Journal of Paediatric Surgeons of Bangladesh (2021) Vol. 12 (1 & 2)
Official Journal of the Association of Paediatric Surgeons of Bangladesh

Journal of Paediatric Surgeons of Bangladesh

Original Article

Outcomes and Predictors of Ventriculoperitoneal Shunt Failure in Children with Hydrocephalus

Hossain M D[1], Ferdous K M N[2], Rahman A[3]

Abstract

Background: Pediatric hydrocephalus is a common neurological condition requiring surgical intervention, primarily through ventriculoperitoneal (VP) shunt placement. Despite widespread use, VP shunt systems face complications, with failure rates remaining high, particularly in low- and middle-income countries (LMICs). Identifying risk factors for shunt failure is critical for improving outcomes. This study aimed to determine the incidence, types, timing, and predictors of VP shunt failure in children with hydrocephalus at a tertiary pediatric neurosurgical center in Bangladesh.

Methods: This prospective observational study was conducted in the Department of Pediatric Neurosurgery, Bangladesh Shishu Hospital and Institute, from July 2021 to June 2024. A total of 226 pediatric patients (aged 0–18 years) who underwent primary or revision VP shunt procedures were included in this study. Baseline demographic and clinical data were collected. Patients were followed for one year postoperatively to assess shunt failure incidence and timing. Statistical analyses included chi-square and t-tests to identify risk factors associated with failure.

Results: The overall shunt failure rate was 32.7%, predominantly due to mechanical obstruction (20.4%) and infection (10.2%). Most failures occurred within six months post-surgery (75.7%). Significant predictors of failure were age under six months (p=0.004), emergency surgery (p=0.024), post-infectious hydrocephalus (p=0.001), and longer surgery duration (p<0.001).

Conclusion: VP shunt failure in pediatric hydrocephalus is influenced by patient age, surgical urgency, etiology, and operative factors. Tailored surgical strategies and stringent perioperative care are essential to improve outcomes in this vulnerable population.

Keywords: Ventriculoperitoneal shunt, hydrocephalus, pediatric neurosurgery, shunt failure, risk factors, Bangladesh.

1. Associate Professor
   Department of Pediatric Neurosurgery, Bangladesh Shishu Hospital and Institute, Dhaka, Bangladesh
2. Professor (CC)
   Department of Pediatric Surgery and Stem cell therapy Unit, Bangladesh Shishu Hospital and Institute, Dhaka, Bangladesh
3. Professor and Head
   Department of Neonatal Surgery and Head Division of Pediatric Surgery, Bangladesh Shishu Hospital and Institute, Dhaka, Bangladesh

Correspondence to: Dr. Md. Delwar Hossain
Associate Professor, Department of Pediatric Neurosurgery
Bangladesh Shishu Hospital and Institute, Dhaka, Bangladesh
Email: delwarhossaindr.dsh@gmail.com

Introduction:

Hydrocephalus, defined by an overload of cerebrospinal fluid (CSF) inside the brain's ventricles, is frequently found in children and affects both their intellectual growth and daily life. It occurs in about 0.5 to 1 in 1,000 live births globally and typically leads to emergency neurosurgical treatment for children[1,2]. The standard treatment is to insert a ventriculoperitoneal (VP) shunt, which channels fluid from the brain's ventricles to the abdomen to relieve pressure on the brain and avoid more harm[3].

Even though VP shunt systems help patients, they are often troubled by mechanical problems, infections and migrations that must be fixed by revision surgery[4]. Shunts have a higher risk of failure in the first year, and more than half of these cases require another opera

tion within two years[5,6]. Problems in the early stages are mostly mechanical, but infections tend to appear in the later, subacute stage after the operation[7,8].

Patients in Bangladesh and similar regions, who have shunt complications, are affected more than others because they have less access to neurosurgeons, tend to present their symptoms late and lack proper follow-up opportunities[9]. Before, studies from regional institutions found that failed CSF shunt surgeries happen in between 20% and 50% of patients and this is often linked to individual cases, the surgical method and postoperative management[10,11]. Because congenital stenosis, post-infectious challenges, and intraventricular bleeding can all be causes, it adds more difficulties in managing and predicting these outcomes[12].

Risk factors for shunt failure have been extensively explored in the literature. Younger age, particularly infants under six months, has consistently been associated with a higher risk of shunt malfunction, potentially due to immature immune systems and technical difficulties during surgery[13,14]. Emergency surgeries, often performed under suboptimal conditions, have also been linked to higher complication rates compared to elective procedures[15]. In addition, longer operative durations and underlying post-infectious etiologies are significant contributors to poor shunt survival[16].

However, there remains a lack of context-specific data from Bangladesh regarding the incidence, timing, and predictors of VP shunt failure in children. Understanding these variables is essential for developing targeted strategies to reduce complications and improve outcomes. While international studies provide useful insights, local variations in healthcare delivery, patient demographics, and etiological profiles necessitate region-specific research.

This study aims to fill that gap by examining the outcomes and predictors of VP shunt failure in a large cohort of pediatric patients at a leading neurosurgical center in Bangladesh. By analyzing patient demographics, clinical presentations, surgical factors, and postoperative complications, the study seeks to identify key risk factors associated with shunt failure. This evidence can inform surgical planning, patient counselling, and resource allocation for pediatric hydrocephalus management in similar settings.

Methodology & Materials

This prospective observational study was conducted at the Department of Pediatric Neurosurgery, Bangladesh Shishu Hospital and Institute, Dhaka, a tertiary level hospital yearly admitted patients are more than ten thousand with an organized strong manpower and wide range of surgical expertise from July 2021 to June 2024. A total of 226 pediatric patients diagnosed with hydrocephalus and undergoing ventriculo-peritoneal (VP) shunt surgery were included.

Sample Selection

Inclusion Criteria:

- Children aged 0–18 years with a clinical and radiological diagnosis of hydrocephalus
- Underwent primary or revision VP shunt surgery
- Provided informed consent from parents or guardians

Exclusion Criteria:

- Patients with prior endoscopic third ventriculostomy (ETV)
- Lost to follow-up within the study period
- Patients who hadother gross congenital anomalies.

Data Collection Procedure: Data were prospectively collected using a standardized case report form to capture demographic details, clinical presentation, hydrocephalus etiology, surgical details, and postoperative outcomes. The surgical duration was recorded intraoperatively. Follow-up assessments were conducted at regular intervals up to one-year post-surgery to monitor shunt functionality and to detect failures. Clinical assessments were performed by experienced neurosurgeons, and all relevant surgical and postoperative data were documented accurately and consistently. Data entry was cross-checked to ensure reliability and to minimize errors.

Ethical consideration: This study received ethical approval from the Institutional Review Board of Bangladesh Shishu Hospital. Written informed consent was obtained from the parents or guardians before inclusion. Participant confidentiality was strictly maintained by anonymizing the data and limiting access to authorized personnel only.

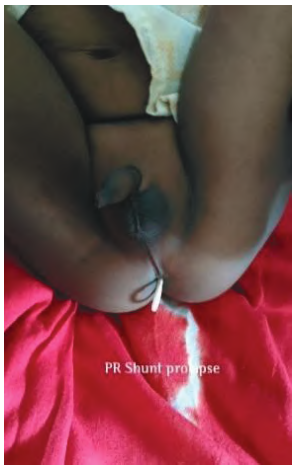
Statistical analysis: Data were analyzed using SPSS version 25.0. Descriptive statistics were used to summarize the demographic and clinical characteristics. Inferential statistics, including chi-square and independent t-tests, were used to assess the association between risk factors and shunt failure. Statistical significance was set at $p < 0.05$.

A-Non-functioning VP shunt

B- CSF Varix

C- CSF leakage through the subcutaneous tunnel

D- Over drainage of CSF



E- Extrusion of shunt tube through anus

F- Extrusion of shunt tube through para spinal lumber region

G- Extrusion of shunt tube through abdominal wound

Figure I: Children with hydrocephalus

Table I: Baseline Characteristics of the Study Population (n = 226)

Characteristic		Number of patients (n)	Percentage (%)
Mean age at surgery (months)		6 ± 4	
Age group	<6 months	125	55.3
	6–12 months	81	35.8
	>12 months	20	8.8
Gender	Male	118	52.2
	Female	108	47.8
Etiology of hydrocephalus	Congenital aqueductal stenosis	108	47.8
	Post-infectious	32	14.2
	Communicating hydrocephalus	16	7.1
	Blockage of ventricular end	29	12.8
	Blockage of peritoneal end	12	5.3
	Intra ventricular haemorrhage	7	3.1
	Others	22	9.7
Type of surgery	Initial shunt	164	72.6
	Revision	62	27.4
Surgery urgency	Elective	215	95.1
	Emergency	11	4.9
Mean duration of surgery (minutes)		65 ± 15	

Table I summarizes the demographic and clinical characteristics of the 226 children included. The mean age at surgery was 6 ± 4 months, with 55.3% aged under 6 months. Males comprised 52.2% of the cohort. The leading etiology was congenital aqueductal stenosis (47.8%), followed by post-infectious hydrocephalus (14.2%). Most patients underwent initial shunt placement (72.6%) electively (95.1%). The average surgery duration was 65 ± 15 minutes.

Table II: Incidence and Types of Shunt Failure

Failure Type	Number of Cases (n)	Percentage (%)
Mechanical obstruction	46	20.4
Infection	23	10.2
Abdominal pseudocyst	3	1.3
Shunt migration/ disconnection	2	0.9
Total shunt failures	74	32.7

Table II reports shunt failure incidence and classification. Out of 226 patients, 74 (32.7%) experienced shunt failure. Mechanical obstruction was the predominant failure type, accounting for 20.4%, followed by infections at 10.2%. Less frequent complications included abdominal pseudocyst (1.3%) and shunt migration or disconnection (0.9%).

Table III: Timing of Shunt Failure Post-Surgery (n=74)

Time Interval	Number of Failures (n)	Percentage of Failures (%)
Within 1 month	27	36.5
1–6 months	29	39.2
6–12 months	12	16.2
After 12 months	6	8.1
Total	74	100.0

Table III details the timing of shunt failure among the 74 affected cases. Failures were most common within the first six months after surgery (75.7%), with 36.5% occurring within one month and 39.2% between one and six months. Failures beyond one-year post-surgery were less common, at 8.1%.

Table IV: Risk Factors Associated with Shunt Failure

Clinical Variable	Shunt Failure (n = 74)	No Failure (n = 152)	p-value
Age < 6 months	51 (68.9%)	74 (48.7%)	0.004
Emergency Surgery	7 (9.5%)	4 (2.6%)	0.024
Post-Infective Hydrocephalus	19 (25.7%)	13 (8.6%)	0.001
Mean Duration of Surgery	71.2 ± 11.4 min	61.6 ± 9.3 min	<0.001

Table IV compares clinical variables between patients with and without shunt failure. Significant associations with failure included age under 6 months (68.9% vs. 48.7%, p=0.004), emergency surgery (9.5% vs. 2.6%, p=0.024), post-infectious hydrocephalus (25.7% vs. 8.6%, p=0.001), and longer mean surgery duration (71.2 ± 11.4 minutes vs. 61.6 ± 9.3 minutes, p<0.001).

Discussion

The present study provides valuable insights into the outcomes and determinants of ventriculoperitoneal (VP) shunt failure in pediatric hydrocephalus in a tertiary care setting. Our observed failure rate of 32.7% aligns with prior findings, which typically range between 20% and 40%[1,4]. This consistency suggests a persistent global challenge in ensuring long-term shunt functionality despite advances in neurosurgical techniques.

Mechanical obstruction was the most common cause of failure in our study, accounting for 20.4% of cases. This is consistent with findings by Fayaz et al., who reported mechanical issues, particularly proximal catheter blockage, as a leading cause of malfunction in pediatric patients[17]. These blockages are often the result of choroid plexus or cellular debris occluding the catheter tip, especially in infants. Infection was the second most common cause (10.2%), similar to results described by Hanak et al., who identified infection rates of 8–12% in pediatric populations[18]. The first six months following shunt placement were found to be the most vulnerable period for failure, in agreement with McGirt et al., who showed that early failure is typically due to technical and infectious complications[6].

Age under six months significantly predicted shunt failure in our cohort. Infants possess smaller ventricular systems, fragile tissues, and immature immune responses, which increase the risk of obstruction and infection. This observation is well-supported in the literature. Tuli et al. highlighted age as a critical factor, demonstrating that infants have higher failure rates and require more frequent revisions than older children[19]. Berry et al. similarly found age under one year to be associated with reduced shunt survival[20]. Our results emphasize the need for enhanced surveillance and individualized perioperative planning for this vulnerable age group.

Emergency surgery also emerged as a significant risk factor for shunt failure. In emergency settings, insufficient time for preoperative optimization may lead to higher infection rates and compromised surgical precision. Paudel et al. found that patients undergoing urgent VP shunt procedures had a significantly higher risk of early failure compared to those undergoing elective surgeries[21]. Elective surgery allows for better planning, proper sterilization, and stabilization of the patient's condition, contributing to improved outcomes.

Postinfectious hydrocephalus was another important predictor of failure. Infections such as meningitis not only damage cerebrospinal fluid (CSF) pathways but also increase the risk of postoperative complications. Hossain et al. noted that Bangladeshi patients with post-infective hydrocephalus had significantly more complications and a higher revision rate than those with congenital hydrocephalus[22]. This correlation may be due to residual inflammation, loculated ventricles, and pre-existing CSF contamination, which predispose patients to shunt failure.

The association between prolonged operative duration and failure was also noted. Longer surgeries may increase tissue exposure and raise the likelihood of contamination and technical errors. Venable et al. observed a higher rate of shunt revisions when the duration of surgery exceeded 60 minutes[16]. Thus, while surgical accuracy must not be compromised, improving intra-operative efficiency is essential in reducing complications. Interestingly we found many patient presented to us with tube extrusion following wound infection.

Although the majority of cases in this study were elective (95.1%), failure was more frequent in emergency cases, reinforcing the benefits of planned procedures. Lazarus et al. documented lower failure rates in patients who underwent scheduled surgeries in a South African pediatric cohort23. This supports the need for strong preoperative protocols and multidisciplinary coordination.

Our findings reinforce broader trends observed in both high- and low-resource settings. While shunt technology and surgical expertise continue to advance, the rates of failure remain a concern, particularly in developing countries where infectious causes of hydrocephalus dominate. As highlighted by Salek et al., addressing these systemic healthcare challenges requires integrating public health strategies with neurosurgical care to reduce the incidence of preventable complications[9].

Overall, the results underscore the multifactorial nature of VP shunt failure, with patient-related factors (age and etiology), surgical timing, and operative factors all contributing. Our study highlights the importance of tailored patient assessment, optimization of surgical conditions, and vigilant postoperative monitoring, especially in younger children and those undergoing emergency or post-infective shunt placement.

Future research should focus on improving shunt design to minimize obstruction, refining perioperative infection control practices, and developing clinical decision tools that incorporate known predictors to guide the timing and technique. Addressing these

areas could substantially improve outcomes in pediatric hydrocephalus care, particularly in settings similar to ours in the future.

Conclusion

This study highlights a substantial ventriculoperitoneal shunt failure rate of 32.7% in children with hydrocephalus, primarily due to mechanical obstruction and infections. Younger age (<6 months), emergency surgery, post-infectious etiology, and prolonged operative time significantly increased the risk of failure. These findings underscore the importance of individualized surgical planning and vigilant postoperative care to improve shunt survival and patient outcomes in the management of pediatric hydrocephalus.

References

1. Reddy GK, Bollam P, Caldito G. Long-term outcomes of ventriculoperitoneal shunt surgery in patients with hydrocephalus. World neurosurgery. 2014;81(2):404-10.
2. Limwattananon P, Kitkhuandee A. Ventriculoperitoneal shunt failure in pediatric patients: an analysis of a national hospitalization database in Thailand. Journal of Neurosurgery: Pediatrics. 2021;28(2):128-38.
3. Wright Z, Larrew TW, Eskandari R. Pediatric hydrocephalus: current state of diagnosis and treatment. Pediatrics in review. 2016;37(11):478-90.
4. Khan F, Shamim MS, Rehman A, Bari ME. Analysis of factors affecting ventriculoperitoneal shunt survival in pediatric patients. Child's nervous system. 2013; 29:791-802.
5. Paul SK, Islam R, Ghosh PK, Biswas PK, Hossain D, Rashid MA. Complications of Paediatric Ventriculoperitoneal (VP) Shunt: Experience in A Tertiary Care Hospital. Dhaka Shishu (Children) Hospital Journal. 2021;37(2):129-34.
6. McGirt MJ, Leveque JC, Wellons III JC, Villavicencio AT, Hopkins JS, Fuchs HE, George TM. Cerebrospinal fluid shunt survival and etiology of failures: a seven-year institutional experience. Pediatric neurosurgery. 2002;36(5):248-55.
7. McGirt MJ, Zaas A, Fuchs HE, George TM, Kaye K, Sexton DJ. Risk factors for pediatric ventriculoperitoneal shunt infection and predictors of infectious pathogens. Clinical infectious diseases. 2003;36(7):858-62.
8. Shah SS, Hall M, Slonim AD, Hornig GW, Berry JG, Sharma V. A multicenter study of factors influencing cerebrospinal fluid shunt survival in infants and children. Neurosurgery. 2008;62(5):1095-103.
9. Salek MA, Faisal H, Islam MA. Ventriculo-Peritoneal Shunt Infection: Three Years Experience in Combined Military Hospital, Dhaka. Journal of Armed Forces Medical College, Bangladesh. 2022;18(1):16-8.
10. Rahman MM, Khan SK, Khan RA, Islam R, Sarker MH. Endoscopic third ventriculostomy in children: problems and surgical outcome: analysis of 34 cases. Chinese Neurosurgical Journal. 2021;7(02):137-42.
11. Das S, Rahman A, Nath HD, Halder R, Ghosh D. Thirty days complications of pediatric hydrocephalus following ventriculoperitoneal shunt surgery. Infection. 2021; 10:8-33.
12. Pan P. Outcome analysis of ventriculoperitoneal shunt surgery in pediatric hydrocephalus. Journal of pediatric neurosciences. 2018;13(2):176-81.
13. Khan B, Hamayun S, Haqqani U, Khanzada K, Ullah S, Khattak R, Zadran N, Bibi Z, Khan AW, Khattak R, Khan A. Early complications of ventriculoperitoneal shunt in pediatric patients with hydrocephalus. Cureus. 2021;13(2).
14. Piatt, Jr JH, Carlson CV. A search for determinants of cerebrospinal fluid shunt survival: retrospective analysis of a 14-year institutional experience. Pediatric neurosurgery. 1993;19(5):233-42.
15. Ahmadvand S, Dayyani M, Etemadrezaie H, Ghorbanpour A, Zarei R, Shahriyari A, Emadzadeh M, Ganjeifar B, Zabihyan S. Rate and risk factors of early ventriculoperitoneal shunt revision: a five-year retrospective analysis of a referral center. World neurosurgery. 2020;134: e505-11.
16. Venable GT, Rossi NB, Jones GM, Khan NR, Smalley ZS, Roberts ML, Klimo P. The Preventable Shunt Revision Rate: a potential quality metric for pediatric shunt surgery. Journal of Neurosurgery: Pediatrics. 2016;18(1):7-15.
17. Fayaz M, Khalid A, Wani AA, Arif SH. Mechanical shunt failure in hydrocephalus: a common but

remediable complication with technical nuances. Egyptian Journal of Neurosurgery. 2024 Mar 11;39(1):15.

18. Hanak BW, Bonow RH, Harris CA, Browd SR. Cerebrospinal fluid shunting complications in children. Pediatric neurosurgery. 2017;52(6):381-400.

19. Tuli S, Drake J, Lawless J, Wigg M, Lamberti-Pasculli M. Risk factors for repeated cerebrospinal shunt failures in pediatric patients with hydrocephalus. Journal of neurosurgery. 2000;92(1):31-8.

20. Berry JG, Hall MA, Sharma V, Goumnerova L, Slonim AD, Shah SS. A multi-institutional, 5-year analysis of initial and multiple ventricular shunt revisions in children. Neurosurgery. 2008;62(2) :445-54.

21. Paudel P, Bista P, Pahari D, Sharma G. Ventriculoperitoneal shunt complication in pediatric hydrocephalus: risk factor analysis from a single institution in Nepal. Asian Journal of Neurosurgery. 2020;15(01):83-7.

22. Hossain MD, Rashid MA, Saifullah M, Ferdous KM. Ventriculoperitoneal (VP) Shunt Surgery and their Complications in Children: A Prospective Observational Study. East African Scholars Journal of Medical Sciences. 2023; 6(3): 94-99.

23. Lazarus JS, Ohonba E, Li YJ, Rohlwink UK, Figaji AA, Enslin JM. Ventriculoperitoneal shunt failures at Red Cross War Memorial Children's Hospital. Child's Nervous System. 2024;40(9):2871-81.