CASE REPORT

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Shunt fracture as ventriculoperitoneal shunt complication in pediatric: a case series

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INTRODUCTION

Hydrocephalus is a condition in which there is an increase in intracranial pressure due to cerebrospinal fluid accumulation in the brain's ventricular system due to an imbalance in the production, flow, and absorption of cerebrospinal fluid.¹ Aqueduct stenosis, neural tube defects, developmental cysts, neoplasms, vascular malformation, and inflammation are the most common causes of hydrocephalus.³ This condition is detrimental in children because it can affect the brain, nerves, and surrounding tissues.⁴ It is estimated that there are 380,000 new cases every year worldwide.⁵

Operative procedures in hydrocephalus patients are generally used as the primary treatment. Two surgical methods are commonly performed as definitive therapy in cases of hydrocephalus, namely shunt and endoscopic third ventriculostomy (ETV). The ventriculoperitoneal (VP) shunt is the most frequently used type. VP shunt drains cerebrospinal fluid from the ventricles to the peritoneal space for absorption into the systemic circulation. However, their efficacy is still debated, even today.⁶ The shunt failure rate is about 30–40% in the first year and 50% in the second insertion year.⁷ It is recognized that a shunt carries a risk of complications that can occur throughout the patient's life, especially in children.⁸

Shunt fracture is one of the VP shunt failures or complications. The incidence of shunt fractures as an immediate shunt complication is rarely reported. A report from Qena stated that from 2012-2016 there were only 6.6% of shunt fractures compared to other shunt complications.⁹ Shunt fractures are generally related to shunt material choice. Naturally, shunt materials with annual use will become calcified, stiff, and brittle. Shunt fracture occurs because of a discontinuity, so the shunt flow is disturbed.¹⁰ Shunt fracture management could be complex. Patients can present with fulminant hydrocephalus or more insidious symptoms if left untreated.¹¹⁻¹⁰

Based on those mentioned above, this case series aims to describe our experience in treating shunt fractures and to find out each risk factor in this case, including clinical manifestations, nutritional status, and age of VP shunt insertion, at the tertiary care center Dr. Soetomo General Academic Hospital, Surabaya, Indonesia.

METHODS

This study was conducted at the Department of Pediatric Neurosurgery, Dr. Soetomo General Academic Hospital, Surabaya, Indonesia, between 2016 and 2021. Dr. Soetomo General Academic Hospital is a top referral and the largest academic hospital in eastern Indonesia. Children from birth to 18 years admitted as inpatients and had a confirmed diagnosis of VP shunt fracture in the database were included in the case series. Diagnosis of VP fracture is confirmed on...
Table 1. Evaluation and characteristics of pediatric hydrocephalus with shunt fracture

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<th>No</th>
<th>Sex</th>
<th>Age (Year)</th>
<th>Nutrition</th>
<th>Status*</th>
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<th>Age of previous Shunt Surgery (Months)</th>
<th>Onset of Complication (month)</th>
<th>Shunt Position</th>
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B: Boy; G: Girl; *Nutritional status in percentile; BW: Body Weight; BH: Body Height

**CASE REPORT**

**Table 1. Evaluation and characteristics of pediatric hydrocephalus with shunt fracture**

conventional radiographs (shunt series, which show the entire shunt length from skull to abdomen).

A retrospective audit of Dr. Soetomo General academic hospital database and five cases with VP shunt fractures were found within 6 years between 2016 when we diagnosed our first case in 2021. The hospital Database mainly includes clinical, laboratory and radiological patient information. Patient biodata, history, and clinical features of patients are summarized in Table 1.

Data were compiled from patient notes, pre-operative assessment forms, operative notes, imaging reports and follow-up documentation. Installment of elective VP shunt in pediatric patients was 375 cases and emergency VP shunt installation was 477 cases from 2016 to 2021, and found 5 hydrocephalus pediatric patients with shunt fractures. The incidence of shunt fracture was 0.58% (5/852) in 6 years. Clinical manifestations, imaging, and diagnosis were assessed for pre-procedural and post-procedural conditions. Patients were obtained from the patient polyclinic and the emergency department. Assessment of the prevalence of each risk factor in this case report includes clinical manifestations, age of VP shunt insertion, and a review of the literature on shunt fractures.

**RESULTS**

The mean age was 5.2 years, ranging from 4-8 years. All patients were diagnosed with shunt fracture and hydrocephalus. Four of five cases had poor nutritional status by their body weight (<50th percentile and <3rd percentile). Most patients underwent previous first shunt surgery with the ventricular shunt positioned in keen, and most of the shunt types were burr holes (Table 1). The following is the detailed description of each case below.

**First Case**

A 5-year-old boy was brought to the hospital for a scalp wound for over 2 months and a neck wound for 4 days. The scalp wound was getting bigger. No fever or vomiting was noted. Right and left VP shunt placement was performed when the patient was 2 months old and 4 years old. His body weight was 14 kg. Computed tomography (CT) scan of the head showed the tip of the VP shunt in the right lateral ventricle (Figure 1A). Abdominal X-ray showed a shunt fragment in the peritoneum cavity of the right ileac region (yellow arrow). The patient had shunt removal for the treatment (Figure 1C). The patient had improved clinical outcomes, such as reduced intracranial pressure and improved neurological function. The patient was discharged from hospital care. The patient was followed up 6 months later with improved clinical outcomes and a satisfactory result.

**Second Case**

A 4-year-old girl complained of persistent headaches and could not walk for 2 weeks. The patient had a VP shunt when she was 1 month old. Her body weight was 18 kg. A head CT scan was performed prior to the surgical procedure and showed the shunt tip in the left lateral ventricle (Figure 2A). The thoracoabdominal X-ray showed no shunt catheter along the shunt tract and the distal portion of the shunt completely migrated into the peritoneal cavity (yellow arrow).
the shunt tract and the distal portion of the shunt completely migrated into the peritoneal cavity (Figure 2B). The patient was planned and operated on for shunt revision. The patient was discharged home within 48 hours after surgery. The patient was followed up 3 months later with improved clinical outcomes. The headache pain symptoms have diminished, and the patient has begun to ambulate and exhibit an improved neurological status. A satisfactory result was reported from the parents.

Third Case
An 8-year-old boy came to the emergency department complaining of swelling in the right neck of the VP shunt line for 9 days. The patient had a history of VP shunt installation when he was 4 months old and shunt revision at 7 months of age. His body weight was 18 kg. A head CT scan showed hydrocephalus (Figure 3A). The thoracoabdominal X-ray showed no shunt catheter along the shunt tract and shunt fragment in the peritoneal cavity (Figure 3B). The patient underwent a shunt revision. After a six-month follow-up, the patient had improved clinical outcomes, including the swelling resolved. There is no pain or discharge at the surgical site and no complaints related to the shunt revision.

Fourth Case
A 5-year-old boy was hospitalized due to headache and vomiting for over 7 days. The patient had a VP shunt placed at the age of 2 months. His body weight was 17 kg. A head CT scan was performed before the surgical procedure (Figure 4A). The thoracoabdominal X-ray showed the distal portion of the shunt fracture entering the peritoneal cavity (Figure 4B). The patient was planned and operated on for a laparoscopic shunt extraction and VP shunt insertion (Figure 4C). The patient had improved clinical outcomes. The patient no longer experiences nausea or vomiting, and there are no symptoms of shunt leakage. The patient was then discharged from hospital care. The patient was followed up 6 months later with a good clinical outcome with no other complaints or observed neurological disturbances during the follow-up assessment. A satisfactory result was reported from the parents.

Fifth Case
A 4-year-old boy was brought by her parents to the emergency department due to vomiting and seizure. The patient also had a history of headaches in the last...
1 week prior to hospital admission. The patient had a VP shunt surgery when he was 5 months old and skull reconstruction surgery when he was 2 years old. His body weight was 16 kg. CT scan of the head was performed before the surgical procedure (Figure 5A). Abdominal X-ray showed a shunt fragment in the peritoneal cavity (Figure 5B). The patient underwent a laparoscopic shunt extraction and VP shunt revision. The improved clinical outcomes include symptoms of increased intracranial pressure that are no longer observed. Seizures are well controlled. There are no other complaints during the follow-up visit after a three-month follow-up period.

**DISCUSSION**

This study is an analysis of all cases treated within a period of 6 years, from 2016 to 2021. The inclusion criteria were all pediatric patients with shunt fractures. Clinical manifestations and diagnosis were assessed for pre-procedural and post-procedural conditions. Patients were obtained from the outpatient and the emergency department.

The clinical manifestations of shunt malfunction vary among age groups. Headache, lump in the shunt line, vomiting, and seizure were the main complaints of the 5 patients in this case series.11 Meanwhile, in adult patients, the patient's clinical manifestations were headache and vomiting because of intracranial hypertension due to flow obstruction in the shunt catheter. In some cases, shunt fractures do not even cause any symptoms.12,13 However, worsening can occur if this improvement is allowed to continue.

Four out of five cases had poor nutritional status based on their body weight (<50th percentile and <3rd percentile). Meanwhile, one case had good nutritional status (>50th percentile) (Table 1). Poor nutritional status may be an important risk factor for developing shunt fractures.14 Greater postoperative complications, such as shunt infection, were seen in the malnourished group and were reflected in the revised rate shunt rates were higher in this group. This incidence increased with decreasing nutritional levels.15 Our findings noted that most patients had poor nutritional status. However, no reports have specifically discussed the relationship between nutritional status and shunt fractures, so it is necessary to conduct further research to discuss the mechanism.

An 81% incidence of shunt malfunction was reported at 12 years of follow-up. The incidence of fracture or catheter disconnection was 13.6%.16 Calcification of the shunt catheter is a contributing factor to shunt fracture. Pathomechanism is theorized as a fibrous reaction that creates adhesion to soft tissue. This adhesion prevents the catheter from adjusting to the growing child. Child growth and height gain result in chronic tube stretching. The fragility of the shunt often causes fractures. The occipital and lateral cervical regions are the most common fracture sites. Repeated neck motion and continuous stretching will make the shunt susceptible to fracture in this series of cases.10,17 Early shunt insertion also results in a longer mechanical stress time and dissolution. All patients in this case series had a first VP shunt placed at less than one year old. Puberty is a significant factor in the occurrence of shunt fractures. Indicated for routine follow-up every 6 months between the ages of 10 and 16 years to evaluate the condition of the shunt.16,17 Age also contributes to shunt malfunction. High calcium and phosphate deposition at a younger age triggers calcification in a younger age group. Pediatric patients had a 4.22-fold tendency to undergo shunt revision.18 Patients with revised shunts also tended to develop shunt malfunction.19 Infection is the most feared complication in the young age group, known to be a contributing factor to impaired skin integrity which will affect shunt degradation. Shunt infection is defined as the isolation of organisms from ventricular fluid, shunt tube, reservoir or blood culture with clinical signs and symptoms suggestive of shunt infection or malfunction, such as fever, peritonitis, meningitis, signs of infection along the shunt tube, or other nonspecific symptoms such as headache, vomiting, altered mental status and seizures.20-23 If the shunt is infected, revision of the shunt or external ventricular drain may be necessary as indicated.

Currently, no guidelines govern the surgical decisions for shunt fractures patients. Because of the risk of worsening hydrocephalus, immediate surgical management should be performed if a neurologic deficit is present. However, conservative treatment with routine observation may still be considered in asymptomatic patients with shunt fractures, with the possibility that the patient can reach a shunt-free state. However, our study is limited by a retrospective study design that relies on the accuracy and availability of medical records. We lack a control group, making comparing and generalizing populations difficult.

A suggestion to address the limitations of this case series is to conduct a prospective cohort study, which would involve following a larger cohort of patients with similar conditions over time. This approach would provide more comprehensive data, including baseline characteristics, treatment outcomes, and long-term follow-up, leading to more robust and reliable conclusions.

**LIMITATION**

This case series is focused on a limited set of outcomes, which may not capture the full range of potential effects or provide comprehensive data on safety and efficacy. This can limit the ability to evaluate the intervention or treatment fully.

**CONCLUSION**

Shunt fracture is a VP shunt problem requiring shunt revision with incidence rates of 0.58% in 6 years. Knowing the process of shunt fracture is important as a modality to determine the next management. A comprehensive clinical and radiological examination is mandatory to rule out a shunt fracture. Routine follow-up with patients with VP shunt is an important thing that must be done to prevent further complications.

**CONFLICT OF INTEREST**

The authors declare that there is no conflict of interest regarding this manuscript.
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ETHICS CONSIDERATION
Ethical clearance is not applicable as no patient identity is disclosed. However, this study has followed COPE and ICMJE protocols regarding the publication ethics guidelines.

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AUTHOR CONTRIBUTIONS
Fachriy Balafif contributed to the conceptualization, data collection, writing, and editing of the study. Muhammad Arifin Parenrengi and Wihasto Suryaningtyas contributed to reviewing, editing, and finalizing the manuscript of the study.

REFERENCES