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Case Report

Complications of ventriculoperitoneal shunts: Infection and exposure in hydrocephalus patients: A case series

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ABSTRACT

Background: Ventriculoperitoneal shunt (VPS) is an effective intervention for managing hydrocephalus; however, various complications may arise, one of which is infection due to shunt exposure. In this study, we report the incidence, risk factors, clinical presentation, and management strategies of four cases of shunt exposure in patients with hydrocephalus.

Case Description: The first case involves a 1-year-10-month-old female who underwent her initial VPS placement at 7 months old due to hydrocephalus. The second case is a 3-month-old female who had a VPS placed at 20 days old for obstructive hydrocephalus and ventriculomegaly secondary to toxoplasmosis. The third case is a 15-year-old female who received a VPS due to a cerebral abscess with a prior history of tuberculous meningoencephalopathy. The fourth case is a 38-year-old male who underwent VPS placement for hydrocephalus. Two years post-intervention, the fourth patient was diagnosed with VPS exposure and subsequently underwent shunt removal.

Conclusion: The identification of risk factors and clinical symptoms in patients, supported by ancillary examinations such as cerebrospinal fluid analysis, can predict the incidence of VPS infections. Bacterial VPS infections can be managed with appropriate antibiotics tailored to the specific bacterial species. However, in certain cases, surgical removal of the VPS may be considered as a measure to eradicate infectious pathogens.

Keywords: Case report, Exposed shunt, Hydrocephalus, Infection, Ventriculoperitoneal shunt

INTRODUCTION

Hydrocephalus is a neurological disorder characterized by the abnormal accumulation of cerebrospinal fluid (CSF) within the brain's ventricles. The clinical manifestations of hydrocephalus vary across different age groups and most frequently occur in children. Common clinical symptoms in pediatric patients include changes or abnormalities in head circumference (occipital frontal circumference), disproportionate enlargement of the skull relative to facial growth, irritability, bulging fontanelles, and the presence of the sun-setting sign.[12] The management of hydrocephalus typically involves the placement of a ventriculoperitoneal shunt

(VPS).[8] Although VPS is an effective intervention, it is associated with various potential complications, one of which is infection due to shunt exposure.[12] This study presents four cases of shunt exposure in patients with hydrocephalus. The authors describe instances of VPS infection, detailing clinical symptoms, bacterial types, and varying treatment approaches.

CASE PRESENTATION

Case 1

A 1-year-10-month-old female was diagnosed with hydrocephalus and subsequently underwent her initial VPS placement at 7 months old. The patient presented with symptoms of redness and pus discharge at the VPS insertion site. These complaints began with intermittent fever occurring 2 months post-VPS revision. The patient was diagnosed with hydrocephalus with exposed VPS and post-debridement wound skin exposure. The patient underwent a shunt diversion to an external ventricular drain through Kocher's point. No signs of ventriculitis were found on the head computed tomography (CT) scan. Bacterial infection is characterized by an increase in the number of leukocytes, increased protein levels, decreased glucose levels in CSF analysis and the growth of *Staphylococcus aureus* in the patient's VPS chamber pus culture.

Case 2

A 3-month-old female underwent her initial VPS placement at 20 days old due to severe obstructive hydrocephalus with suspected ventriculomegaly secondary to toxoplasmosis. Two months post-VPS placement, the patient presented with complaints of clear, odorless fluid leakage from the hydrocephalus surgical site, redness around the VPS site, visible VPS tubing post-surgery, as well as cough and abdominal distension. The patient did not report fever or seizures. The diagnoses included exposed VPS in the left temporal region, hydrocephalus ex vacuo on VPS at Kocher's point, and upper respiratory tract infection. Subsequent intervention involved the removal of the Kocher's point shunt and insertion of a VPS at the lumbar puncture (LP) site through Kocher's point. However, 1 day post-shunt removal, the patient experienced recurrent seizures and respiratory distress. The diagnoses were status epilepticus due to bacterial meningoencephalitis, severe obstructive hydrocephalus post-re-VPS at LP Kocher's point, pneumonia, and upper gastrointestinal bleeding due to stress. A Head CT scan showed severe obstructive hydrocephalus as high as aqueductus Sylvii with VPS in place with thinning of the cerebri parenchyma. Bacterial infection is characterized by an increase in the number of leukocytes, increased protein levels and decreased glucose levels in CSF analysis and the growth of *Acinetobacter baumannii* extremely drug-resistant (XDR) in both the VPS chamber pus culture and CSF culture.

Case 3

A 15-year-old female underwent VPS placement due to a cerebral abscess following a history of tuberculous meningoencephalopathy. The patient experienced symptoms of infection approximately 1 year post-VPS placement, presenting with headaches. A Head CT scan showed a right frontal lobe lesion leptomeningeal blockage of the bilateral frontotemporal region suggestive of meningoencephalitis with ventriculitis. CSF analysis indicated bacterial infection characterized by increased leukocyte count, elevated protein levels, and decreased glucose levels. *Klebsiella pneumoniae* growth was found in the patient's VPS chamber pus culture.

Case 4

A 38-year-old male diagnosed with hydrocephalus underwent VPS placement. However, 2 years post-VPS insertion, the patient experienced headaches and was diagnosed with exposed VPS, necessitating removal. No signs of ventriculitis were found on the head CT scan. CSF analysis indicated bacterial infection characterized by increased leukocyte count, elevated protein levels, and decreased glucose levels. *Pseudomonas aeruginosa* growth was found in the patient's VPS chamber pus culture and wound swab culture.

DISCUSSION

This study aims to describe cases of VPS infection in four patients over 1 year, from January to December 2022. Three patients included in this study were under 17 years old, with two of them undergoing VPS placement before the age of 1 year [Table 1]. Age is a significant risk factor for shunt complications; specifically, pediatric patients exhibit a higher incidence of VPS infection (21.3%) compared to adults (5.9%). Furthermore, VPS placement before the age of 1 year is associated with a higher risk of VPS infection.[1] Shunt complications in pediatric patients carry a 4.22-fold increased likelihood of shunt revision compared to adults.[12]

There is some data indicating that the likelihood of infection among male patients is 1.67 times higher than that among female patients, although the reason for this difference remains unclear.[1] This study differs, as the number of female patients exceeds that of male patients, a phenomenon that has not yet been explained.

Risk factors for infection include young age, frequent revisions, and causes of hydrocephalus such as post-infection hydrocephalus, post-hemorrhagic hydrocephalus, or hydrocephalus due to spina bifida or other neurological

defects that cause CSF contact with the skin.[2] In this study, VPS placement was performed in 2 patients (50%) due to congenital hydrocephalus, in 1 patient (25%) due to post-hemorrhagic hydrocephalus, and in 1 patient (25%) due to post-tuberculosis infection.

Clinical symptoms associated with VPS infection can vary depending on the causative organism. In the early stages, these infections often manifest as biofilm growth, which complicates and delays diagnosis and treatment in some cases.[11] VPS infections may present with symptoms such as neck stiffness, changes in mental or neurological function, headaches, and nausea. These symptoms are associated with VPS obstruction caused by infection, occurring in <50% of cases overall.[1] The clinical symptoms experienced by patients in this study include fever, headaches, and CSF leakage at the VPS insertion site, corresponding to the specific characteristics of the bacteria isolated in the culture.

VPS infections are most likely to occur in the early days following placement, with approximately 56–87% of infections occurring within 1 month after VPS insertion.[10] In this study, patients experienced symptoms of VPS infection between 1 month and <1 year after placement, while one patient exhibited symptoms of VPS infection after more than 1 year.

Table 1: Characteristics of VPS infection patients.

Characteristic	*n*	%
Age		
<1 year old	1	25
<18 years old	2	50
>18 years old	1	25
Sex		
Male	1	25
Female	3	75
Clinical symptoms		
Fever	2	50
Headache	1	25
CSF leak at VPS installation site	1	25
Glasgow coma scale		
≥13	1	25
>8–<13	2	50
≤8	1	25
Onset since VPS placement		
<1 month	-	-
month–1 year	3	75
>1 year	1	25
Risk factor		
Repeat shunt revision	2	50
Supporting examinations		
CSF leukocyte increased	4	100
CSF protein increased	4	100
CSF glucose decreased	4	100

VPS: Ventriculoperitoneal shunt, CSF: Cerebrospinal fluid

This study involved CSF analysis, which aimed to confirm the presence of infection.[12] In the CSF analysis of the four patients in this study, an increase in leukocytes and protein and a decrease in glucose were found in all patients (100%).

Based on the results of VPS chamber pus cultures in all patients, VPS infections were identified along with the antibiotics to which each bacterial species remained sensitive [Table 2]. The Gram-positive bacteria *S. aureus* showed sensitivity to antibiotics such as cloxacillin, gentamicin, erythromycin, and clindamycin. These findings have been extensively discussed in previous research, as *S. aureus* remains the predominant Gram-positive organism.[9] On the other hand, Gram-negative bacteria like *K. pneumoniae* were sensitive to antibiotics such as ampicillin, gentamicin, and ceftriaxone. However, biofilm formation by *K. pneumoniae* potentially reduces sensitivity to ampicillin, gentamicin, and ciprofloxacin.[3] *P. aeruginosa* exhibited sensitivity to gentamicin, ciprofloxacin, and ceftazidime, consistent with previous studies.[13] Moreover, co-trimoxazole showed continued sensitivity against *K. pneumoniae* and *A. baumannii*, aligning with the findings of López *et al*.[7]

In addition to the administration of antibiotics, the removal of infected VPS is crucial for the rapid eradication of infectious pathogens, as certain microorganisms, such as *P. aeruginosa*, have the potential to adhere to and form biofilms on the catheter.[14]

VPS infections are mostly caused by normal skin flora such as coagulase negative *Staphylococcus* (CoNS), *S. aureus,* and *Propionibacterium acnes*, which are thought to be introduced during the incision process, although Gram-negative organisms and Candida species have also been reported.[5]

Table 2: Antibiotic sensitivity profiles for VPS infections identified in culture results.

	Genus	Species	Antibiotic sensitive
Gram-positive bacteria	*Staphylococcus*	*S. aureus*	Cloxacillin Gentamicin Erythromycin Clindamycin Co-trimoxazole
Gram-negative bacteria	*Klebsiella*	*K. pneumoniae*	Ampicillin/sulbactam Gentamicin Ceftriaxone Co-trimoxazole
	Acinetobacter	*A. baumannii*	Co-trimoxazole
	Pseudomonas	*P. aeruginosa*	Gentamicin Ciprofloxacin Ceftazidime

S. aureus: Staphylococcus aureus, A. baumannii: Acinetobacter baumannii, K. pneumoniae: Klebsiella pneumoniae, P. aeruginosa: Pseudomonas aeruginosa

Staphylococcus spp. infections mostly occur in the skin and superficial areas, and infections caused by these bacteria are difficult to avoid. This may explain why surgical incisions are prone to infection. Therefore, in culture and antibiotic sensitivity tests, *Staphylococcal* bacteria are often isolated.[1]

S. aureus is one of the bacteria that can form biofilms and adhere to the surface of implant devices so that it can cause VPS infections. Biofilm-forming bacteria such as *Staphylococcus epidermidis* and *S. aureus* attach to the surface of implantable devices and cause VPS infections.[5] In the two culture results of this study, the biofilm-forming bacteria *S. aureus* and *P. aeruginosa* were isolated.

Over the past decade, the spectrum of infectious bacteria in VPS infections has begun to shift from previously common causative agents such as *S. aureus*, CoNS, and Gram-positive *Enterococcus* bacteria to Gram-negative bacilli, especially *Acinetobacter* species, *Pseudomonas* species, and *Enterobacterales.*[2] It is also confirmed in other studies that the incidence of VPS infections varies widely from 1% to 30%, and Gram-negative bacteria cause more than 35% of these infections. According to one study, post-procedure infections occurred in 11 of 142 patients (7.7%) who underwent ventricular access device insertion: *S. epidermidis*, four patients; *Enterococcus faecalis*, two patients*; Escherichia coli*, two patients; *P. aeruginosa*, two patients; and *Enterobacter cloacae*, one patient.[1]

Lee *et al*.,[6] showed that 35 out of 333 (10.5%) VPS could be infected. Four of these infections were secondary infections due to Gram-negative bacteria (1.2%). Meanwhile, Ochieng *et al*.,[10] suggest that the incidence of infection by Gram-negative bacteria causing VPS infection may be higher outside the United States. In this study, 39.6% of Kenyan children with VPS infection were infected with Gram-negative bacteria.[1]

Another study in Turkey of infants with VPS infection found the growth of micro-organisms from Cerebrospinal Fluid (CSF) or blood specimens in 53.8% of cases, and the most commonly isolated was *K. pneumoniae* in 13 patients (46.4%). *K. pneumoniae* as a pathogen was also reported in the study of Yakut *et al*.,[15], where the bacteria was found in 15 cases (10.1%) of 290 patients with VPS infection.

In accordance with the above studies, in this study, 3 out of 4 bacteria (75%) isolated from the culture of VPS pus chamber specimens were Gram-negative rods, namely, *P. aeruginosa, K. pneumoniae,* and *A. baumanii*. Each of these bacteria is often associated with healthcare-associated infections.

In a study in Pakistan, it was stated that in 7 years (2015–2021), from CSF samples of patients with VPS infection, 14.473 isolates from 13,937 CSF samples were identified and analyzed for their susceptibility patterns to 14 clinically significant antimicrobials. The proportions of Gram-positive and Gram-negative bacteria were 3443 (245) and 11.030 (76%), respectively. The dominant bacteria were *Acinetobacter* species (*n* = 5898, 41%), followed by *Pseudomonas* species (*n* = 2.368, 16%) and CoNS (*n* = 1880, 13%). About 100% of *S. aureus* and CoNS were sensitive to vancomycin and linezolid (*n* = 2.580). *Acinetobacter* showed a maximum sensitivity to meropenem of 69% (2.759/4.768). *Pseudomonas* 80% (1.385/1.863) were sensitive to piperacillin-tazobactam, *E. coli* showed 72% sensitive to amikacin (748/1055), while *Klebsiella* spp. were 57% (574/1170) sensitive to piperacillin-tazobactam.[2] In this study, in 1 year (January–December 2022), from 4 VPS pus chamber samples of patients with VPS infection, four isolates were obtained, and the antibiotics tested on these four isolates were in accordance with the antibiotic panel of each isolate based on the Clinical Laboratory Standard Institute (CLSI). The proportion of Gram-positive and Gram-negative bacteria was 1 (25%) and 3 (75%), respectively. The four isolates were *S. aureus* (*n* = 1, 25%), *K. pneumoniae* (*n* = 1, 25%), *P. aeruginosa* (*n* = 1, 25%), and *A. baumannii XDR* (*n* = 1, 25%). *S. aureus* was sensitive to cloxacillin, gentamicin, erythromycin, clindamycin, and co-trimoxazole. While for Gram-negative bacilli, the antibiotics with the highest sensitivity were gentamicin at 66.7% and cotrimoxazole at 66.7%.

Based on the sensitivity to antibiotics of each bacterium found as described in Table 2 above, there is one bacterium that is classified as XDR because it is only sensitive to one type of antibiotic, namely, co-trimoxazole. The bacteria are *A. baumannii,* which is one of the problems in infection treatment in health-care facilities. The incidence of *A. baumannii* resistance is increasing worldwide, and this makes it difficult to eradicate. Treatment of patients with VPS infected with *A. baumannii* is difficult due to its tendency to develop pandrug-resistance to commonly used antibiotics.[4]

Initial empiric therapy should be broad-spectrum, with appropriate coverage for resistant Gram-negative pathogens, including cefepime, ceftazidime, or meropenem. While it can be used for patients allergic to beta-lactam antibiotics, intravenous meropenem is recommended due to its lower risk of seizures compared to imipenem, and clinical studies have shown its benefit in the empirical treatment of bacterial meningitis. Once Gram-negative organisms are identified, antibiotics can be switched to pathogen-specific therapy. In patients who cannot tolerate or have contraindications to carbapenems, aztreonam or ciprofloxacin may be used as alternatives. Table 3 shows the organisms and their recommended therapies and alternatives.[1]

In addition to antibiotic administration, the removal of the infected VPS is crucial for the rapid eradication of infectious pathogens, as certain microorganisms, such as *P. aeruginosa*, have the potential to adhere to and form biofilms on the catheter. This was demonstrated in a study where the removal

Table 3: Organisms and their recommended and alternative therapies.

Organism	Recommended Therapy	Alternative
Sensitive Gram-negative rod bacteria	Ceftriaxone/cefotaxime	-
Pseudomonas spp.	Cefepime/ceftazidime/meropenem	Aztreonam/fluoroquinolone
ESBL – Gram-negative rod	Meropenem	Cefepime/fluoroquinolone
Acinetobacter spp.	Meropenem	Colistimethate sodium/Polymyxin B

ESBL: Extended-spectrum beta-lactamase

of all infected internal ventricular catheter components, along with targeted antimicrobial therapy, was effective in 85% of patients. In certain clinical cases, the evaluation of CSF analysis, culture results, and the treatment of hydrocephalus, as well as the insertion of a temporary external ventricular conduit, may be considered before replacing the long-term VPS.[1]

CONCLUSION

Shunting remains a routine therapy in neurosurgery, although alternatives such as Endoscopic Third Ventriculostomy (ETV) are increasingly performed. Risk factors and clinical symptoms in patients, supported by ancillary examinations such as CSF analysis, can predict the incidence of VPS infections due to shunt exposure. It is crucial to review the pathogens commonly associated with VPS infections and their antibiotic sensitivities to guide empirical antibiotic therapy effectively. In addition to antibiotic administration, timely removal of infected VPS is essential for rapid eradication of infectious pathogens, particularly as certain microorganisms have the potential to adhere to and form biofilms on catheters.

Ethical approval

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Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent.

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Use of artificial intelligence (AI)-assisted technology for manuscript preparation

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