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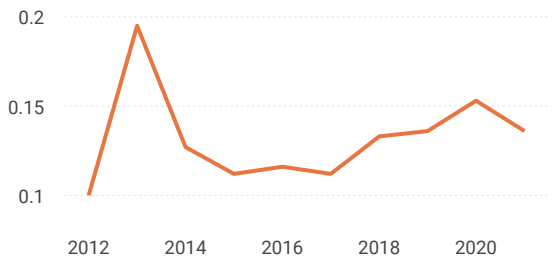

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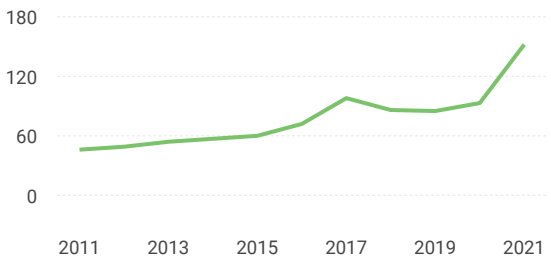

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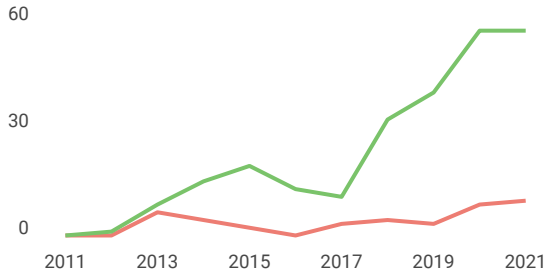

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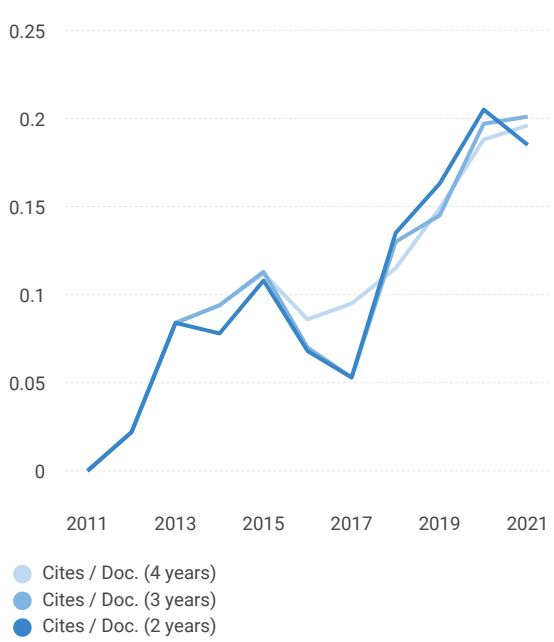

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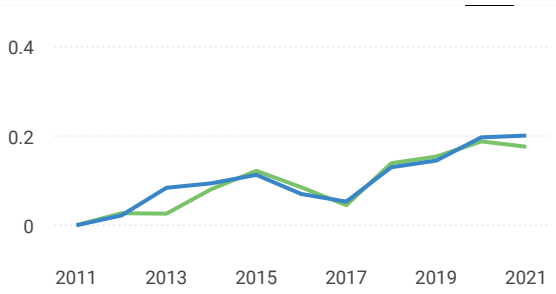

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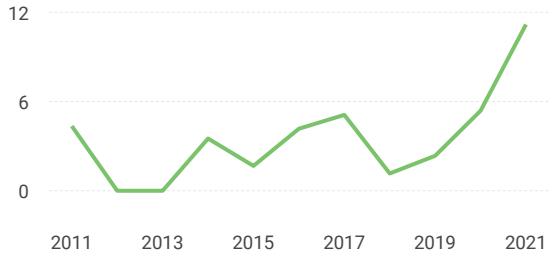

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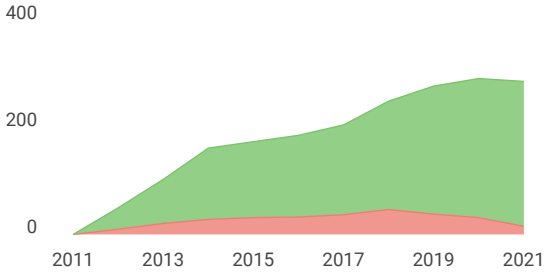

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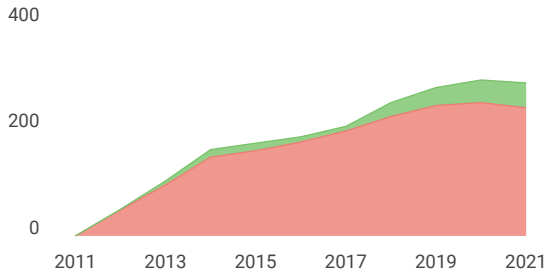

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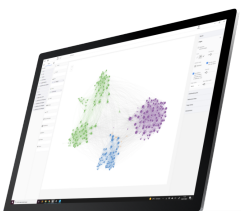

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Cerebrospinal fluid culture and analysis in paediatric patients with shunt infection

Alivia Retra Kusumowardani[1], *Prastiya Indra Gunawan[2], Deby Kusumaningrum[3], Wihasto Suryaningtyas[4]

Sri Lanka Journal of Child Health, 2021; **50**(3): 436-441

Abstract

Background: Shunt insertion is an invasive procedure frequently done in patients with excess cerebrospinal fluid (CSF). It comes with the risk of infection which could be ascertained through CSF examination.

Objectives: To present the results of CSF culture and analysis in paediatric patients with shunt infection in Dr. Soetomo General Hospital, Surabaya, Indonesia.

Method: A retrospective study was conducted by reviewing medical records of patients with shunt infection aged 0–18 years old who were treated from January 2016 to December 2019.

Results: Seventeen cases of paediatric shunt infection were identified in this study. Six (35.3%) patients belonged to the 1–12 month age group. The aetiology of shunt insertion was hydrocephalus in all cases. Seizure was the most common chief complaint (23.5%) at presentation. During hospitalisation, recurrent fever was found in 7 (41.5%) cases. CSF analysis showed increased white blood cells in 12 (70.6%) cases, decreased glucose level in 11 (64.7%) cases and elevated protein level >100mg/dl in 12 (70.6%) cases. The most frequently isolated pathogens were *Staphylococcus aureus* and *Staphylococcus epidermidis*, each appearing in 4 (23.5%) cases, followed by *Escherichia coli* in 3 (17.7%) cases.

Conclusions: In this study paediatric patients with shunt infection showed raised white blood cells, decreased glucose and increased protein level on CSF examination. The most common pathogens were *Staphylococcus aureus*, *Staphylococcus epidermidis*, and *Escherichia coli*. Significant resistance to ampicillin was present.

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(Key words: Shunt infection, ventriculo-peritoneal shunt, infection, cerebrospinal fluid, paediatrics).

Introduction

Shunt insertion is one of the therapeutic measures to divert excess cerebrospinal fluid (CSF). It is an invasive procedure that comes with the risks of infection. One of the risk factors that have been tied to infection is host susceptibility. This predisposition could be found in younger age patients with immature immune systems, causing a great number of infections by commensal or low virulence bacteria. However, results vary between researches, and there has been no previous study to identify bacterial pathogens causing shunt infection in the present facility.

Objectives

To present the causative bacteria of shunt infection, their drug susceptibility pattern and CSF analysis in Dr. Soetomo General Hospital, Surabaya, Indonesia.

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Method

A retrospective study was conducted in Dr. Soetomo General Hospital, Surabaya, Indonesia. The hospital is a tertiary health facility in East Java and serves as the referral centre for all eastern parts of Indonesia. Data were sourced through patients' medical records. Cases with shunt infection occurring in patients aged 0–18 years from January 2016 to December 2019 were collected. Observed variables included age, gender, aetiology of shunt insertion, chief complaints, clinical features during hospitalisation, the result of CSF analysis, and the result of CSF culture and its susceptibility pattern. Inclusion criteria were cases with an intracranial manifestation of shunt infection and positive CSF culture. Cases without complete information on observed variables were excluded.

Ethical issues: Ethical clearance was obtained from the Health Research Ethics Committee of Dr. Soetomo General Academic Hospital, Surabaya, Indonesia (No.1431/KEPK/VIII/2019). As it was a

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The authors declare that there are no conflicts of interest
Personal funding was used for the project.

retrospective study informed consent was not possible. Confidentiality is assured.

Results

Out of 119 cases with shunt insertion, 27 (22.7%) developed infection. However, only 17 cases were eligible for this study. The demographic and clinical characteristics of the 17 patients are shown in Table 1.

Table 1

Demographic and clinical characteristics (n=17)

Variable	n (%)
Gender	
Female	09 (52.9)
Male	08 (47.1)
Age group	
<1 month	0 (0)
1 to 12 months	06 (35.3)
1 to <3 years	05 (29.4)
3 to <6 years	05 (29.4)
6 to <12 years	01 (05.9)
12 to 18 years	0 (0)
Aetiology of shunt insertion	
Hydrocephalus	05 (29.4)
Communicating hydrocephalus	04 (23.5)
Non-communicating	03 (17.7)
hydrocephalus	03 (17.7)
Multi-lobulated hydrocephalus	02 (11.8)
Severe hydrocephalus	
Chief complaints	
Surgical wound	02 (11.8)
Shunt displacement	03 (17.7)
Exposed shunt	02 (11.8)
Fever	01 (05.9)
Vomiting	01 (05.9)
Seizure	04 (23.5)
Loss of consciousness	01 (05.9)
Increased head circumference	01 (05.9)
Shunt leakage	01 (05.9)
Department transfer	01 (05.9)
Clinical features during	
hospitalisation	07 (41.5)
Fever	03 (17.7)
Seizure	07 (41.5)
No symptoms	
Prophylactic antibiotics	
Ceftriaxone	09 (52.9)
Cefazolin	05 (29.4)
No name provided	03 (17.7)

Nine (52.9%) patients were female and 6 (35.3%) patients were 1–12 months of age. The aetiology of shunt insertion was hydrocephalus in all cases. Frequently appearing chief complaints were seizure in 4 (23.5%) cases and shunt displacement in 3 (17.7%) cases. During hospitalisation, fever occurred in 7 (41.5%) cases, while an equal amount showed no additional symptoms. Prophylactic antibiotics were used in all cases, the most common being ceftriaxone, used in 9 (52.9%) cases.

CSF analysis is shown in Table 2.

Table 2: ***Cerebrospinal fluid analysis (n=17)***

Parameter	n (%)
Colour	
Colourless	08 (47.1)
Yellow	08 (47.1)
Red	01 (05.9)
Clarity	
Clear	14 (82.4)
Turbid	03 (17.7)
Clots	
Negative	17 (100.0)
Positive	0 (0)
pH	
8	17 (100.0)
< or > 8	0 (0)
White blood cell count	
Pleocytosis*	12 (70.6)
Normal	05 (29.4)
Mononuclear: Polymorphonuclear	
Polymorphonuclear > Mononuclear	11 (67.4)
Mononuclear > Polymorphonuclear	06 (35.3)
Nonne	
Positive	12 (70.6)
Negative	05 (29.4)
Pandy	
Positive	13 (76.5)
Negative	04 (23.5)
Glucose	
Decreased$^{\varpi}$	11 (67.4)
Normal	06 (35.3)
Total protein^{+}	
Slight increase	02 (11.8)
Moderate increase	01 (05.9)
Great increase	08 (47.1)
Very great increase	04 (23.5)
Normal	02 (11.8)

* *Pleocytosis if WBC >50/mm^3*

$^{\varpi}$ *Decreased if glucose <40 mg/dl*

$^{+}$ *Slight increase 45–75 mg/dl; Moderate increase 75–100mg/dl; Great increase 100–500mg/dl; Very great increase >500mg/dl; Normal 45mg/dl or less*

CSF analysis showed no colour in 8 (47.1%) cases and was clear in 14 (82.4%) cases. White blood cells (WBC) count above 50/cu mm occurred in 12 (70.6%) cases, with polymorphonuclear (PMN) cell predominance in 11 (67.4%) cases. Lowered glucose level below 40 mg/dl was found in 11 (67.4%) cases and an increased protein level of more than 100 mg/dl appeared in 12 (70.6%) cases.

Identified bacteria from CSF cultures are shown in Table 3.

Table 3
Identified bacteria from CSF cultures (n=17)

Culture result	n (%)
Staphylococcus aureus	04 (23.5)
Staphylococcus epidermidis	04 (23.5)
Staphylococcus hominis	01 (05.9)
Escherichia coli	03 (17.7)
Pseudomonas aeruginosa	02 (11.8)
Enterobacter cloacae	01 (05.9)
Enterococcus faecalis	01 (05.9)
Acinetobacter lwofii	01 (05.9)

The most frequently appearing pathogens were *Staphylococcus aureus* and *Staphylococcus epidermidis*, each in 4 (23.5%) cases. *Staphylococcus aureus* was found to be more sensitive to gentamycin, oxacillin, co-trimoxazole, and quinupristin-dalfopristin. *Staphylococcus epidermidis* was found to be more susceptible to chloramphenicol and fosfomycin. *Escherichia coli* appeared in 3 (17.7%) cases and were found to be more susceptible to amikacin, piperacillin-tazobactam, chloramphenicol, fosfomycin, imipenem and meropenem.

Discussion

The prevalence of shunt infection in the present study lies on the higher end of the spectrum. The rate of infection in other studies was estimated at around 1–20%[1-3]. This study showed that infection occurred mainly in earlier age groups, similar to several other studies[4-6]. Such occurrence had been described due to immature immune systems and inadequate skin barrier[3]. Age-related changes in normal skin flora were also found to be more concentrated in the head than extremities[7], which may further increase the risk of infection in children undergoing neurosurgery. As stated in previous studies, one of the main aetiologies of shunt infection is congenital hydrocephalus[4,6,8], which was also seen in this study. However, other types of hydrocephalus were also present that could indicate underlying infection or haemorrhage.

The most common chief complaints were seizure and shunt displacement, while a frequently present clinical symptom during hospitalisation was fever. Fever is said to be one of the most commonly encountered signs of shunt infection[3,6]. In this study, a low number of fever as the main concern was probably caused by parents' underestimation, mistaking it as a usual self-limiting course of disease. Additionally, the hospital in which this study was conducted was a tertiary health facility, increasing the likelihood that such clinical features may have been handled in the lower facilities. While being closely monitored, fever appeared in almost half of the cases. In another study, altered neurologic status as a sign of shunt infection was found in approximately 30 – 40% of patients[6]. The presence of this sign could raise the probability of further neurological complications[9]. Cases with displaced shunt mainly migrated to the genitals or anus.

Cephalosporin was used as prophylactic antibiotics in all cases. The use of these antibiotics was suitable with the most commonly isolated pathogen in this study. It covered gram-positive bacteria with extended coverage to gram-negative in the latest generation. However, susceptibility patterns should be observed as continuous use may induce resistance.

The macroscopic result of CSF analysis was mostly within normal limits, while abnormal results indicated a pathologic process. Yellow colour shows the presence of protein >150mg/100ml, red shows the presence of blood >1000 cells/cu mm, and turbidity shows the presence of polymorphonuclear (PMN) cells >300/cu mm[10]. For macroscopic abnormalities to occur, the pathologic process should have occurred in a rather significant way. In that sense, an infection should still be suspected in normal analysis, as this study showed positive culture in all cases. Increased pH was shown to be a suitable environment for bacterial growth[11], as it presented in all cases in this study.

The dominance of CSF pleocytosis and PMN cells is a clear indicator of central nervous system infection in an active manner. However, one study found that low white blood cell (WBC) count is a predictor for bad prognosis[12] and two cases in this study fell into the category. This may increase the likelihood of delayed treatment under the assumption of normal values.

Glucose level below 40 mg/dl most likely indicates a pathologic process[10]. The lowered amount is possibly due to increased metabolic demand of WBC and bacterial pathogens, therefore taking up CSF storage. Cases with normal glucose levels showed lower WBC count, suggesting its association with WBC activity as there is no remarkable storage depletion on account of relatively lower metabolic demand. Even so, the amount of bacterial load should also be considered.

The majority of protein levels exceeded 100 mg/dl. Escalated level of protein was said to be a risk factor for neurological complications[9]. It resulted from the increase of blood-brain barrier permeability due to inflammatory conditions and presence of persistent increase suggesting continuous inflammation[6,10]. Cases with protein >100 mg/dl also appeared to have reduced glucose levels and raised WBC count. This finding is common in central nervous system infection. Cases

with protein less than 100 mg/dl showed normal glucose level and WBC count. As WBC count shows defence activity against pathogens, its number corresponds to the severity of infection, and consequently its response, one of which is in the form of cell permeability.

In this study, CSF culture was dominated by normal skin flora, which was also present in other studies[3,6,13-16]. The presence of these bacteria suggest that infection started during surgery through inoculation while shunt was being inserted. Infection by these pathogens usually appeared soon after shunt placement[16]. Commensal bacteria gain their ability to become pathogenic depending on host immunity and access to adequate growth[17]. Predisposing factors of *Staphylococcus aureus* and *Staphylococcus epidermidis* infection are surgery and newborns[15]. It fits the findings in this study which was dominated with patients in earlier age group whose immunity is yet immature. The number of bacterial density on the skin prior to surgery could also be taken into account, considering lower amount of bacteria was needed to start an infection in the presence of foreign material[7].

Escherichia coli infection predominance occurred in other studies[18,19]. These bacteria are normally found in the intestines and may induce infection through the distal shunt end. Two out of three cases with *Escherichia coli* had shunt displacement to the genitals and anus. Other pathogens are commonly associated with nosocomial infection or related to neurosurgical instrumentation[20-22]. Therefore, the duration of hospitalisation and any condition that may prolong the stay should be considered.

A staphylococcal infection could be treated with beta-lactam antibiotics[23]. However, in this study, resistance towards penicillin, namely ampicillin and penicillin G, had appeared. Oxacillin still showed good response, though one case showed resistance, marking the possibility of emerging hospital-acquired methicillin-resistant *S. aureus*. Fosfomycin was said to have adequate coverage for biofilm produced by *Staphylococcus aureus* and *Staphylococcus epidermidis*[24], presenting good sensitivity results. Empirical therapy for *Escherichia coli* infections includes ampicillin, gentamycin, and cefotaxime. In this study, empirical therapy showed suitability with the result of susceptibility tests. However, it could be suggested to reduce ampicillin use, noting the considerable amount of resistance to it.

A limitation in this study is its full reliance on the completeness of medical records. Several cases had to be eliminated due to lack of information to make a comprehensive analysis.

Conclusions

Paediatric patients with shunt infection on CSF analysis had raised white blood cells, decreased glucose, and increased protein level. The most common pathogens were *Staphylococcus aureus*, *Staphylococcus epidermidis*, and *Escherichia coli*. Significant resistance to ampicillin was present in this study.

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