

A Study of Ventriculoperitoneal Shunt in Management of Pediatric Hydrocephalus

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Abstract

Background: Hydrocephalus is one of the most common clinical conditions affecting the central nervous system and Ventriculoperitoneal (VP) shunt is the most common procedure used. We report an outcome analysis of various risk factors and etiological factors for shunt failure in pediatric patients from a single institution.

Methods: A single institutional cross-sectional observational study was conducted in 45 operated cases of hydrocephalus below 16 years of age from 2020 to 2022. Etiology, various risk factors, surgery time, cerebrospinal fluid (CSF) analysis, and shunt complications were analyzed using the Chi-square test and binary logistic regression.

Results: Forty-five patients who fulfilled the inclusion criteria were enrolled. About 57.8% of patients were male, and the mean age at the time of VP shunt was six months. The commonest etiology of hydrocephalus was congenital aqueduct stenosis (42.22%). Overall shunt complication was found in 20% of patients. Emergency surgery compared to elective surgery ($p = 0.01$), long duration of surgery (≥ 1 hour) compared to short duration of surgery (< 1 hour) ($p = 0.01$), and increased protein content in CSF analysis ($p = 0.001$) were significantly associated with shunt failure. Only increased CSF analysis ($p = 0.04$) was found to be significant predictor of shunt complication when adjusted with other significant variables in binary logistic regression.

Conclusion: Emergency surgery, long duration of surgery, and increase protein content in CSF analysis were found to be associated with shunt complications. Protein CSF was found to be significant predictor of shunt failure after adjusting with other variables.

Keywords: Hydrocephalus; Infections; Ventriculoperitoneal Shunt.

Declarations

Ethics approval and consent to participate: Ethical approval obtained from the Institutional Review Committee, B. P. Koirala Institute of Health Sciences (Ref. no.: 50/077/078- IRC). Written informed consent was taken from the legal guardian of the participants.

Consent for publication: Not applicable

Availability of data and materials: The full data set supporting this research will be available upon request by the reader.

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Hydrocephalus is a neurological condition that arises from any disorder in normal hydrodynamics of cerebrospinal fluid. This may result from any disorders in the process of cerebrospinal fluid (CSF) formation, disorder of CSF flow between the ventricular systems, or disorder in CSF absorption, all of which lead to the accumulation of excessive amounts of CSF in the brain [1]. This increased CSF volume causes dilatation of the ventricles of the brain and may cause an increase in intracranial pressure. Communicating hydrocephalus is defined as a condition in which there is full communication between all ventricles of the brain and subarachnoid spaces [2]. Non-communicating hydrocephalus is defined as the condition where the flow of CSF is blocked in the passages bridging the ventricles. Obstruction of the cerebral aqueduct of Sylvius is the most common cause of congenital hydrocephalus. Other common cause includes congenital malformations like Arnold Chiari malformation, dandy walker malformation, and neural tube defects like myelomeningocele or meningocele [3].

Ventriculoperitoneal (VP) shunts are used to alleviate or prevent the symptoms and complications in hydrocephalic children. It works on the principle to drain excess accumulated CSF into the peritoneal cavity thus relieving the CSF pressure in Brain. The success of VP shunt surgery is influenced by many factors which can be studied and modified accordingly to ensure better outcomes [4]. The aim of this study is to assess the effectiveness of procedures against proven standards of care, to study complications of VP shunt, and to study factors influencing shunt malfunction.

METHODS

After ethical approval from the IRC board of BPKIHS, this cross-sectional study was performed over years from 28th August 2020 to December 2022, at the Neurosurgery unit, Department of Surgery, BPKIHS, Dharan. Forty-five children below 16 years of age who were clinically and radiologically diagnosed with hydrocephalus and who underwent shunt surgery for the first time were enrolled in the study. Incompletely filled records or parents not consenting to the study were excluded. Demographic data, etiology of hydrocephalus, types of complications, and CSF analysis factors for shunt malfunction were recorded. The shunt failure was categorized as complication present and absent and the association was assessed with the etiology of hydrocephalus, patients' demographic status, duration

of surgery, type of surgery (elective or emergency), CSF analysis, as well as follow-up reviews for up to 6 months. Data was entered Into Microsoft Excel version 2018 and further analysis was performed using SPSS version 17. Descriptive information was presented in mean \pm SD, and Median (Q1, Q3) for quantitative data and categorical data were presented in frequency and proportions. Chi-square was used to see the association of shunt complication with various variables of interest. The p-value <0.05 was considered significant. Binary logistic regression was performed to identify the factors associated with shunt complications for those variables which were significant at $p = 0.2$ in univariate analysis.

RESULTS

Out of 61 patients, 45 patients who fulfilled the inclusion criteria were enrolled in our study. Male patients were predominant with 57.8%. The median age (Q1, Q3) of patients at the time of VP shunt was 6 (3, 11) months where a majority of the patients belonged to 0 - 1 years of age with 77.8%. The commonest etiology of hydrocephalus was congenital aqueduct stenosis (42.2%)

Table 1: Distribution of patients according to demographic characteristics (n = 45). Values are presented as number (%)

	Number (percentage)
Age (months) Median (Q3,Q1) = 6 (11, 3)	
<=12	35 (77.8%)
13- 50	6 (13.3%)
51-100	3 (6.7%)
101-150	1 (2.2%)
Sex	
Male (M)	26 (57.8%)
Female (F)	19 (42.2%)
Diagnosis	
Congenital aqueductal stenosis	19 (42.2%)
Communicating hydrocephalus	13 (28.9%)
Meningocele/ Myelomeningocele	5 (11.1%)
Post meningitis	4 (8.9%)
Tumor	2 (4.4%)
Dandy walker malformation	1 (2.2%)
Chiari malformation	1 (2.2%)
Complications	
Yes	9 (20%)
Shunt malfunction	7 (77.8%)
Shunt infection	2 (22.2%)
No	36 (80%)

Table 2: Association of type of surgeries and CSF analysis with VP shunt complications among the hydrocephalic children (n = 45). Values are presented as number (%)

Variables	Shunt Complications		Total	*p value
	Complications Number (percentage)	No Complications Number (percentage)		
Age				
≤ 1 Year	8(22.9)	27(77.1)	45	0.65
> 1 Year	1(10.0)	9(90.0)		
Type of Surgery				
Emergency surgery	6(46.2)	7(53.8)	13	0.01
Elective surgery	3(9.4)	29(90.6)	32	
CSF protein analysis				
Increased	6(66.7)	3(33.3)	9	0.001
Normal	3(8.3)	33(91.7)	36	
CSF glucose analysis				
Increased	1 (25.0)	3(75.0)	4	0.79
Normal	8(19.5)	33(80.5)	41	
Duration of Surgery				
< 1 hour	3(9.4)	29(90.6)	32	0.01
≥1 hour	6(46.2)	7(53.8)	13	
Condition of wound				
Infected	3(75)	1(25)	4	0.021
Healthy	6(14.6)	35(85.4)	41	
Total	9(20.0)	36(80.0)	45(100%)	

*Fischer Exact Test. CSF: cerebrospinal fluid

Table 3: Association of demographic and clinical variables with VP shunt complications using binary logistic regression

Variables	Odds Ratio	95% CI	p value
Surgeries			
Emergency	2.34	0.29 - 018.54	0.42
Elective	1		
Condition of wound			
Infected	2.92	0.24 – 359.6	0.66
Healthy	1		
Duration of surgery			
> 1 hour	4.36	0.57 – 33.57	0.15
≤= 1 hour	1		
CSF Protein Analysis			
Increased	9.78	1.11 – 85.95	0.04
Normal	1	1	

CSF: cerebrospinal fluid

followed by communicating hydrocephalus (28.9%). Overall shunt complication was found in 20% (n = 9) of patients, out of which seven cases were shunt malfunction and two cases were shunt infection (**Table 1**). The shunt-related mortality was 1.2% in our study (not shown in the table).

Chi-square analysis of variables of interest and shunt complications revealed the type of surgery (p = 0.011), increase protein content in CSF analysis (p = 0.001), condition of wound (p = 0.21), and duration of surgery (p = 0.01) were statistically significant variable for shunt complication, whereas CSF glucose analysis (p = 0.79) and age (p = 0.65) were not significantly associated with shunt complications in our study (**Table 2**). Binary logistic regression analysis showed only protein CSF analysis (OR: 11.99; p = 0.37) was significant predictor of shunt complication when adjusted with duration of surgery, type of surgery and type of wound (**Table 3**).

DISCUSSION

This study reported 20% of patients with shunt-related complications presented within 12 months of shunt placement. The overall shunt complication rate in our study (20%) was comparable to or less than reported in the literature including that from the developed world. Shannon et al. in their study of 2 years of follow up found that (49%) of patients experienced one or more shunt failures. Shannon et al. reported the overall infection rate ranges from 3% to 15% [1]. The shunt infection rate of 4.4% in this study was within this range of infection rates throughout the world [5]. The majority of shunt infections occurred early after surgery between 0-12 months of age in this study but the association was not statistically significant. The study conducted by Choux et al. showed infection within 6 months of age is about 90 % [2]. Another study conducted in the USA in 2003 April, by McGirt et al showed that infection was the most common cause of shunt failure at about (45%) within 1st month [4].

In this study, we assessed clinical, surgical, and demographic variables to learn their association with shunt complications. Out of these, long duration of surgery, and emergency cases were found to be significantly associated with shunt failure. Tuli et al. study elaborated on the outcome of patient characteristics, shunt hardware, and surgical details in patients who underwent right sided VP shunts [3]. Their findings suggested that age (prematurity and infants), certain etiology of hydrocephalus (intraventricular hemorrhage, post-meningitis, and tumor), and concurrent other surgical procedures were

significantly associated with increased risk of failure. Although our study found duration of surgery, and emergency cases as significant factors of failure, there is no regularity in these associations in different reported literature. Tuli et al. and Griebel et al. in their study could not relate the duration of surgery and emergency surgery as the crucial prognostic indicators of shunt failure [6, 7].

The role of age at the time of shunt insertion has been evaluated previously in studies done by Liptak et.al, Di Rocco et.al and Shannon et.al. Di Rocco et al. concluded that there are increased shunt failures in pediatric patients who had received shunt placement at age < 6 months [1, 8, 9]. Piatt et.al had similar results in patients < 2 years of age [10]. A similar observation was made by Liptak et.al et.al in children < 1 year of age [8]. The present study also discloses that the age of the patient at the time of shunt insertion is a salient predictor of shunt function.

This study revealed that increased CSF protein analysis was the sole predictor variable of shunt malfunction when adjusted with other significant variables in logistic regression. This finding was in line with the study findings of study done by Shanon et al. and Mc Grit et al. [1, 4]. Paulson et al. in their article reported that shunt-related mortality ranging from 8.6%–13.7% [11]. Agrawal et al. give an account of 4.17% shunt-related mortality in their study [12], whereas, in our study, it was 1.2%. This could be due to more strict sterile guidelines followed by our study, for example, the non-touch shunt technique. This is because the absolute sterile technique can bring down mortality due to shunt infection.

CONCLUSION

Emergency surgery, duration of surgery, condition of wound and increased protein content in CSF analysis were found to be associated with shunt complication among the children and CSF analysis was significant predictor of shunt malfunction when adjusted with other variables. The shunt infection and malfunction were found to be two complications in this study with congenital aqueductal stenosis being the most common etiology. Though there are complications, shunt surgery still remains the procedure of choice for hydrocephalus.

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