Ventriculoperitoneal shunt infection in Haji Adam Malik Hospital, Medan

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Abstract. Installation of ventriculoperitoneal shunts (VP) represented a substantial progress in the neurosurgical management of hydrocephalus in children. However, infection is the most common postoperative complication of a ventriculoperitoneal shunt. It is important because it is related to substantial morbidity and mortality, and exerts a negative impact on the quality of life of patients. We retrospectively analyzed all 20 cases of shunt infection from 2013 to 2016. The types of infections found were exposed shunts15 cases (75%), and 5 cases of ventriculitis (25%). Length of infection time which calculated from the beginning of surgery was 350.20 days or 11 months. The most common pathogen types are S. epidermidis followed by P. aeruginosa, E. coli, and A. baumannii. There were many risk factors for shunt infection, but the interesting fact was the level of pre-operative albumin. There was a significant difference between low albumin levels (<3.0) and normal albumin (≥3.0) levels against the risk of exposure shunt, p = 0.015. It means there is a significant difference between low pre-operative albumin and normal level for the risk of the exposed shunt.

1. Introduction
Infection is the most common post-operative complication of a ventriculoperitoneal shunt (VP shunt).[1] It happens almost 10% of all cases. Shunt infections are common in the first two to three months postoperatively.[2] The main pathogen cause of shunt infection is Staphylococcus epidermidis.[3] Management of shunt infections is shunt removal, external drain (EVD) installation, intraventricular antibiotic administration, and new shunt installation if cerebrospinal fluid (CSF) culture is sterile.[3]

The purpose of this retrospective study was to describe VP shunt infection occurring in the department of neurosurgery of Haji Adam Malik hospital Medan, North Sumatara. This hospital is the center of reference for patients with shunt infections.

2. Methods
Shunt infections are confirmed when the following criteria are; surgical wound infection or wound dehiscence, positive CSF culture of chamber shunt aspiration with sterile technique, or peritoneal infection. In the period of three years from 2013 to 2016, we obtained 20 patients who meet the above criteria. Medical record data from 20 patients were collected and then tabulated with age data, shunt installation etiology, duration of infection, bacterial culture, albumin level before surgery. Data analysis using chi-square is done to determine whether there was any difference in albumin levels in shunt infection patients.

3. Result
Total from 391 shunt installation over three years, there were 20 cases (5.1%) of shunt infections were seven male patients (35%) and 13 female patients (65%). The etiology of shunt insertion is congenital hydrocephalus with 11 cases (55%) and 9 cases (45%) of acquired hydrocephalus (including tumor, intraventricular hemorrhage).
The types of infections found were exposed shunts, 15 cases (75%), and 5 cases of ventriculitis (25%). Ventriculitis was a condition in which a positive CSF culture contained bacteria in the absence of an operative wound infection.

The mean age of the patient at the time of the first shunt VP shunt installation was 123.25 months with a minimum age of 1 month and a maximum of 780 months. The mean age of patients with shunt infection was 129.10 (SD = 208.28, min = 3 months, max = 780 months). The length of infection time which calculated from the beginning of surgery was 350.20 days or 11 months (SD = 630.87, min = 7 days, max = 2190 days).

**Table 1.** Patient’s age with shunt infection and time of infection from first shunt installation.

| Patient Age | Time of Infection |
|-------------|-------------------|
| 1 – 6 months| <10 days          |
| 7 – 12 months| 10 – 30 days     |
| 13 – 72 months| 31 – 60 days   |
| > 72 months  | >60 days          |
| **Total**    | **Total**         |

**Table 2.** Pre-operation albumin serum level of patient with VP shunt infection.

| Albumin Level | Frequency | Percentage |
|---------------|-----------|------------|
| Normal (≥ 3.0) | 7         | 35 %       |
| Low (< 3.0)    | 13        | 65 %       |
| **Total**      | **20**    | **20 %**   |

The most common pathogen types are *S. epidermidis* followed by *P. Auriginosa, E. Coli* and *A. Baumannii*, the table below shows the percentage of each pathogen.

**Table 3.** Pathogen type VP shunt infection.

| Pathogen     | Frequency | Percentage |
|--------------|-----------|------------|
| *S. Epidermidis* | 8         | 40 %       |
| *P. Auriginosa*  | 5         | 25 %       |
| *E. Coli*       | 4         | 20 %       |
| *A. Baumannii*   | 3         | 15 %       |
| **Total**       | **20**    | **100 %**  |

All patients CSF with shunt infection were taken and cultured with sensitivity and resistance to antibiotics, with results like the table below.

**Table 4.** Sensitivity and resistance test result.

| Culture | Antibiotic |
|---------|------------|
|         | Ciprofloxacin |
|         | Gentamycin  |
|         | Vancomycin  |
| Sensitive | Meropenem  |
|         | Polymixin  |
|         | Amikacin   |
| Resistant | Ampicillin |
|         | Amoxicillin |
|         | Benzyl Penicillin |
|         | Cefotaxim  |
Due to colonization of the shunt with bacteria belonging to the skin flora, infections are caused by intraoperative or early postoperative contamination with a subsequent positive bacteria mostly start within the first month and eight 60 days, 50% between 10 to 60 days. Several studies have revealed that infections due to the first literature ranges from 15 days to 12 months after shunt placement; 80% of the infections occur within three months, 90% within the first six months. Different data is in this study, 45% occurs in more than 60 days, 50% between 10 to 60 days. Several studies have revealed that infections due to Gram-positive bacteria mostly start within the first eight weeks after surgery. Therefore, most VP shunt infections are caused by intraoperative or early postoperative contamination with a subsequent colonization of the shunt with bacteria belonging to the skin flora. Secondary infectious events due to gram-negative bacteria and Candida spp. Tend to occur later in the clinical course.

Chi-square test was then performed to see the difference between the pre-operative albumin level and the risk of shunt exposed. With this test, we obtained \( p = 0.015 \) (\( p < 0.15 \)). OR = 16, this means that there is a difference in albumin levels and the lower albumin levels, the higher the risk of the exposed shunt.

4. Discussion

Ventriculoperitoneal shunts represented a major progress in the treatment of hydrocephalus. The draining of liquor into the peritoneal cavity proved to have significant benefits and became the standard therapy.[4] An infection of the VPS is the most serious complication of ventricular shunt therapy for hydrocephalus. It causes the highest morbidity and mortality and results in high follow-up costs to health care systems.[5]

The incidence of VP shunt infections [5] and the infection rate [6] vary from study to study. There are incidence rates of up to 39%; in recent studies, the incidence ranges from 5 to 10%. [7,8] In our center, the rates are 5.1%. Confirmed risk factors for VP shunt infections are [4]:

- Low gestational age and preterm birth.
- Age at shunt placement (a higher risk at a younger age).
- Etiology of hydrocephalus (increased risk of IVH, infectious etiology, or children with the malignant disease, chemotherapy-associated immunosuppression or long-term application of steroids above the Cushing threshold).[9]
- Postoperative CSF leaks caused by impaired wound healing and wound dehiscence.
- Several studies documented a significantly higher risk of infection for preterm infants.[10]

This association might be explained by the poorly developed humoral and cellular immune system, the immaturity of the skin barrier and the high density of colonizing bacteria on the skin of preterm infants treated in neonatal intensive care units.[11]

The infection rate is influenced not only by preterm birth but also by the age at shunt placement.[6] Infants < 6 months old run an increased risk [9]; 63% of the children with VPS infection were preterm infants, 29% neonates (\( \leq 4 \) weeks old) and 20% infants (5 weeks to 12 months old). Only 4.6% (1–7 years of age) and 1.6% (8–14 years of age) of the infections were in older children (\( p < 0.01 \)).[6] For each year the patient was younger, 4% increase in the risk of shunt infection was observed.[12]

In this study mean age is 123.25 months with a minimum age of 1 month and a maximum of 780 months. The age range is greatly reduced by the presence of patients with shunt infections at 65 years of age in the acquired hydrocephalus group. When analyzed in the congenital hydrocephalus group, the mean age of infection was 5.9 months (age one month and maximum 24 months). There was no correlation between the initial age of shunt installation and the risk of shunt infection in this group, \( p = 0.738 \).

Also, we found an interesting fact about the level of pre-operative albumin. There was a significant difference between low albumin levels (<3.0) and normal albumin (\( \geq 3.0 \)) levels against the risk of exposure shunt, \( p = 0.015 \). It means there is a significant difference between low pre-operative albumin and normal level for the risk of the exposed shunt.

The period between surgery and first occurrence for shunt infection as documented in the current literature ranges from 15 days to 12 months after shunt placement; 80% of the infections occur within the first three months, 90% within the first six months. Different data is in this study, 45% occurs in more than 60 days, 50% between 10 to 60 days. Several studies have revealed that infections due to Gram-positive bacteria mostly start within the first eight weeks after surgery. Therefore, most VP shunt infections are caused by intraoperative or early postoperative contamination with a subsequent colonization of the shunt with bacteria belonging to the skin flora. [16] Secondary infectious events due to gram-negative bacteria and Candida spp. Tend to occur later in the clinical course.
Most VP shunt infections are caused by gram-positive opportunistic pathogens colonizing the skin of the patient.[12,13] Coagulase-negative staphylococci (CoNS) have been in 17–78% of the cases and *Staphylococcus epidermidis* accounts for 47–64% of all gram-positive VPS infections [14], 40% in this study.

Gram-negative bacteria were in 7–24% of all VP shunt infections.[15] In most cases, common nosocomial gram-negative pathogens have involved, such as *Enterobacteriaceae* and nonfermenters (e.g., *Pseudomonas aeruginosa*, *Acinetobacter baumannii* and *Stenotrophomonas maltophilia*). *Pseudomonas aeruginosa* has been in 25% of the cases, *E. coli* accounts for 20%, and 15% for *Acinetobacter baumannii*. The detection of gram-negative bacteria may be related to an intraperitoneal inflammation or a hematogenous spread from another focus. Asymptomatic perforations of the bowel wall by the distal tip of the catheter have been reported.

According to the US American authors and the Infectious Diseases Society of America (IDSA) guidelines of 2004, empirical therapy for suspected VP shunt infection should be carried out with a glycopeptide, if necessary in combination with ceftazidime, cefepime or meropenem.[15] Though, this fact is not suitable for this study. Ceftazidime is resistant, followed with ampicillin, amoxicillin, Benzyl Penicillin, cefotaxime, oxacillin, and levofloxacin. The sensitive antibiotic is ciprofloxacin, gentamycin, vancomycin, meropenem, polymixin, and amikacin.

The predominantly bacteriostatic effect of glycopeptides (vancomycin 60 mg/kg/day; teicoplanin 20 mg/kg/day; adapted dose recommendations for preterm infants and neonates; vancomycin trough level: 15–20 mg/l) correlates with the duration of time. The concentration in the target area is above the minimal inhibitory concentration of the corresponding pathogen.[16]

Gram-negative infections (except extended-spectrum β-lactamase-producing isolates) and Gram-positive infections (except MRSE, MRSA, *Enterococcus* spp. And *Listeria monocytogenes*) and has been the treatment of meningitis in children,[16,17] Treatment with cefepime in combination with fosfomycin may be an effective option for the initial empirical treatment of VPS infections.

In case of suspected gram-negative infection, for example after intestinal perforation or forming of an abdominal pseudocyst, antimicrobial therapy with piperacillin/tazobactam or meropenem should be considered.[17] Gram-positive pathogens often cause VPS infections after an abdominal infection.

Multiresistant Gram-negative bacteria often require therapy with meropenem or ciprofloxacin. Fluoroquinolones have been approved by the American Academy of Pediatrics as an option for severe infections caused by multidrug-resistant pathogens. There is no safe and effective alternative.[17]

### 5. Conclusion

In this study, the rate of shunt infections at RSUP Haji Adam Malik for three years (2013 - 2016) is 5.1%, 75% of which were exposed shunt and 25% were ventriculitis. Congenital hydrocephalus is the most common cause of VP shunt action in this center. The risk factors that most affect the occurrence of shunt infection is the age of the patient at the time of first installation and pre-operative albumin levels. At this center, age has no significant relationship (p=0.738), but there is an insignificant difference in pre-operative albumin level with risk of the exposed shunt (p=0.015). The most common pathogens were *S. epidermidis* (40%), and also found gram-negative bacteria *P. aeruginosa* (25%), *E. coli* (20%), *A. baumanii* (15%). The sensitive culture of ciprofloxacin, gentamicin.

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