Endoscopic third ventriculostomy versus ventriculoperitoneal shunt placement in children with obstructive hydrocephalus

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Abstract

Background: Uncertainty persists on the best treatment for patients with obstructive hydrocephalus: endoscopic third ventriculostomy (ETV) or ventriculoperitoneal shunt (VPS), particularly in the younger age groups. The author investigated and compared 1-year outcomes for ETV and VPS treatment categories at Zewditu Memorial Hospital (ZMH), Ethiopia.

Methods: This was a retrospective, hospital-based study. The study reviewed 259 paediatric patients with hydrocephalus in whom VPS or ETV with or without choroid plexus cauterisation (CPC) was done as a primary treatment, between January 2013 and January 2016 at ZMH. Patients' medical records, operative notes, and neural tube database records were used to complete a structured questionnaire. The difference in proportions was examined using the chi-square test.

Results: Sixty-seven (25.9%) children initially underwent ETV and 192 (74.1%) underwent VPS placements. The median age was 5 months (range 3 days-168 months). Children who underwent VPS placement rather than ETV had a statistically significant higher risk of postoperative infection (27.0% vs 6.1%; P = 0.001), complications (27.0% vs 12.2%; P = 0.025), and a higher but insignificant operative failure rate at 1 year (45.3% vs 38.8%; P = 0.27). Sex and age were not associated with the occurrence of complications, while VPS and myelomeningocele or encephalocele (MMC/EC) were strongly associated. Complication and infection were significantly and negatively associated with complication-free 1-year survival rate (P < 0.001 each), while gender, age, procedure, and cause of hydrocephalus did not show any association with survival. There was a significant reduction of VPS success rate from 76.9% at 6 months postsurgery to 54.7% at 1 year (P < 0.001), while ETV success rate remained constant during the same period (66.7% and 61.2%, respectively). Mortality frequencies for ETV and VPS insertion were 3 (4.5%) and 9 (4.7%), respectively, for a combined total of 12 deaths (4.6%).

Conclusions: Sex and age were not associated with complications, while VPS and MMC/EC were strongly associated. Children who underwent VP shunt placement rather than ETV had a higher risk of postoperative infection and complications, but there was no difference in operative failure or success rate and mortality rates between the procedures. ETV failure rate was less likely after 6 months.

Keywords: obstructive hydrocephalus, endoscopic third ventriculostomy, ventriculoperitoneal shunt, children, paediatric surgery, neurosurgery, Ethiopia

Introduction

Endoscopic third ventriculostomy (ETV) has been widely applied in paediatric patients over the last several decades, with many centres reporting successful outcomes.[1-5] Determining the best candidates for ETV has been difficult, with conflicting reports on who are the best candidates,

particularly with regards to the effect of age and aetiology. Reports have indicated that outcome is dependent on age,[6,7] independent of age,[8-10] dependent of aetiology,[8,9,11,12] or dependent on both age and aetiology.[13] More recent evidence has supported the finding that age is the main determinant of outcome, with younger children, particularly neonates, faring worse.[5,14]

Ventriculoperitoneal shunt (VPS) placement is the standard of care for patients with communicating hydrocephalus, but the procedure has a high failure rate—up to 40% fail within 1 year and 50% fail within 2 years. It has long been assumed that ETV would not work in this population and is better suited to patients with obstructive hydrocephalus. Recent small studies have shown that ETVs can work in a good percentage of children with communicating hydrocephalus.[15,16]

Recently, our department demonstrated a higher success rate among operations performed on patients with obstructive (noncommunicating) hydrocephalus (when the ventricles do not communicate through their foramina or the aqueduct of Sylvius) compared with the nonobstructive (communicating) type (caused by lesions that obstruct the subarachnoid space, wherein there is a free flow of fluid out of the ventricles).[16]

Methods

This was a retrospective cohort analysis of 259 children with obstructive hydrocephalus, in whom cerebrospinal fluid (CSF) diversion was performed using either ETV or VPS placement, at Zewditu Memorial Hospital (ZMH) in Addis Ababa, Ethiopia, between January 2013 and January 2016. Patients' medical records, operative notes, and spina bifida/hydrocephalus database records were reviewed for sociodemographic data, aetiology, as well as procedure history—including complications, infection, and success or failure.

The causes of hydrocephalus were categorised into 6 classes: postinfectious, aqueductal stenosis, tumours, Dandy-Walker malformations, myelomeningocele (MMC)-related, and undetermined. Postinfectious hydrocephalus (PIH) was defined as a history of meningitis, ventriculitis, or febrile illness just preceding onset of hydrocephalus; imaging showing loculation or septations in the ventricles; or intraoperative findings of haemosiderin or yellow deposits. All patients with obstructive hydrocephalus were included, while children with nonobstructive aetiology were excluded.

Selection of patients for ETV was mainly based on computed tomography (CT) or magnetic resonance imaging (MRI), as well as intraoperative findings: adequate size of the foramina of Monro and third ventricle, absence of prepontine cisternal fibrosis or scarring, and good intraventricular and intracisternal anatomy. In general, ETV (as opposed to VPS) has preferentially been offered to patients with more favourable prognostic features, while VPS can be chosen based on the surgeon's preference and for those patients who are not candidates for ETV. The surgical failure was defined as the need for a repeat diversion operation, revision of surgery, or death within 1 year of the initial operation. The success and failure rates of ETV and VPS placement surgery were compared. Data were analysed using SPSS version 20.0. The independent samples t-test for dichotomised variables was used in the analysis, and a P-value < 0.05 was considered significant. Ethical clearance was obtained from ZMH.

Results

Of 421 patient records screened for this study, 259 (61.5%) had obstructive hydrocephalus and 162 (38.5%) had nonobstructive hydrocephalus. Of the obstructive hydrocephalus patients, 67 (25.9%) underwent ETV and 192 (74.1%) underwent VPS placement. The combined median age was 5 months (range 3 days-168 months). Peak age incidence of hydrocephalus was between 1 and 6 months of age (44.8%). There was a nearly equal distribution of male and female participants (Table 1).

Table 1: Sociodemographic characteristics of children with obstructive hydrocephalus, between January 2013 and January 2016 at Zewditu Memorial Hospital, Ethiopia			
Characteristic	**n (%)**	**Treatment Modalities**	
		VPS n (%)	**ETV n (%)**
Age range (months)	(0.1-168)	192 (0.2-168)	67 (0.1-132)
Mean age (months) ± SD	11.36 ± 24.3	10.24 ± 23.5	14.54 ± 26.5
Median age (months)	5	5	6
Age categories			
< 1 month	29 (11.2)	19 (9.9)	10 (14.9)
1-6 months	116 (44.8)	86 (44.8)	30 (44.8)
6-12 months	66 (25.8)	54 (28.1)	12 (17.9)
1-5 years	34 (13.1)	27 (14.1)	7 (10.4)
5-10 years	8 (3.1)	3 (1.6)	5 (7.5)
> 10 years	6 (2.3)	3 (1.6)	3 (4.5)
Gender			
Male	137 (52.9)	104 (54.2)	33 (49.3)
Female	122 (47.1)	88 (45.8)	34 (50.7)
VPS = ventriculoperitoneal shunt; ETV = endoscopic third ventriculostomy; SD = standard deviation			

Table 2: Age, aetiology, complications, infection, and mortality versus procedure among patients with obstructive hydrocephalus

Characteristics	Procedure			P-value
	ETV (%)	VPS (%)	Total	
Age				
≤ 1 year	49 (18.9)	157 (60.6)	206 (79.5)	0.093
> 1 year	18 (6.9)	35 (13.5)	53 (20.5)	
Cause				
MMC/Encephalocele	20 (29.9)	108 (56.2)	128 (49.2)	
Postinfectious	10 (14.9)	28 (14.6)	38 (14.7)	
Dandy-Walker malformation	9 (13.4)	85 (11.2)	38 (14.7)	
Aqueductal stenosis	20 (29.9)	12 (15.1)	32 (12.4)	< 0.001
Tumour	6 (9.0)	10 (5.2)	16 (6.2)	
Undetermined	2 (3.0)	5 (2.6)	7 (2.7)	
Total	67 (25.9)	192 (74.1)	259 (100.0)	
Complication				
Yes	6 (12.2)	37 (27.0)	43	0.025
No	46 (93.9)	100 (73.0)	146	
Infection				
Yes	3 (6.1)	37 (27.0)	40 (21.5)	0.001
No	46 (87.8)	100 (77.0)	146 (78.5)	
Overall death	3 (4.5)	9 (4.7)	12 (4.6)	0.62

ETV = endoscopic third ventriculostomy; VPS = ventriculoperitoneal shunt; MMC = myelomeningocele

Table 3: Operative success rates by age and procedure among children with obstructive hydrocephalus

Age (years)	Surgery result	n (%) within procedure			P-value
		ETV	VPS	Total	
< 1/12	Successful	3 (37.5)	7 (53.8)	10 (47.6)	0.39
	Failed	5 (62.5)	6 (46.2%)	11 (52.4)	
1/12 - 6/12	Successful	14 (66.7)	32 (53.3)	46 (55.4)	0.17
	Failed	7 (33.3.)	30 (48.4)	37 (44.6)	
6/12 to 12/12	Successful	5 (55.6)	21 (56.8)	26 (56.5)	0.62
	Failed	4 (44.4)	16 (43.2)	20 (43.5)	
1-5	Successful	3 (75.0)	11 (55.0)	14 (58.3)	0.44
	Failed	1 (25.0)	9 (45.0)	10 (41.7)	
5-10	Successful	3 (75.0)	2 (66.7)	4 (66.7)	0.71
	Failed	1 (25.0)	1 (33.3)	2 (33.3)	
> 10	Successful	2 (66.7)	2 (100.0)	3 (60.0)	0.60
	Failed	1 (33.3)	0 (0.00)	2 (40.0)	
Total	Successful	30 (61.2)	75 (54.7)	105 (56.5)	0.27
	Failed	17 (38.8)	66 (45.3)	81 (43.5)	
Total		49 (100.0)	137 (100.0)	186 (100.0)	

Table 4: Factors associated with complication of procedures in children with obstructive hydrocephalus				
Variable	**Complication – n (%)**			**P-value**
	Yes	**No**	**Total**	
Sex: Male	27 (14.5)	72 (38.7)	87 (46.8)	0.10
Female	16 (8.6)	71 (38.2)	99 (53.2)	
Total	43 (23.1)	143 (76.9)	186 (100.0)	
Age: ≤ 1 year	35 (18.8)	109 (58.6)	144 (77.4)	0.31
> 1 Year	8 (4.3)	34 (18.3)	42 (22.6)	
Total	43 (23.1)	143 (76.9)	186 (100.0)	
Procedure: ETV	6 (3.2)	43 (23.1)	49 (26.3)	0.025
VPS	37 (19.9)	62 (53.8)	137 (73.7)	
Total	43 (23.1)	143 (76.9)	186 (100.0)	
Cause: MMC/Encephalocele	25 (13.4)	67 (36.0)	92 (15.6)	
Postinfectious	9 (4.8)	17 (9.1)	26 (14.0)	
Dandy-Walker malformation	2 (0.5)	20 (15.1)	12 (15.6)	0.004
Aqueductal stenosis	154 (1.1)	7 (10.8)	29 (15.6)	
Tumour	3 (1.6)	10(5.4)	13 (7.0)	
Undetermined	3 (1.6)	1 (0.5)	4 (2.2)	
Total	43 (23.1)	143 (76.9)	186 (100.0)	

ETV = endoscopic third ventriculostomy; VPS = ventriculoperitoneal shunt; MMC = myelomeningocele

Of 259 patients with obstructive hydrocephalus, 186 (71.8%) completed a 1-year follow-up visit. Table 2 shows age, aetiology, complications, infection, and mortality versus procedure among these patients. MMC or encephalocele (MMC/EC) was the leading cause of hydrocephalus, and most common indication for VPS insertion (108 patients [56.2%]; P < 0.001), while ETV was frequently performed for aqueductal stenosis and MMC/EC (20 patients [29.9%] each). Most study participants (n = 206 [79.5%]) were 1 year old or younger, but there was no association with age and the preference to perform either ETV or VPS placement (P = 0.093). Children who underwent VPS placement rather than ETV had a statistically significant higher risk of postoperative infection (27.0% vs 6.1%, respectively; odds ratio [OR] = 1.35; 95% confidence interval [CI], 1.17 to 1.56; P = 0.001). The intraoperative complication rate for VP shunt placement was higher than that for ETV (27.0% vs 12.2%; OR = 1.23; 95% CI, 1.05 to 1.45; P = 0.025). There was no difference in mortality between the 2 procedures (P = 0.62).

Table 5: Factors associated with 1-year postoperative success among children with obstructive hydrocephalus

Variable		Outcome at 1-year postsurgery		COR (95% CI)	P-value
		Successful (%)	Failed (%)		
Sex	Male	53 (53.5)	46 (46.53)	0.89 (0.68 to 1.16)	0.24
	Female	52 (59.8)	35 (40.2)	1.15 (0.84 to 1.57)	
Age	≤ 1 year	78 (54.2)	66 (45.8)	0.91 (0.78 to 1.06)	0.16
	> 1 year	27 (64.3)	15 (18.5)	1.39 (0.79 to 2.43)	
Procedure	ETV	30 (61.2)	19 (38.8)	1.22 (0.74 to 2.00)	0.27
	VPS	75 (54.7)	62 (45.3)	0.93 (0.79 to 1.11)	
Complication	Yes	10 (24.4)	31 (75.6)	0.22 (0.12 to 0.42)	< 0.001
	No	103 (69.1)	46 (30.9)	1.41 (1.18 to 1.80)	
Infection	Yes	2 (5.0)	38 (95.0)	0.04 (0.10 to 0.16)	< 0.001
	No	103 (70.5)	48 (29.5)	1.85 (1.50 to 2.27)	
Cause	MMC/EC	53 (57.6)	39 (42.4.1)		0.60

COR = crude odds ratio; CI = confidence interval; ETV = endoscopic third ventriculostomy; VPS = ventriculoperitoneal shunt; MMC = myelomeningocele; EC = encephalocele

There was a reduction in operative success from 76.9% at 6 months postsurgery to 54.7% at 1 year for children who had VPS placement, and assessment of ETV success at the 6-month follow-up point was comparable to that at 1 year (66.7% and 61.2 %, respectively) (P < 0.01). Infection (95%) and complications (75.6%) were the main causes of increased operative failure. The were 2 (1.5%) early postoperative deaths among ETV patients and 5 (2.6%) among patients who received VPS surgery. The deaths were caused by bleeding and neural injury during ETV; and sepsis, meningitis, chest infections, and acute hydrocephalus following VPS insertion. In terms of late mortality within 1 year after discharge, 1 child (0.8%) suffered delayed sudden death after ETV; during follow-up at home, 4 children (2.1%) who underwent VPS surgery were reported to have died (from unknown causes). Overall mortality (death from any cause within 1 year of surgery), was 4.5% (3 patients) among patients who underwent ETV and 4.7% (9 patients) among those who underwent VPS insertion (P = 0.62); the combined mortality for both procedures was 4.6% (12 patients).

Discussion

In this study, the average age at the time of first operation was similar to ages reported elsewhere[5,17,18] but lower than that reported by Drake et al., who reported mean ages of 6.5 and 1.6 years for ETV and VPS, respectively, among North American and European randomised trial participants.[18] CNS infection has been reported as the most common cause of paediatric hydrocephalus in Uganda[5]; this differs from Ethiopia, where the leading causes of paediatric hydrocephalus have been congenital malformations (myelomeningocele and encephalocele).[16,17,19-23]

Choosing the best procedure for CSF diversion in paediatric patients is difficult, particularly in very young patients. Recent research has demonstrated that outcome for ETV is a function of age, with younger patients having a lower probability of success.[14,24,25] Indeed, age has been found to be the main determinant of outcomes associated with CSF diversion (either ETV or VPS insertion, with worse outcomes in younger patients)[24,26]; in the present study, however, age was not significantly associated with operative success or failure, in agreement with other previous work, which reported that failure is age-independent.[8-10.] The higher risk of postoperative infection and complications among VPS patients in our study was in agreement with a number of previous studies.[16,18,27]

Similar to a study conducted at a teaching hospital in Iraq,[27] age and sex were found to have no association with complication risk, while type of procedure and cause of hydrocephalus were strongly associated with complications—children who underwent shunt surgery and were diagnosed to have myelomeningocele or encephalocele had high complication rates in our study. The majority of patients with myelomeningocele or encephalocele who developed complications were younger than 1 year of age, which is in line with published results[2,26,28,29] for infants and supports the suggestion that these congenital conditions are risk factors for shunt infection and complications. Myelomeningocele and encephalocele are strongly associated with hydrocephalus as well as additional congenital abnormalities; this is likely part of the explanation for the higher infection and complication rate in this group of patients.

A recent large retrospective analysis, comparing ETV with VPS placement, reported a significantly higher operative failure rate for ETV at 1 year postsurgery.[25] In contrast, our study demonstrated increased operative failure among children who underwent VPS placement compared to ETV; there are other studies that reported a similar finding,[15,16,18] and this might partly be accounted by an increased infection rate among younger patients who underwent VPS placement surgery.

Predictably, patients who developed complications had a significantly higher failure rate at 1-year postsurgery compared to those who did not have complications.

Study limitations

There are several limitations to this study. The data were not all prospective in nature and therefore might be subject to bias. Although the data used represent the largest and most accurate assessments of outcome following ETV and VPS placement, we recognise that direct comparison can be difficult because of differences between patients selected for 1 procedure over the other.

Conclusions

Age, sex, and the cause of hydrocephalus were found to have no association with the development of complications. Children who underwent VPS placement had a significantly higher risk of postoperative infection and complications but similar likelihood of operative success and mortality as children who underwent ETV. Postoperative complication and infection were significantly and negatively associated with complication-free 1-year survival. ETV failure rate was less likely after 6 months.

Recommendations

Further prospective randomised trials, including investigations of the cost and impact of surgeon and hospital experience, are necessary to determine which treatment modality is more effective in this setting in the long term for different age categories and aetiologic factors.

Acknowledgements

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