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ORIGINAL RESEARCH

Analysis of risk factors for Ventriculo Peritoneal (VP) shunt failures

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ABSTRACT

Introduction: Ventriculoperitoneal (VP) shunt surgery is a frequently conducted neurosurgical technique. Shunt failure can lead to serious health problems and a significant risk of death. We examined the complications associated with these shunts and conducted an analysis to identify the risk factors for shunt failure. **Material and methods:** The present prospective study was conducted 50 among pediatric patients diagnosed with hydrocephalus at department of neurosurgery during the study period one year. Demographic information, clinical observations, and preoperative radiological images were collected for all cases from medical records. Results were analyzed using SPSS version 25.0. **Results:** Out of 50 patients 12 (24%) came back with complications like Ventriculo Peritoneal(VP) shunt failures after the surgery. The main etiology was congenital aqueductal stenosis (41.6%). Time taken to perform the surgery was greater than one hour in 75% of subjects.66.6% of cases were emergency cases. On bivariate logistic regression analysis, duration of surgery (P = 0.027) and priority of case (P = 0.001) were significantly correlated with outcome. On multivariate analysis, urgency of the case was only significantly associated with higher complications (P = 0.024). **Conclusion:** Extended duration of the surgical procedure, and the urgency of the case (emergency) were distinct factors that increased the chance of shunt problems.

Keywords – hydrocephalus, infection, risk factors, shunt, Ventriculo Peritoneal(VP)

INTRODUCTION

Hydrocephalus is defined as the condition of an increased volume of cerebrospinal fluid in the central nervous system and there are >380,000 new cases annually.[1] The incidence of the disease is highest in the Latin American, Southeast Asian, and African regions and lowest in Canada and the United States.[2] The mainstay treatment of hydrocephalus is placement of a Ventriculo Peritoneal shunt (VPS). The estimated rate of VPS failure is 11% to 25% during the first year after primary shunt insertion, and some evidence shows that the number of shunt revisions is lower in adult patients than in pediatric patients.[3]

Shunt infection is linked to a higher likelihood of developing seizure disorder, worse intellectual function, and a doubling of the long-term mortality rate. Commonly reported risk factors for CSF shunt infection include the cause of hydrocephalus, the age of the patient, previous shunt failure, and the length of the shunt surgery [4-8]. Applying these findings to diverse paediatric populations is challenging due to the lack of examination in previous studies about the influence of patient characteristics on the likelihood of infection. According to a recent study, the researchers found that premature delivery, postoperative CSF shunt leak, and gloves that were breached during surgery were all separate risk factors for CSF shunt infection [9].

Staphylococcus aureus and coagulase-negative bacteria. Staphylococcus species, a kind of gram-negative bacteria, Propionibacterium species, and Enterococcus faecalis are significant contributors to shunt infections [10,11]. Previous studies have not attempted to identify clinical characteristics that are independently linked to shunt infections caused by specific pathogens. Consequently, the ability to suspect the bacterial pathogen's identity in clinical practice relies heavily on the individual experience of the doctor.[12]

Each instance of a child with hydrocephalus undergoing a surgery poses a higher probability of shunt infection, which can have adverse consequences for the individual, their family, and society as a whole. Every failure has a negative impact on the child's cognitive development and, ultimately, their overall quality of life.[13]

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Timely recognition and control of potential hazards can contribute to enhancing the overall prognosis of the patient. In this study, we provide our findings in which we managed paediatric patients with hydrocephalus who had ventriculoperitoneal (VP) shunts. We examined the complications associated with these shunts and conducted an analysis to identify the risk factors for shunt failure.

MATERIAL AND METHODS

The present prospective study was conducted among pediatric patients diagnosed with hydrocephalus at department of neurosurgery during the study period one year. Ethical clearance was taken from institutional ethics committee before commencement of study. Patients parents/guardian were asked to sign an informed consent form after explaining them about the study.

Through convenience sampling a total of 50 pediatric patients with Hydrocephalus were selected on the basis of inclusion and exclusion criteria.

Inclusion criteria- All paediatric patients with hydrocephalus (HCP) who were 15 years old or younger and received their first ventriculoperitoneal (VP) shunting procedure, and gave their agreement to participate, were included in the study.

Exclusion criteria- The patients who had previously undergone a VP shunt or other diversion procedures such as ventriculoatrial shunts, ventriculopleural shunts, or external ventricular drainage were excluded from the study.

The patient underwent VP shunt surgery, which was conducted in a specialised operating room only used for neurosurgery procedures, while under general anaesthesia with endotracheal intubation. All cases utilised nonantimicrobial impregnated material, which was constructed, immersed, and washed with a solution of 80 mg of gentamycin diluted in 100 ml of normal saline. Aseptic procedure was employed to prevent any physical contact between the shunt, the patient's skin, and the surgeon's gloves. This involved the use of specialised instruments and sterile gauze to handle the shunt components. Prior to the start of the surgery, the patient received antibiotics through an intravenous route. The administration of antibiotics was maintained for a period of one week after the surgery.

Demographic information, clinical observations, and preoperative radiological images were collected for all cases from medical records. The surgical factors were recorded on a specifically created data sheet for the study. The patient underwent a computed tomography scan of the head, and the results, along with the clinical status and cerebrospinal fluid analysis, were recorded prior to the patient's discharge. Each patient had evaluation for issues upon admission, discharge, standard outpatient department follow-up, and emergency department visits specifically for shunt complications.

The main result was the occurrence of shunt infection or dysfunction. According to previous research,[14] shunt infection is defined as the detection of a bacterial pathogen in the cerebrospinal fluid (CSF) reservoir or an increase in the number of white blood cells (more than 50 leukocytes/cumm) in the reservoir CSF, along with a positive blood culture. This definition applies when a patient experiences any of the following symptoms after surgery: (1) Fever is defined as a body temperature that exceeds 100.1°F. (2) Neurologic symptoms include headache, vomiting, or a Glasgow Coma Scale score of 14 or below. (3) stomach symptoms consist of stomach discomfort, abdominal distension, or abdominal tenderness. (4) Shunt malfunction refers to a malfunction in the shunt system. Malfunction was defined as any obstruction, overdrainage, underdrainage, or malposition and migration of the shunt catheter following surgery.

Dichotomous and categorical variables were presented using frequencies and percentages, while the mean was stated for continuous variables. Stratification was performed based on age, gender, duration of disease, aetiology, duration of surgery and priority of case. The relationship between the independent variables and the major outcome variable (shunt complication) was examined using a Chi-square test. The statistical significance was established at a significance level of $P < 0.05$. Bivariate logistic regression was conducted to get the unadjusted odds ratio (OR) along with a 95% confidence interval (CI). Subsequently, a multivariate logistic regression model was constructed for the variables that exhibited a significance level of $P < 0.01$ in the bivariate analysis. This model was used to generate the adjusted odds ratio (OR) along with a 95% confidence interval (CI). The analysis was conducted using SPSS 25 software (IBM, Chicago, IL, USA).

RESULTS

Out of 50 patients 12 (24%) came back with complications like Ventriculo Peritoneal(VP) shunt failures after the surgery as shown in figure 1. 20 % had shunt malfunction and 4% had infection.

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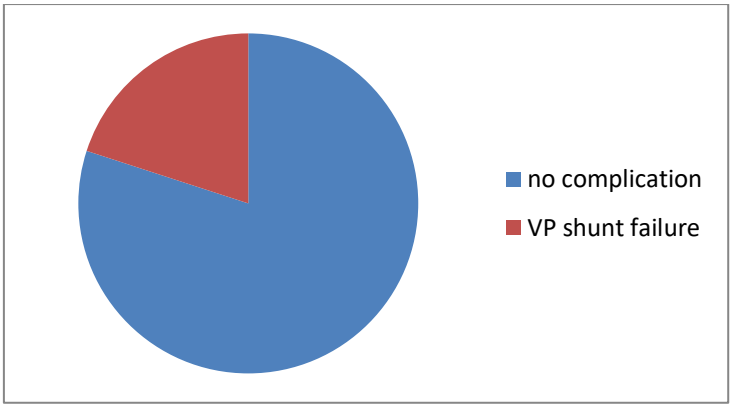

Figure 1 distribution of patients according to complication

In the present study 75% of cases were above the age of one year and 25% were below one year. Male cases were greater in number (66.6%) as compared to females (33.3%). 41.6% cases within one month of surgery and 58.3% cases came after one month of surgery. The main etiology was congenital aqueductal stenosis (41.6%). Time taken to perform the surgery was greater than one hour in 75% of subjects.66.6% of cases were emergency cases as shown in table 1.

Table 1 Characteristics of patients having VP shunt failure

Variable		N(%)
Age	Infants	3 (25)
	Older children (>1 year)	9 (75)
Gender	Male	8 (66.6)
	Female	4 (33.3)
DOI	1 month or less	5 (41.6)
	>1 month	7 (58.3)
Etiology	Congenital aqueductal stenosis	5 (41.6)
	Tumor	4 (33.3)
	Infection and inflammation	2 (16.6)
	Others	1 (8.3)
Duration of surgery (h)	<1	3 (25)
	>1	9 (75)
Priority of case	Routine	4 (33.3)
	Emergency	8 (66.6)

On bivariate logistic regression analysis, duration of surgery (P = 0.027) and priority of case (P = 0.001) were significantly correlated with outcome. On multivariate analysis, urgency of the case was only significantly associated with higher complications (P = 0.024) as shown in table 2.

Table 2 Association of complication with demographic and clinical variables

Variables		Bivariate regression analysis			Multivariate regression analysis		
		Unadjusted OR	95% CI	P value	Unadjusted OR	95% CI	P value
Age	Infants	0.43	0.16-1.13	0.08	1.25	0.42-3.98	0.698
	Older children	1			1		
Duration o f surgery	<1	2.57	0.15-0.88	0.027	2.34	0.98-5.97	0.067
	>1	1			1		
Priority of case	Emergency	3.98	1.70-9.34	0.001	3.32	1.18-9.34	0.024
	Routine	1			1		

DISCUSSION

VPS is the mainstay management for hydrocephalus in both adult and pediatric patients; however, besides the benefits, some complications may arise and lead to shunt failure.[15] In this study, we examined the complications associated with these shunts and conducted an analysis to identify the risk factors for shunt failure.

This study showed that one-fourth of the pediatric patients (24%) developed complications after VP shunting within 30 months of surgery. Shunt malfunction was more common than infection.

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Complications were found to be more frequent among male, older children other than infants, congenital aqueductal stenosis etiology, operation time more than 1 h, cases operated by resident doctors, and emergency procedures. Of them duration of surgery, and priority of case were significantly associated with failure. Shunt failure occurred as early as 1 week up to 30 months after surgery.

The overall incidence of shunt complications in our study was 24%, which is similar to or lower than what has been reported in the literature, including studies from industrialised countries. The previously documented rate of shunt failure in paediatric patients was 30%–40% at 1 year and about 50% at 2 years.[16-18] Shannon et al. discovered that over half of the patients (49%) encountered one or more instances of shunt failure within a two-year period of observation.[19] A multicenter prospective cohort study investigated the risk factors for shunt malfunction in paediatric hydrocephalus. The study found a failure rate of 33.2%, with 23% of the failures attributed to infection.[17] A further study conducted in Pakistan found that the rate of shunt failure was 23% after an average follow-up period of 11 months.[20] Our study found that shunt complications occurred with a mean follow-up period of 16 months. Among these complications, malfunction (20%) was more common than infection (4%).

The infection rate documented in the literature varies between 3% and 15%.[21]. The shunt infection rate of 4% observed in our study met the internationally acknowledged standard. The HCP Clinical Research Network Quality Improvement Initiative documented an infection rate of 5.7% in the year 2011.[22] The research group implemented a novel protocol involving the use of an antibiotic-impregnated catheter (AIC). They discovered that the infection rate associated with this new protocol was 6%, which was comparable to their previous infection rate of 5.7% regardless of whether the AIC was used or not.The number 18 is enclosed in square brackets [23]. For all patients in our research, a standard catheter was utilised primarily for cost considerations.

The majority of shunt infections arise shortly after surgery. Choux et al. discovered that the majority of the infections (90%) took place within the initial 6-month period.[24] A further investigation conducted by McGirt et al. revealed that infection accounted for 45% of the instances of failure occurring within the initial month.[25] Regarding our situation where infections took place within the initial 2 months following the surgery, with half of them occurring in the first month. The predominant organism observed was coagulase-negative Staphylococcus, accounting for 50% of the cases, while Staphylococcus aureus accounted for 17%, consistent with findings from prior investigations. [14]

We did not assess the effect of comorbidities or any other simultaneous surgical procedure or neurosurgical intervention prior to the shunt, which may have altered the result and serve as a limitation to our study

CONCLUSION

The incidence of shunt complications in paediatric patients with hydrocephalus who underwent their initial ventriculoperitoneal (VP) shunt surgery was 24%. Logistic regression study revealed that the lengthier duration of operation and the priority of the case (emergency) were identified as separate risk variables for shunt complications. It is advisable to conduct a bigger prospective cohort study to further analyse the risk variables that contribute to shunt failure. This study will aid in reducing the morbidity and mortality rates related with shunt failure.

REFERENCES

1. Nassar BR, Lippa CF. Idiopathic normal pressure hydrocephalus: a review for general practitioners. Gerontol Geriatr Med. 2016;2:2333721416643702.
2. Dewan MC, Rattani A, Mekary R, Glancz LJ, Yunusa I, Baticulon RE, Fieggen G, Wellons JC, Park KB, Warf BC. Global hydrocephalus epidemiology and incidence: systematic review and meta-analysis. Journal of neurosurgery. 2018 Apr 27;130(4):1065-79.
3. Paff M, Alexandru-Abrams D, Muhonen M, Loudon W. Ventriculoperitoneal shunt complications: a review. Interdisciplinary Neurosurgery. 2018; 13:66-70.
4. Ammirati M, Raimondi AJ. Cerebrospinal fluid shunt infections in children: a study on the relationship between the etiology of hydrocephalus, age at the time of shunt placement, and infection rate. Childs Nerv Syst 1987; 3:106–9.
5. Serlo W, Fernell E, Heikkinen E, Anderson H, von Wendt L. Functions and complications of shunts in different etiologies of childhood hydrocephalus. Childs Nerv Syst 1990; 6:92–4.
6. Choux M, Genitori L, Lang D, Lena G. Shunt implantation: reducing the incidence of shunt infection. J Neurosurg 1992; 77:875–80.
7. Pople IK, Bayston R, Hayward RD. Infection of cerebrospinal fluid shunts in infants: a study of etiological factors. J Neurosurg 1992; 77: 29–36.
8. Mancao M, Miller C, Cochrane B, Hoff C, Sauter K, Weber E. Cerebrospinal fluid shunt infections in infants and children in Mobile, Alabama. Acta Paediatr 1998; 87:667–70.
9. Kestle JR, Hoffman HJ, Soloniuk D, Humphreys RP, Drake JM, Hendrick EB. A concerted effort to prevent shunt infection. Childs Nerv Syst 1993; 9:163–5.
10. Bayston R, Leung TS, Wilkins BM, Hodges B. Bacteriological examination of removed cerebrospinal fluid shunts. J Clin Pathol 1983; 36: 987–90.
11. Shapiro S, Boaz J, Kleiman M, Kalsbeck J, Mealey J. Origin of organisms infecting ventricular shunts. Neurosurgery 1988; 22:868–72.
12. Odio C, McCracken GH Jr, Nelson JD. CSF shunt infections in pediatrics: a seven-year experience. Am J Dis Child 1984; 138:1103
13. Kulkarni AV. Questionnaire for assessing parents' concerns about their child with hydrocephalus. Dev Med Child Neurol. 2006;48(2):108–113.
14. Lee JK, Seok JY, Lee JH, Choi EH, Phi JH, Kim SK, et al. Incidence and risk factors of ventriculoperitoneal shunt infections in children: A study of 333

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consecutive shunts in 6 years. J Korean Med Sci 2012;27:1563-8
15. Khan F, Rehman A, Shamim MS, Bari ME. Factors affecting ventriculoperitoneal shunt survival in adult patients. Surg Neurol Int. 2015;6:25.
16. Browd SR, Ragel BT, Gottfried ON, Kestle JR. Failure of cerebrospinal fluid shunts: Part I: Obstruction and mechanical failure. Pediatr Neurol 2006;34:83-92.
17. Riva-Cambrin J, Kestle JR, Holubkov R, Butler J, Kulkarni AV, Drake J, et al. Risk factors for shunt malfunction in pediatric hydrocephalus: A multicenter prospective cohort study. J Neurosurg Pediatr 2016;17:382-90.
18. Buster BE, Bonney PA, Cheema AA, Glenn CA, Conner AK, Safavi-Abbasi S, et al. Proximal ventricular shunt malfunctions in children: Factors associated with failure. J Clin Neurosci 2016;24:94-8.
19. Shannon CN, Acakpo-Satchivi L, Kirby RS, Franklin FA, Wellons JC. Ventriculoperitoneal shunt failure: An institutional review of 2-year survival rates. Childs Nerv Syst 2012;28:2093-9.
20. Khan F, Shamim MS, Rehman A, Bari ME. Analysis of factors affecting ventriculoperitoneal shunt survival in pediatric patients. Childs Nerv Syst 2013;29:791-802.
21. Kulkarni AV, Drake JM, Lamberti-Pasculli M. Cerebrospinal fluid shunt infection: A prospective study of risk factors. J Neurosurg 2001;94:195-201.
22. Kestle JR, Riva-Cambrin J, Wellons JC 3rd, Kulkarni AV, Whitehead WE, Walker ML, et al. A standardized protocol to reduce cerebrospinal fluid shunt infection: The hydrocephalus clinical research network quality improvement initiative. J Neurosurg Pediatr 2011;8:22-9
23. Kestle JR, Holubkov R, Douglas Cochrane D, Kulkarni AV, Limbrick DD Jr., Luerssen TG, et al. A new hydrocephalus clinical research network protocol to reduce cerebrospinal fluid shunt infection. J Neurosurg Pediatr 2016;17:391-6.
24. Choux M, Genitori L, Lang D, Lena G. Shunt implantation: Reducing the incidence of shunt infection. J Neurosurg 1992;77:875-80
25. McGirt MJ, Leveque JC, Wellons JC 3rd, Villavicencio AT, Hopkins JS, Fuchs HE, et al. Cerebrospinal fluid shunt survival and etiology of failures: A seven-year institutional experience. Pediatr Neurosurg 2002;36:248-55.