hydrocephalus cases, the difference was not statistically significant ($p = 0.76$).[19] The result is compatible with the study done by Yadav et al.[18] and Chugh et al.[19,20] Hydrocephalus with tubercular etiology had a lower success rate as compared with hydrocephalus caused by aqueductal stenosis. High cellular and protein content of CSF in tubercular etiology leads to frequent shunt obstruction and closure of stoma in ETV. This could be the possible reason for high failure in both the groups.

In this study, age was significantly associated with success or failure rate in both groups. There were higher failure rates ($n = 3$; 42.86% in the ETV group and $n = 5$; 38.46% in the VPS group) in children less than 6 months of age as compared with higher age in both the groups, but the differences were not statistically significant ($p = 0.608$). Most of the previous studies had reported that success and failure of both the procedure vary with age, but there was no statistically significant difference between ETV and VPS.[12,20] Drake et al[21] stated that age has been found to be the main determinant of outcomes associated with both the procedures with worse outcomes in younger patients. The success of ETV depends upon the pressure difference between the third ventricle and SASs, which is present before surgery but is lost with time as ETV starts functioning and leads to stoma closure and ETV failure. In infants with open fontanels, gradient development fails to occur between two compartments, leading to the low success rate of ETV as compared with the higher age group. The high rate of closure of stoma in infants has been ascribed to impeded CSF absorption leading to a greater tendency of new arachnoid membrane formation and growth of gliotic,

ependymal, and scar tissue. Stoma size and Liliequist membrane perforation are also equally important.

ETV had lower complications ($n = 7$, 16.28%) than VPS ($n = 38$, 25.0%) in our study. The study done by Kulkarni et al[22] had reported similar trends. Also, ETV had lower incidence of infections ($n = 2$; 4.64%) as compared with VPS ($n = 21$; 13.82%). The study done by Erşahin et al[23] is compatible with our study. The reason for this could be that the hardware increases the infections in the VPS group.

In the present study, most of the complications were seen in less than 1 year of age group in both the groups. Although ETV had higher ($n = 4$; 33.33%) complications than VPS ($n = 9$; 29.03%) in children less than 1 year of age group, it was statistically not significant ($p = 0.07$). Similar results were described by Kulkarni et al[24] in children less than 1 year of age group as compared with higher age group. Etiologically, most of the complications were seen in TBM ($n = 2$; 28.57% in ETV and $n = 10$; 32.26% in VPS) and in communicating-type hydrocephalus ($n = 3$; 27.27% in ETV and $n = 16$; 35.56% in VPS) in both the groups. The reason for this is the poor general condition of the patients and also the presence of higher protein and cellular content of CSF leading to more frequent obstruction of stoma and shunt. Agrawal et al reported a similar complication rate in his series.[25]

During the initial 0.5 month of follow-up, the ETV group had more number of cases that required revisions as compared with the VPS group ($n = 6$; 13.95% vs. $n = 15$; 9.87%). As time passed after surgery, a trend was observed that the ETV group had more numbers of cases that were remained revisions free as compared with the VPS group ($n = 30$; 69.77% vs. $n = 102$; 67.11%). The study done by Drake et al[21] that adjusted for age and hydrocephalus etiology showed that ETV failure was higher than shunt surgery in early follow-up. After 3 months, the ETV failure rate was lower than shunt surgery. Kulkarni et al[26] reported that the relative risk of ETV failure is initially higher than that for the CSF shunt. However, the risk becomes progressively lower at approximately 3 months following the procedure and is approximately half the risk of shunt failure at 2 years. ETV has high revision rates in early postoperative periods. It may be due to:

1. Poor selection of cases for ETV.
2. Incorrect surgical techniques as
   (a) Inadequate size of stoma (i.e., < 5 mm).
   (b) Closed Liliequist membrane or other membranes (if present) in prepontine cistern.
3. There are more chances of closure of stoma in the early postoperative period by infective debris or by a blood clot. In the late postoperative period, infective debris is resolved with antibiotic/antitubercular drugs treatment so chances of stoma closure are reduced.
4. In infants, it is due to a greater tendency for new arachnoid membrane formation.
5. Learning curve of the surgeon is also an important factor for early ETV failure.

This high failure rate of ETV in the early postoperative period can be avoided by considering certain techniques. These include:

(a) Proper patient's selection by detailed preoperative radiological evaluation. It includes:
   1. Prepontine cisternal space should be generous. There should be no prepontine scarring or fibrosis.
   2. Detailed knowledge of Liliequist membrane or other membranes present in the prepontine cistern should be obtained.
   3. The size of the foramen of Monro and third ventricle should be adequate.
   4. Decrease or absent cranial SAS leads to poor CSF absorption and ETV failure. Measurement of lumbar elastance and resistance can predict the patency of cranial SAS.[27]

(b) Intraoperative techniques:
   1. Stoma should be of adequate size (i.e., 5 mm)
   2. If any membrane (Liliequist membrane or other prepontine membranes) is present in the third ventricle floor, it should be opened.
   3. There should be generous irrigation of the ventricle to clean any debris or blood clot.
   4. Functionality of stoma and subarachnoid space can be assessed by intraoperative ventriculo-stomography. The flow of contrast agent across the stoma and its disappearance from the subarachnoid space should be noted. Husain et al had found this technique to be simple and safe and it helps in confirming the adequacy of endoscopic procedures during surgery.[28]

(c) Postoperative care:
   1. Postoperatively, cine phase-contrast MRI may be used to determine the patency of the stoma and may be used in follow-up.[29] Minor flow across the stoma appears to be an early sign of closure. The measurement of stroke volume in the ventriculostomy using cine phase-contrast MRI provides functional information about the third ventriculostomy.[30]
   2. Cine phase-contrast MRI can also be used to assess the distal CSF pathway beyond the basal cistern, around the brain stem and cervicomedullary junction, that may play an essential role in achieving ETV success in addition to an adequate fenestration.[31]
   3. A cycle of one to three lumbar punctures should always be performed in patients who remain symptomatic after ETV, before ETV is assumed to have failed and an extracranial shunt is implanted. Lumbar puncture helps by increasing the compliance and the buffering capacity of the spinal subarachnoid space.[18]

Study Limitations and Future Perspective

Being a retrospective study, this has its own limitations. The small sample size may have affected the power of the study to detect all statistical significance. Future large-scale randomized control trials should be conducted focusing on specific adverse events and on the evaluation of treatment effects in patients with specific characteristics.

Conclusion

The success and failure of both the procedure vary according to age at surgery, etiology and type of hydrocephalus, complications, and failure rates on follow-up. Although ETV had higher success rates than VPS in children more than 1 year of age group and in noncommunicating hydrocephalus and had lower success rates than VPS in children less than 1 year of age group and in communicating hydrocephalus, the differences were statistically not significant. Overall, ETV had lower complication rates than VPS. So, ETV should be the first CSF diversion procedure of choice irrespective of age, etiology, and type of hydrocephalus. If the failure occurs, then the second choice should be the repeat ETV or shunt surgery.

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