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Original Article (Pages: 17599-17605)

Evaluating the Results of Ventriculoperitoneal Shunt Surgery in Pediatric Patients

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Abstract

Background: Surgical placement of ventriculoperitoneal (VP) shunt constitutes the most common surgical treatment for hydrocephalus in pediatric patients. However, complications of VP shunt surgery are associated with increased mortality and morbidity. We aimed to investigate the results of ventriculoperitoneal shunt placement surgery in pediatric patients.

Methods: This is a single-center retrospective study performed from the 21st of March 2018 to the 21st of March 2022 in the neurosurgery ward of Akbar pediatric hospital, Mashhad, Iran. All pediatric patients undergoing ventriculoperitoneal shunt placement surgery with hydrocephalus were evaluated and followed.

Results: In total, 192 patients, including 107 males (56.6%), with a mean age of 58.85 ± 41.16 months, were studied. The mean follow-up period was 26.53 ± 13.61 months. Hydrocephalus was idiopathic in the majority of patients (86.5%). The most frequent indication for surgery was brain tumor (47.7%). Cognitive, verbal, and motor development were normal in 84.5%, 72.7%, and 41.8% of cases. Shunt infection and dysfunction occurred in 8.8% and 18.2% during the follow-up period, respectively. The overall mortality rate was 23.4%.

Conclusion: Our study provides valuable insights into the prevalence of complications and outcomes of VP shunt surgery in pediatric patients with hydrocephalus in northeastern Iran. Further research is warranted for developing measures to prevent or reduce the prevalence of these complications.

Key Words: Hydrocephalus, Surgery, Ventriculoperitoneal Shunt.

* Please cite this article as: Keykhosravi E, Rezaee H, Samini F, Ganjeifar B, Abouei Mehrizi MA, Toutounchian N, Hasanpour M. Evaluating the Results of Ventriculoperitoneal Shunt Surgery in Pediatric Patients. Int J Pediatr 2023; 11 (04):17599-17605. DOI: **10.22038/ijp.2023.70230.5176**

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Received date: Jan.22,2023; Accepted date:Apr.24,2023

1- INTRODUCTION

Disruptions in the production or reabsorption of Cerebrospinal Fluid (CSF) could lead to abnormal accumulation of CSF in brain ventricles, a serious condition known as hydrocephalus or hydrocephalus (1, 2). Hydrocephalus in neonates and infants is characterized by rapid enlargement of the head, fontanel bulging, vomiting, poor feeding, agitation, decreased muscular tone, drowsiness, and seizures. This condition presents symptoms of increased intracranial pressure in children and adults, including headache, nausea and vomiting, ataxia, impaired cognition, memory, decreased consciousness, and, if untreated, death (3). Hydrocephalus can be either acquired or congenital. The acquired type may occur any time after birth, most frequently because of head trauma, brain tumors, intraventricular hemorrhage, meningitis, and other infections of CNS (4). Congenital hydrocephalus is caused by complex interactions of genetic and environmental factors during embryogenesis. Common etiologies include spina bifida and other brain defects (4, 5). Hydrocephalus could also be categorized according to its pathogenesis. Communicating hydrocephalus is caused by an imbalance between CSF production and absorption, while non-communicating hydrocephalus arises due to obstruction of CSF flow (6-8).

Hydrocephalus is somewhat rare, with studies in the United States and Europe estimating its prevalence to be 0.5 to 4 in 1000 births. However, mortality rates are high without treatment; more than 50% of patients die before age 4, and 80% never reach adulthood (1, 9). Moreover, hydrocephalus constitutes the most frequent reason for brain surgery in pediatric patients. Surgical intervention is usually successful, although more than one surgery might be needed (6). Surgical placement of ventriculoperitoneal (VP) shunts accounts for the most used surgical intervention. Numerous studies have demonstrated the efficacy of these shunts in draining the extra CSF from brain ventricles and controlling intraventricular pressure (10-12). Nonetheless, surgical complications such as infection and subdural hemorrhage remain a severe and relatively usual problem. In particular, infections affect 5 to 15% of patients. Treating shunt infections poses several challenges and often requires surgery to remove or replace the catheter, which further increases mortality risk and neurologic sequels (13).

VP shunt placement surgery complications are associated with increased mortality, morbidity, hospital stay duration, and costs. The frequent use of shunts for treating hydrocephalus and a relatively high prevalence of complications after surgery necessitate the need to better control such complications, which warrants further research in this field. Thus, in this article the results of ventriculoperitoneal shunt placement surgery in pediatric patients was evaluated.

2- MATERIALS AND METHODS

2-1. Study design

This article is a single-center retrospective study performed from the 21st of March 2018 to the 21st of March 2022 in the neurosurgery ward of Akbar pediatric hospital, Mashhad, Iran.

2-2. Study population and variables

All under 18-year-old patients with hydrocephalus admitted to Akbar hospital for ventriculoperitoneal shunt placement surgery during the study period were enrolled. Patients' data, including age, gender, weight, and head circumference at birth and time of surgery, type of hydrocephalus, and the number of surgeries, were extracted from hospital archives. The patients were followed at one week, one month, three months, and

six months after surgery and were evaluated for signs of shunt dysfunction or infection (such as fever or local erythema). CSF analysis and culture were performed for the patients suspected of shunt infection.

2-3. Ethical considerations

The protocol of the current study was approved by the Research Ethics Committee of Mashhad University of Medical Sciences (Ethic code: IR.MUMS.MEDICAL.REC.1398.924). Parental consent for publication was also obtained.

2-4. Data analysis

Qualitative variables were reported as frequencies and percentages, and quantitative data were presented as mean ± standard deviation (SD) or median (interquartile range). Statistical analyses were performed using SPSS software version 24 (SPSS Inc., Chicago, Illinois, USA).

3- RESULTS

In total, 192 patients, including 107 males (56.6%) and 82 females (43.4%), with a mean age of 58.85 ± 41.16 months (range: 4-179 months), were studied. The mean follow-up period was 26.53 ± 13.61 months (range: 12-60 months). The average head circumference was 43.41 ± 5.61 cm before surgery and 48.14 ± 5.31 cm at the last follow-ups, which had normal distributions ($p < 0.05$). These findings are presented in **Table 1**.

Table-1: demographic characteristics of patients

Variable		N (%), mean ± SD	Range
Age (months)		58.82 ± 41.16	4-179
Gender	Male	107 (56.6)	-
	Female	82 (43.4)	-
Birthweight (gr)		2933.17 ± 850.31	920-4900
Weight before surgery (gr)		7589.47 ± 6408.51	920-39000
Head circumference before surgery (cm)		43.41 ± 5.61	35-58
Head circumference at last follow-up (cm)		48.14 ± 5.31	35-58

Hydrocephalus was idiopathic in most patients (86.5%). The most frequent indication for surgery was brain tumors (47.7%), followed by myelomeningocele (27.7%). Nearly two-thirds (65.7%) of patients had undergone surgery only once, while 6 cases (4%) needed more than three surgeries (**Table 2**).

Table-2: hydrocephalus and shunt surgery in patients

Variable		N (%)
Hydrocephalus type	Idiopathic	90 (86.5%)
	Non-idiopathic	14 (13.5%)
Shunt surgery indication	Brain tumors	31 (47.7%)
	Myelomeningocele	16 (24.7%)
	Meningitis	9 (13.8%)
	Hemorrhage	9 (13.8%)
Number of surgeries	One	99 (65.1%)
	Two	35 (23%)
	three	12 (7.9%)
	More than three	6 (4%)

Cognitive development according to age was normal in 84.5% of cases, while the other 15.5% showed retarded development. Verbal and motor development according to age was normal in 72.7% and 41.8%, respectively. Also, head circumference stopped increasing in 84.7% of patients after surgery. **Table 3** summarizes the developmental status of patients according to their latest follow-up.

Table-3: developmental status of patients according to their latest follow-up

Variable		N (%)
Cognitive development	Normal	93 (84.5%)
	Abnormal	17 (15.5%)
Verbal development	Normal	80 (72.7%)
	Abnormal	30 (27.3%)
Motor development	Normal	46 (41.8%)
	Abnormal	64 (58.2%)
Head circumference growth after surgery	Halted	102 (84.3%)
	Continued	19 (15.7%)

During the follow-up period, shunt infection and dysfunction occurred in 8.8% (15 cases) and 18.2% (31 cases), respectively. By the follow-up end, 45 cases had died, indicating a mortality rate of 23.4% in the study population (**Table 4**).

Table-4: patients' status according to their latest follow-up

Variable		N (%), mean ± SD	Range
Follow-up length (months)		26.53 ± 13.61	12-60
Parents satisfaction	Satisfied	87 (76.3%)	-
	Dissatisfied	27 (23.7%)	-
Shunt infection		15 (8.8%)	-
Shunt dysfunction		31 (18.2%)	-
Mortality		45 (23.4%)	-

4- DISCUSSION

Ventriculoperitoneal shunt surgery is one of the most used treatments for patients with hydrocephalus. In our study center, a tertiary care hospital in northeastern Iran, 192 pediatric patients with hydrocephalus had undergone surgery for shunt placement during the five-year period of the study. Shunt surgeries, although most effective, can be accompanied by various complications. Shunt infection and dysfunction are associated with considerable morbidities and may even lead to death. Thus, it is essential to obtain accurate data on such complications to take necessary measures to prevent them. The results of our study demonstrated that VP shunt surgery had effectively stopped head growth in most cases. Nonetheless, more than half of the patients suffered from abnormal motor development during their follow-up after surgery. In addition, our study population had considerable shunt infections and mortality rates.

Hydrocephalus represents a significant problem among neonates and infants worldwide, with a considerable burden on

healthcare systems and patients' families (14). Shunt placement surgery effectively treats this condition, but patients require routine follow-ups after surgery. Symptoms of infection and shunt dysfunction include fever, headache, photophobia, diplopia, nausea and vomiting, seizure, head and neck pain, surgery site redness and tenderness; and recurrence of hydrocephalus symptoms should be carefully monitored (15). Subdural hemorrhage is another important complication of shunt surgery seen in 5 to 10% of patients (16).

Prematurity, younger age, and CSF leak account for some of the critical risk factors of shunt infection (17). Ensuring proper disinfection of surgical tools, use of Antibiotic-Impregnated Shunts (AIS), and administering intraventricular antibiotics could decrease the risk of infection, lowering morbidity and mortality rates (18, 19).

In our study, most patients (65.7%) only required one surgery. Shunt dysfunction occurred in 18.2% of patients, while 8.8% experienced shunt infection. For comparison, in a study by Wilson et al. on 249 patients who had undergone VP shunt surgery, shunt dysfunction occurred in 14% of patients during the first year of follow-up (20). In another study, Sacar et al. evaluated 124 adult and pediatric cases of shunt surgery and reported an infection rate of 17.7% (21). Similarly, Pradyumna et al. investigated the outcomes of VP shunt surgery in 137 patients with hydrocephalus (mean age: 20.7 months). In their study, shunt blockade and infection occurred in 45.9% and 16.2% of the patients, respectively, and the mortality rate was determined to be 5.10% (22). Compared with the studies mentioned above, infection rates were lower in our study. However, we observed a considerably higher mortality rate in our study population. This discrepancy could be due to differences in the lengths of the follow-up period. Further research to determine mortality by cause can better explain our study's observed high death rate.

Although shunt surgery alleviates the complications of hydrocephalus, it has been well-established that many children with shunted hydrocephalus still suffer from developmental delay (23). Recently, Sobana et al. conducted a meta-analysis of 12 publications to assess the neurodevelopmental status of pediatric patients with non-infectious hydrocephalus who had undergone VP surgery. Compared with healthy controls, these patients were at significantly higher risks for mental and motor development delays (24). These findings align with our study, showing that a considerable portion of children with shunted hydrocephalus suffer from cognitive, verbal, and especially motor developmental delay. Indeed, more than half (58.2%) of our study population showed a motor delay in their follow-up period.

5- CONCLUSION

This study provides valuable insights into the prevalence of complications and outcomes of VP shunt surgery in pediatric patients with hydrocephalus in northeastern Iran. However, our study was limited by its retrospective nature. In addition, we only evaluated the all-time mortality and did not compare the different causes of death. Lastly, we did not assess the microbiology of shunt infections. Considering the frequent occurrence of complications after VP shunt surgeries, further research is warranted for developing measures to prevent or reduce the prevalence of these complications.

6- ACKNOWLEDGEMENTS

The authors would like to thank the clinicians who contributed to this case. Also, we would like to thank the pediatric ward personnel of Akbar Hospital for their kind cooperation.

7- CONFLICTS OF INTERESTS

None.

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