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Original Article

Pediatric shunt revision analysis within the first year of shunt placement: A single center experience

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ABSTRACT

Background: Hydrocephalus is a common problem in neurosurgery with shunt placement remains the mainstay of the management. However, shunt placement generally requires following surgical procedures, including shunt revision. Despite the recent developments, the incidence of shunt failure remains high, approximately 30–51% in the 1st year following the shunt placement.

Methods: An observational retrospective study of pediatric neurosurgery patients whom underwent CSF shunting procedure, both primary and repeated VPS, VAS, CPS, and subdural-peritoneal shunt procedures between January 2018 and May 2019. The patients were observed for 12 months for potential complication requiring shunt revision following the shunt placement.

Results: A total of 142 patients underwent shunt placement. The shunt revision within 12 months was found in 26 patients (18.3%), 25 cases were VPS (96.2%) and one case was CPS (3.8%). The mean period of time between shunt placement to shunt revision was 3.96 months. Age of under 6 months old during the shunt placement showed significantly higher risk for shunt revision (RR 2.32 CI 1.13–4.74, $P = 0.018$). The most common diagnosis requiring shunt revision was congenital anomaly (16 cases, 61.5%). The most common cause of revision was shunt malfunction, with 21 cases (80.8%) followed by infected shunt with 5 cases (19.2%).

Conclusion: The 1st year observation showed relatively high rate for shunt revision. The patient underwent shunt procedure should be regularly followed up in long period for better evaluation of the outcome. The application of shunt registry in some countries appears to be efficient and beneficial for sustainable follow-up in patients underwent shunt placement.

Keywords: Cerebrospinal fluid shunt, Hydrocephalus, Pediatric, Shunt revision

INTRODUCTION

Hydrocephalus is defined as an enlargement of the ventricular system of the brain caused by obstruction in cerebrospinal fluid (CSF) flow, increased CSF production, and disturbance of its absorption into the systemic circulation.^[1] Hydrocephalus remains a common problem in the field of neurosurgery. Depending on the various etiologies and underlying pathophysiology, untreated hydrocephalus can lead to macrocephaly, cognitive dysfunction, and even death.

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Garne ²³ *et al.* reported the prevalence of congenital hydrocephalus of 4.65/10,000 births in Europe.^[5] Isaacs *et al.* in their study found that the prevalence of pediatric hydrocephalus between continents was almost higher in Africa 104.0/100,000 compared with North America 55.6/100,000.^[9]

Placement of CSF shunt for diversion remains a mainstay for treating patients with hydrocephalus, even though surgical complications remain high, becoming a medical and social problem. However, shunt complications generally require several surgical procedures, including shunt revision, during a patient's lifetime. Studies showed that the incidence of shunt failure is approximately 30–51% in the 1st year after shunt placement.^[2,3,7,10,13] Despite the developments in technology and design, shunt failure remains to be a problem. The causes of revision are infection, shunt obstruction, mechanical shunt failure, over-drainage shunt, and distal catheter site-specific failures.

Some studies have conveyed the pediatric shunt revision rate in the 1st year after the placement with varying result.^[2,5,9,10] However, the incidence of shunt failure following shunt revision in Indonesia remains unreported. Therefore, we presented a single-institution retrospective analysis regarding the CSF shunt revision ratio in the 1st year placement. This observation study was aimed to be the preliminary data for further and larger studies.

MATERIALS AND METHODS

A retrospective observational study of pediatric-neurosurgery patients requiring shunting procedure from January 2018 to May 2019. The period of implementation of Hydrocephalus Clinical Research Network (HCRN) protocol in Dr. Soetomo General Academic Hospital was started in 2018. The shunting procedures included are ventriculoperitoneal shunt (VPS), ventriculoatrial shunt (VAS), cystoperitoneal shunt (CPS), and subdural-peritoneal shunt. Shunting procedures performed outside Dr. Soetomo General Academic Hospital, follow-up period under 12 months, and shunt revisions following shunt exteriorization and foregoing revision were excluded from the study.

The patients' age was defined in months and categorized as neonates (within a month old), infants (age 1–12 months), and children (age >12 months). The diagnosis is categorized into infection, congenital, tumor, and hemorrhage. The shunt procedure is divided into emergency, performed in an emergency operating theater, and urgent, in a neurosurgery operating theater. The shunt procedures were in line with the HCRN protocol except for antibiotic-impregnated catheter (AIC) as our health-care system did not provide it. The shunt procedure was categorized into primary for the 1st time insertion and repeated insertion.

The patients were divided into those who underwent and did not undergo revision under 12 months of follow-up. The number of revision procedure was observed within a year after the shunt insertion. The cause of revision was divided into infected shunt and shunt malfunction.

The data were analyzed using IBM SPSS Statistics version 25 for Mac to describe the characteristics of patients underwent shunting and revision procedure and to estimate risk using univariate and Chi-square analyses.

RESULTS

A total of 142 patients underwent shunt insertion procedure in our center. Sixty-nine patients (48.6%) were male and 73 patients (51.4%) were female. The mean age for the reported shunt insertion was 37 months old [Table 1] with most patients being children over 12 months old (72 patients, 50.7%). VPS was the most common type of shunt found in 126 cases (88.7%), followed by VAS in 8 cases (5.6%), CPS in 6 cases (4.2%), and subdural-peritoneal shunt in 2 cases (1.5%) [Figure 1].

The shunt revision within 12 months was found in 26 patients (18.3%) with the mean period of time between the shunt procedure to the shunt revision was 3.96 months. The mean number of revisions within 12 months of follow-up was 1.42 [Table 1]. The most common shunt revision within 12 months was patients who underwent shunt procedure during infant age (age 29 days–12 months old) as many as

Table 1: Descriptive statistics.

	N	Mean	SD
Age of shunt	142	37.13	50.577
Shunt to revision period	26	3.96	3.143
Number of revision within 12 months	26	1.42	0.703

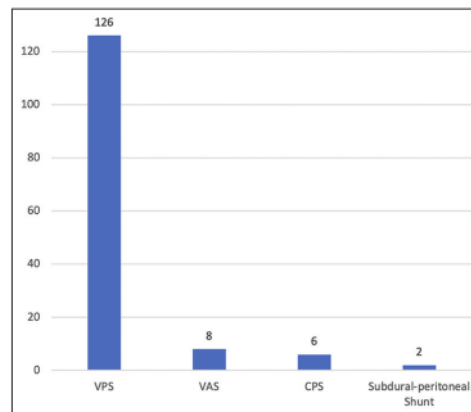


Figure 1: Distribution of types of shunt.

11 cases (42.3%) [Table 2]. Out of the 26 cases of revision, 25 were VPS (96.2%) and 1 case was CPS (3.8%). The most common diagnosis requiring shunt revision was congenital anomaly (16 cases, 61.5%). The number of shunt procedures requiring revision within 12 months in both emergency OT (13 cases, 50%) and central neurosurgery OT (13 cases, 50%) was equal. The most common cause of revision during the first 12 months after shunt procedure was due to shunt malfunction, as many as 21 cases (80.8%) followed by infected shunt in 5 other cases (19.2%).

The univariate analysis showed a significantly higher risk for shunt revision within 12 months (RR: 2.32 CI: 1.13–4.74, $P = 0.018$) on patients under the age of 6 months on the time of the shunt procedure [Table 3]. Location of operating theater during the initial shunt procedure, emergency or central neurosurgery, did not seem to affect the need of shunt revision within the first 12 months in the univariate analysis [Table 4].

DISCUSSION

The CSF shunt procedure conducted in our center is in line with the HCRN protocol 2016 except for the use of AIC. This specific designated catheter is suggested to be able to reduce infection rate among shunt procedures after the univariate

analysis^[11] although this catheter unfortunately is still not provided by the Indonesian health coverage system. The use of non-AIC catheter is still acceptable since the role of AIC remains unclear when compared to another infection prevention procedures.^[11]

Shunt insertion for CSF diversion becomes one of the procedures most prone to failure. Some studies showed the incidence of shunt failure of around 30–51% in the 1st year after the shunt insertion^[2,3,7,10,13] This number is almost 2-fold higher than the incidence of shunt revision during the first 12 months follow-up after the shunt procedure in our center which was 18.3%. There are several factors that might be involved in this difference including the nonexistence of a shunt registry in Indonesia compared to the developed countries where the shunt registry is available to accommodate the sustainable follow-up for patients who had a shunt procedure. It is very challenging for Indonesian pediatric neurosurgeons to evaluate shunt procedures since many patients do not get the routine follow-up and examination needed in the same hospital where the shunt procedure was performed.

The causes of revision in our center were classified into two general categories; malfunction and infection. The malfunctions that lead to shunt revision include shunt obstruction, mechanical shunt failure, over-drainage of the shunt, and distal catheter site-specific failures. The most common cause of shunt revision in our center was shunt malfunction, as many as 80.8% within the 12 months after the shunt procedure.

The advancements of recent technology to assist the shunt placement, for example, endoscopic shunt placement and frameless stereotactic image guidance have not yet resulted in the decrease of shunt failures leading to shunt revisions.^[7,13] This finding was disputable since the insertion of proximal (ventricular) catheter without endoscopy showed significantly higher risk for preventable shunt failure requiring shunt revision.^[4,13] Ventricular catheter obstruction due to cells or tissue is very common, accounting for more than 50% of shunt failures leading to shunt revision in pediatric patients.^[7,10,14,17] Recent study revealed the involvement of astrocyte and microglia attachment to the shunt surface. The protein adsorption in the shunt occurs within microseconds of catheter placement, leading to activation and migration of astrocytes and microglia to the site.^[7]

The risk of shunt revision was significantly higher in patients under 6 months old during the shunt procedure (RR: 2.32 CI: 1.13–4.74, $P = 0.018$). This finding is consistent with the previous studies where patients under 6 months old had significantly higher risk of shunt revision compared to rest of the study population ($P < 0.001$).^[13,16] The increasing age

Table 2: Age distribution in shunt revision.

	N	Percentage
Neonates	5	19.2
Infants	11	42.3
Children	10	38.5

Table 3: Risk relative for shunt revision in age under 6 months old.

	Value	95% confidence interval	
		Lower	Upper
For cohort revision within 12 months = Yes	2.317	1.133	4.740
Pearson Chi-square	Asymptotic significance (two sided): 0.018		

Table 4: Risk relative for shunt revision in emergency OT.

	Value	95% confidence interval	
		Lower	Upper
For cohort revision within 12 months = Yes	0.89	0.45	1.79
Pearson Chi-square	Asymptotic significance (two sided): 0.75		

showed significant association as protective factor in both univariate and multivariate analyses as each additional year was associated with 20% of decreasing the risk of shunt failure leading to shunt revision.^[3]

VPS was the most common type of shunt requiring revision in our center (96.2%). VPS was found to be a predictive factor for preventable shunt failure compared to the other types of shunt with the risk of shunt failure which is highest during the first 6–12 months.^[4,8,12] This novel finding, however, still requires further analysis as the recent studies remain inconclusive. The fact that VPS has been previously reported as the most common procedure for CSF diversion in pediatric hydrocephalus could also interfere with the true interpretation of these findings.^[4,17,15]

CONCLUSION

Shunt procedure has long been known to have complications leading to shunt revision. The 1st year of follow-up showed relatively high rates of shunt revision with continuously increasing risk over the year. Patients undergoing shunt procedures should be regularly followed up in long period for better evaluation of the outcome. The application of shunt registry in some countries is efficient and beneficial for sustainable follow-up in patients who had a shunt procedure.

Study limitation

This study has several limitations. The design of study was a retrospective single-center study, possibly preventing us to identify patients who underwent shunt revision in another hospital. The cause of shunt revision was classified into two major groups, infection and malfunction, which might require further investigation for better results. Future studies with multicenter involvement and longer follow-up period should be performed for better depiction and explanation of shunt revision in Indonesia.

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Declaration of patient consent

Patient's consent not required as patients identity is not disclosed or compromised.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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