



Ventriculoperitoneal Shunt Surgery in Brunei Darussalam: A Population-Based Perspective

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Abstract

Objective Ventriculoperitoneal shunt surgery is commonly performed to treat hydrocephalus. We aimed to characterize the demographics, complications, and outcomes of patients who underwent ventriculoperitoneal shunt surgery in Brunei Darussalam.

Materials and Methods We conducted a retrospective study on patients who underwent ventriculoperitoneal shunt surgery at the Neurosurgery Department of the Raja Isteri Pengiran Anak Saleha Hospital and Brunei Neuroscience Stroke and Rehabilitation Centre between January 2015 and June 2020.

Statistical Analysis All statistical analyses were performed using the Statistical Package for the Social Sciences version 20 (IBM Corporation, Armonk, New York, United States). The χ^2 test, Student's *t*-test, and Mann–Whitney U test were performed for nominal, normally, and non-normally distributed variables, respectively. Multivariate logistic regression was used to assess the predictors of complications and shunt failure.

Results Fifty-three patients with a median age of 33 (interquartile range, 4–49) years were included. A total of 53 shunt operations were performed: 18 in the pediatric population and 35 in adults. The overall complication rate was 22.6%. Infection was the most common (9.4%) complication, with coagulase-negative staphylococci being the common organism causing the infection. The shunt failure rate (defined as removal or revision) was 20.8%. Univariate and multivariate analyses did not identify factors associated with complications or shunt failure.

Conclusion Ventriculoperitoneal shunt surgery, a common and technically non-demanding neurosurgical procedure, is associated with significant complications. We highlighted that shunt infection remains a concern and advocate practices to negate this risk.

Keywords

- ▶ cerebrospinal fluid
- ▶ complications
- ▶ infection
- ▶ hydrocephalus
- ▶ ventriculoperitoneal shunt

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Introduction

Ventriculoperitoneal shunt (VPS) surgery is considered the gold standard procedure for treating hydrocephalus, a neurological condition that affects children and adults across all ages. Hydrocephalus can occur due to congenital or secondary causes, including hemorrhage, trauma, infection, and intracranial tumors.¹ Prevalence rates of 88 cases in 100,000 children (age ≤ 18 years), 11 cases in 100,000 adults (age 19–64 years), and 175 cases in 100,000 elderly individuals (age ≥ 65 years) have been reported.²

The first attempt in shunting of cerebrospinal fluid (CSF) from the ventricle into the peritoneal cavity was performed by Kausch in 1905³. The first successful shunt surgery into the caval vein was performed by Nulsen and Spitz in 1949⁴, and the shunt valve was invented by John Holter in 1959.⁵ In general, VPS surgery involves the insertion of a ventricular catheter and a distal catheter, which is connected to a valve and diverts CSF from the ventricles into the peritoneal cavity. Among the different neurosurgical procedures, VPS is considered technically nondemanding, but it is associated with significant complications such as infection, obstruction, overdrainage, shunt disconnection, catheter leakage/breakage, shunt extrusion, migration, and catheter protrusion.

The complication rates of VPS surgery range from 20 to 40% and may lead to shunt failure. The incidence rate of shunt failure is higher in the first 6 months after VPS surgery.⁶ Moreover, the incidence rate of shunt failure due to infection is 15%, which can negatively affect clinical outcomes.^{7,8} Treating infection is difficult and costly, and requires prolonged hospital treatment, prolonged antibiotic courses, and revision of surgeries to remove the infected shunt and to place a new one once the infection has been treated. Shunt infection affects patients' health-related quality of life, cognitive function, and survival, with the number of infections per patient throughout their lifetime being an independent predictor of death.⁹

At present, the outcomes of patients with hydrocephalus who underwent VPS surgery locally are unknown. This study aims to characterize the outcomes and complications of patients who underwent VPS surgery in Brunei Darussalam.

Materials and Methodology

This retrospective study included patients who underwent VPS surgery in the Neurosurgery Department between January 2015 and June 2020. Our department provides nationwide neurosurgical care to a population of 448,311 at two centers—the Raja Isteri Pengiran Anak Saleha Hospital and the Brunei Neuroscience, Stroke and Rehabilitation Centre. Approval for this study was obtained from the Medical and Health Research and Ethics Committee, Ministry of Health (Reference: MHREC/MOH/2020/11[1]).

The study subjects included all patients who underwent VPS surgery based on the neurosurgery department operating theater registry, irrespective of the cause of hydrocephalus. Data for 56 patients were collected, but three patients were excluded from the final analysis because they had

incomplete data and did not have a minimum of 30-day follow-up. The data collected included age at the time of VPS surgery; sex; cause of hydrocephalus; previous history of intracranial infection; and surgical parameters, including indication, type of shunt valve and catheter, and side and site of the VPS surgery. Patient outcomes included complications from surgery (bleeding, infection, shunt malfunction, shunt blockage, shunt infection), time of complication, shunt failure (defined as the need for revision or removal of the VPS), and organism cultured, if infection was present.

In our practice, the following measures are generally followed: every patient with a history of central nervous system infection undergoing VPS surgery is assessed for absence of active infection. Screening for methicillin-resistant *Staphylococcus aureus* and *Acinetobacter baumannii* and good glycemic control are part of the preoperative preparations. Standardized surgical techniques (with different nuances by individual neurosurgeons) and operation theater practices are used. Special considerations include the use of intravenous antibiotic administration on general anesthesia induction, minimal handling of shunt tubes, gentamicin flushing of shunt tubes, and minimizing operative personnel numbers and movement in and out of the operating theater. In patients whose CSF pressure is expected to vary over time, programmable valves are used. Postoperatively, standard wound dressing and care and intravenous antibiotic are administered for 1 week.

Statistical Analysis

All statistical analyses were performed using the Statistical Package for the Social Sciences version 20 (IBM Corporation, Armonk, New York, United States). The χ^2 test, Student's *t*-test, and Mann–Whitney U test were performed for nominal, normally, and non-normally distributed variables, respectively. Shunt failure, defined as revision or removal of VPS, was calculated as the number of patients with revision or removal of VPS/total number of patients $\times 100\%$. Potential predictors of complications and shunt failure were screened using univariate analysis. Variables that met the cutoff value of *p*-value less than or equal to 0.1 in the univariate analysis were entered into a multivariate logistic regression with backward stepwise elimination. In the final model, predictors of complications and shunt failure in the overall population were identified based on *p*-value less than 0.05.

Results

Patient Demographics and Characteristics

Our cohort consisted of 53 patients (28 males), with a median age of 33 (interquartile range [IQR], 4–49) years, who underwent VPS surgery (► **Table 1**). Most patients underwent shunt surgery as treatment for acquired hydrocephalus (46/53, 86.8%) where the majority was caused by tumors obstructing the CSF pathways (28/53, 52.8%), followed by cerebrovascular causes (10/53, 18.9%). The median follow-up after shunt surgeries was 23 (IQR, 4–38) months.

Table 1 Patient demographics and characteristics

Demographics and characteristics	Overall (n = 53)
Male sex, n (%)	28 (52.8)
Median age, years (interquartile range)	33 (4–49)
Age groups, n (%)	
Pediatrics	18 (34.0)
Adult	35 (66.0)
Etiology, n (%)	
Congenital,	7 (13.2)
Aqueduct stenosis	4 (7.5)
Hydrocephalus	3 (5.7)
Acquired	46 (86.8)
Cerebrovascular	10 (18.9)
Infection	3 (5.7)
Normal pressure	2 (3.8)
Trauma	3 (5.7)
Tumor	28 (52.8)
Shunt characteristics, n (%)	
Fixed pressure	52 (98.1)
Programmable	1 (1.9)
Normal silicone catheter	53 (100)
Shunt location, n (%)	
Frontal	9 (17.0)
Parieto-occipital	44 (83.0)
Previous cerebrospinal fluid infection, n (%)	5 (9.4)

Ventriculoperitoneal Shunt Characteristics

A total of 53 shunt operations were performed (► **Table 1**)—18 (34%) pediatric and 35 (66%) adult shunts. Fixed pressure valves were mostly used (52/53, 98.1%), and in all cases, normal silicone catheters were used.

Shunt Complications and Failure

The overall complication rate for VPS surgeries was 22.6% (12/53, ► **Table 2**). The incidence rates of shunt and wound-related infections were 5.7 (3/53) and 3.8% (2/53), respectively, leading to an overall infection rate of 9.4%. Common isolated organisms for infection include coagulase-negative *staphylococci* and *Pseudomonas aeruginosa*.

Other complications included shunt under-/overdrainage (3/53, 5.7%) and blockage (4/53, 7.5%). There were no cases of shunt disconnection, catheter leakage/breakage, shunt extrusion, migration, or protrusion. The median time to complication was 135 (IQR, 51–204) days.

The overall shunt failure rate was 20.8% (11/53). One patient, who had tumor progression causing shunt blockage, did not undergo revision due to the poor prognosis.

Factors Affecting VPS Surgery Complications and Failure

Univariate and multivariate analyses did not identify factors associated with complications or shunt failure.

Discussion

VPS surgery remains the mainstay of treatment for hydrocephalus, and its widespread use in the neurosurgical field makes the identification and management of complications pertinent. Infections are known to be the most common complication following shunt surgery. In the UK Shunt registry, 15% of shunt revisions are for infection alone.¹⁰ Shunt infection has significant effects on patients' health-related quality of life, cognitive function, and intelligence quotient.¹¹ The number of shunt infection is also an independent predictor of death in patients requiring CSF shunts (hazard ratio, 1.66; 95% confidence interval, 1.02–2.72).⁷ In addition, its burden on healthcare services is also substantial—patients with shunt infections often require prolonged inpatient hospitalization, additional surgery to remove the infected shunt, placement of a temporary external ventricular drain, intravenous and possible intrathecal antibiotic administration, and further surgery to place a new shunt once the infection has been treated. Therefore, strategies to reduce VPS infection are of utmost important.¹²

In this study, the overall complication rate of 22.6% and shunt infection rate of 5.7% corroborated to the findings in the related literature published on VPS surgery complications and outcomes. A study by Reddy et al on long-term outcomes of VPS surgery presented an infection rate of 8.4% for primary VPS surgery.⁶ The use of antibiotic-impregnated shunt (AIS) catheters has been shown to reduce the infection rate significantly.^{13–15} Similar results have also been found with silver-impregnated shunts.^{16,17} Economic analyses have suggested that the use of impregnated shunts, although more costly than other shunts, resulted in fewer complications and can be cost-effective.^{18–23}

Recently, the BASICS trial, the largest multicenter randomized controlled study on VPS surgery conducted between 2013 and 2017, evaluated the clinical efficacy and

Table 2 Ventriculoperitoneal shunt complication and failure rates

Complication	Overall (n = 53)	Pediatrics (n = 18)	Adult (n = 35)
Complication, n (%)	12 (22.6)	5 (27.8)	7 (20.0)
Wound infection	2 (3.8)	1 (5.6)	1 (2.9)
Shunt infection	3 (5.7)	2 (11.1)	1 (2.9)
Shunt blockage	4 (7.5)	1 (5.6)	3 (8.6)
Shunt over-/under-drainage	3 (5.7)	1 (5.6)	2 (5.7)
Shunt failure, n (%)	11 (20.8)	4 (22.2)	7 (20.0)

cost-effectiveness of antibiotics- or silver-impregnated catheters in reducing VPS surgery-related infection.²⁴ The main significant finding was that AIS reduced the incidence rate of shunt infection from 6 to 2% compared with the standard shunts and that the clinical benefits of AIS were observed across all age categories. Our study exclusively comprised a non-antibiotic catheter cohort and our shunt infection rate of 5.7% is similar. Therefore, there is strong evidence to support the adoption of AIS in our patients who are having their first VPS insertion to decrease the infection rate.

In our study, fixed pressure shunts were used 98.1% times (52/53) and had a complication rate of 5.7% owing to under-/over-drainage. Farahmand et al reported a decreased 6-month failure rate in patients who used an adjustable shunt valve.²⁵ Lee et al showed that the rate of shunt revision was lower in patients with programmable valves following aneurysmal subarachnoid hemorrhage, and their use was more cost effective.²⁶ At the same time, patients with programmable devices also had better neurological outcomes. Therefore, in patients with hydrocephalus who may have variable intracranial pressures, programmable shunts, albeit being more expensive, should be considered.

As this was a retrospective study, limitations, including the loss of patient data, are inherent and reported findings should be regarded in this context. These results also represent a single-center experience. However, these limitations are overcome by being the sole provider of neurosurgical care in Brunei Darussalam. There was minimal referral bias and patients who were lost to follow-up would present to the department should they experience any VPS issues. The centralized health management system also aided in the long-term follow-up of patients and enabled the identification of late complications and clinical status. Lastly, these findings reflect the “real world” management of VPS in the country and it is as close as possible as to a population-based experience.

Conclusion

Our study presents the outcomes and failure rates of patients who undergo VPS surgery in Brunei Darussalam. We highlighted that shunt surgery, a common and technically nondemanding neurosurgical procedure, is associated with significant complications. Shunt infection remains a concern and we advocate for practices to negate this risk.

Ethics

The study was approved by the local ethics committee and conducted in accordance with the ethical principles outlined by the Declaration of Helsinki.

Funding

None.

Conflict of Interest

None declared.

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