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Ventriculitis: Clinical Outcomes and Management in Pediatric Neurosurgery

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Abstract
Ventriculitis is a serious complication in pediatric neurosurgery, often associated with ventriculoperitoneal (VP) shunt procedures. This study explores ventriculitis's clinical, microbiological, and imaging characteristics and evaluates its prognosis and management strategies. Data were gathered from a cohort of pediatric patients with VP shunts who developed ventriculitis. Findings indicate that early diagnosis and targeted antimicrobial therapy are crucial for positive outcomes. However, a lack of standardized definitions and treatment protocols poses challenges to optimal care. The study recommends the adoption of unified criteria for ventriculitis diagnosis and further research to develop best-practice guidelines.

Keywords: Ventriculitis, Pediatric Neurosurgery, VP Shunts, Central Nervous System Infections, Shunt Complications

Introduction

Serious side effects of invasive neurosurgical procedures, such as craniotomies, the implantation of an internal or external ventricular catheter, intrathecal infusions, spinal anesthesia, or lumbar punctures, include meningitis of ventriculitis [1]. These conditions of pediatric patients are more vulnerable due to developing immune systems and distinct anatomical and physiological characteristics. Both infections pose significant risks, including prolonged hospitalizations, neurological impairments, and high mortality rates, especially when diagnosis and treatment are delayed [2]

Children with hydrocephalus may benefit from cerebrospinal fluid (CSF) shunt devices, which have increased survival and lower mortality [3]. Ventriculoperitoneal shunt infection, on the other hand, is a significant complication that can result in fatal complications. Ventriculitis is difficult to diagnose in the early stages since there are no established diagnostic standards and the clinical symptoms can be vague and difficult to distinguish from postoperative complications or underlying neurological diseases. This study aims to determine predictors of adverse outcomes in pediatric patients with ventriculitis.

Literature Review

In pediatric neurosurgery, ventriculoperitoneal (VP) shunts are commonly utilized to manage hydrocephalus resulting from conditions such as traumatic brain injuries, CNS infections, and congenital

abnormalities like myelomeningocele and Arnold-Chiari malformation. However, ventriculitis, a serious complication, remains a significant concern with infection rates ranging from 2% to 27%. Despite its clinical importance, ventriculitis is often overlooked in medical literature, where most studies concentrate on healthcare-associated infections, especially those related to external ventricular drainage. The lack of comprehensive studies on its other causes, including meningitis and brain abscesses, highlights a gap in understanding its broader clinical implications.

One of the primary challenges in ventriculitis research is the absence of a universally accepted definition, making it difficult to compare findings across studies. The limited scope of available research, often based on small case series, restricts the generalizability of results. Moreover, clinical, microbiological, and imaging characteristics remain poorly documented, even though ventriculitis is widely recognized for its poor prognosis in CNS infections. Addressing these gaps through more extensive research and standardized definitions is crucial to better comprehend its pathophysiology and improve patient outcomes, particularly in neurosurgical procedures like VP shunting.

Research Objective

To determine predictors of adverse outcomes among pediatric patients with Ventriculitis

Methodology

Study Design: Retrospective cross-sectional design

Study Setting: Pediatric neurosurgery department of Vicente Sotto Memorial Medical Center

Population and Sampling: Pediatric patients with VP shunts who developed ventriculitis from January 2010 to December 2021.

Inclusion Criteria:

- Pediatric patients with confirmed VP shunts
- Diagnosis of ventriculitis based on clinical, microbiological, and imaging findings
- Patients who were given preoperative antibiotics before cutting

Exclusion Criteria:

- Patients who were operated outside of VMMC but had signs of ventriculitis on admission
- Patients who have undergone VP shunting related to Tuberculosis Meningitis, and Post- Meningitis Hydrocephalus

Data Collection:

- Clinical assessments, microbiological cultures, and imaging studies were reviewed.
- Demographic data, clinical presentation, and treatment outcomes were recorded.

Statistical Analysis:

- Descriptive statistics for patient characteristics and outcomes
- Comparative analysis to evaluate prognostic markers

Table 1. Demographic, Clinical, and LaboratoryCharacteristics of Pediatric Patients with Ventriculitis (N = 272)

Patients Demographic	Frequency (%)
Age	
Below 1 year old	115 (42%)
1 year old to 5 years old	85 (31%)
6 years old to 10 years old	39 (14%)
11 years old to 15 years old	20 (7%)
16 years old to 18 years old	13 (5%)
Gender	
Male	156 (57%)
Female	116 (43%)
Clinical Characteristics	
Immunocompromised state	
Yes	146 (54%)
No	126 (46%)
Glucose	
Decreased	72 (26%)
Increased	3 (1%)
Within Normal Limits	197 (72%)
Comorbidities	
Yes	159 (58%)
None	113 (42%)
Protein	
Decreased	4 (1.47%)
Increased	128 (47.05%)
Within Normal Limits	140 (51.47%)
Signs and Symptoms (Multiple answers)	
Headache	66 (24%)
Changes in Mental Status	34 (13%)
Nausea/Vomiting	13 (5%)
Focal Neurological Deficit	56 (21%)
Neck Stiffness	13 (5%)
Seizures	11 (4%)
Increase in Head Circumference	104 (38%)
VP Shunt Placement	13 (5%)
CSF Leak	10 (4%)
Laboratory Investigations	
Positive CSF Gram stain	100 (37%)
Positive CSF culture	35 (13%)
Positive blood cultures	29 (11%)

Management (Multiple answers)	
Tube Ventriculostomy	19 (7%)
Use of Empirical Antibiotics	272 (100%)
Use of Steroids	96 (35%)

Table 3. Glasgow Outcome Scale (GOS) Categories and Frequency of Pediatric Patients with Ventriculitis

Glasgow Outcome Scale (GOS)	Frequency (%)
1 – Dead	63 (23%)
2 - Persistent Vegetative State	4 (1%)
3 - Severely Disabled	49 (18%)
4 - Moderately Disabled	128 (47%)
5 - Good Recovery	28 (10%)

Table 4. Association between Pediatric Patient's Demographic, Clinical and Laboratory Characteristics to Adverse Outcomes

Variables	Estimate	Std. Error	Odds Ratio	95% C.I. [LB, UB]	P-value*
Age	0.060	0.025	1.062	[1.011, 1.117]	<0.05
Gender (Ref: Female)					
Male	0.152	0.249	1.164	[0.716, 1.9]	0.540
Immune state (Ref: No)					
Yes	1.900	0.281	6.684	[3.901, 11.778]	<0.01
Comorbidities (Ref: No)					
Yes	2.138	0.304	8.479	[4.761, 15.777]	<0.01
Glucose (Ref: Decreased)					
Increased	0.299	1.248	1.349	[0.124, 29.815]	0.811
Within Normal Limits	-0.968	0.282	0.380	[0.217, 0.658]	<0.01
Protein (Ref: Decreased)					
0.756	1.237		2.129	[0.199, 46.489]	0.541
0.063	1.237		1.065	[0.1, 23.259]	0.959
CSF Gram Stain (Ref: Negative)					
0.799	0.257		2.224	[1.349, 3.693]	<0.01
Tube Ventriculostomy					
1.149	0.510		3.155	[1.205, 9.229]	<0.05
Use of Steroids					
1.273	0.266		3.571	[2.134, 6.059]	<0.01
CSF Culture (Ref: Positive)					
1.820	668.717		6.172	[0, 9.66]	0.978

*p values were determined using linear regression analysis. A p-value less than 0.05 indicates statistical significance. All tests were two-tailed

Findings

This study presents a cohort of pediatric patients with Ventriculitis Results revealed that patients affected by ventriculitis are mostly infants less than 1 year ago, males with compromised immune systems, and with comorbidities. In 2014 and 2018, two retrospective cohort studies conducted in Taiwan reported that ventriculitis occurred in 15.3% to 20.8% of infants with central nervous system infections [48.49]. Ventriculitis has demonstrated its severity, leading to high rates of morbidity and mortality. Further, It has been documented as a common complication of bacterial meningitis in newborns, associated with increased rates of both morbidity and mortality [4,5].

Patients in the study manifest ventriculitis caused by gram-negative infection. While ventriculitis is recognized as a concerning complication in various central nervous system infections, it has been relatively underexplored, leading to a lack of consensus regarding diagnostic criteria [6]. Lyke et al. [7] defined nosocomial ventriculitis as a positive culture of cerebrospinal fluid (CSF) obtained from an intraventricular catheter at least 2 days after insertion. On the other hand, Lozier et al. [8] identified ventriculitis in patients who underwent ventriculostomy based on the presence of clinical and biological markers of meningitis, irrespective of the results of CSF culture and brain neuroimaging. However, advancements in brain imaging techniques, particularly magnetic resonance imaging (MRI), have significantly enhanced our capability to diagnose ventriculitis.

Cerebrospinal fluid (CSF) cultures are crucial in confirming the diagnosis of Ventriculitis [7]. However, repeated CSF sampling from external ventricular drains (EVDs) in the absence of clinical signs of ventriculitis has been associated with higher infection rates and a reduced ability to accurately diagnose the condition [8, 9,10]. The diagnosis of catheter-related ventriculitis via CSF can be intricate due to subtle findings, making it challenging to determine whether the abnormalities are linked to infection, device placement, or post-neurosurgery factors [11].

Most of the patients manifest signs and symptoms of increased head circumference, headaches, focal neurological deficits, and exhibited mental status. Symptoms of ventriculitis include fever and manifestations of meningism, such as nuchal rigidity, headache, photophobia, reduced mental alertness, seizures, or a critically ill state. In instances of ventriculitis stemming from catheters, trauma, or neurosurgery, the onset typically exhibits greater subtlety, often marked by a relative absence of fever and severe initial symptoms. This observation underscores the higher prevalence of this condition among immunocompromised patients [6,12]. It's worth noting that patients may experience fever unrelated to the infection, potentially attributable to factors like central fever, drug-induced fever, or chemical meningitis [11]. The presence of redness or tenderness over the subcutaneous shunt tubing may serve as an indicator of infection [13]. Patients may also manifest symptoms of obstructive hydrocephalus, especially in infants with inflammatory aqueduct blockage.

Notably, the demographic analysis revealed a higher risk of adverse outcomes with increasing patient age (p-value < 0.05), underscoring the need for tailored care for older pediatric patients. Immunocompromised patients and those with comorbidities faced significantly elevated risks of adverse outcomes (p-value < 0.01), emphasizing the importance of targeted interventions and infection control measures in these high-risk groups. Glucose levels within normal limits were associated with a lower risk of adverse outcomes (p-value < 0.01), while positive CSF Gram Stain results were indicative of increased risk (p-value < 0.01).

Additionally, the use of steroids was significantly associated with a higher risk of adverse outcomes (p-value < 0.01).

Conclusion

The results offer important insights into the elements that affect adverse outcomes in children with ventriculitis, informing clinical choices and emphasizing the necessity for tailored care approaches. The research highlights the significance of prompt diagnosis, especially in vulnerable populations such as infants, males, and individuals with weakened immune systems or existing health issues. It also illustrates the challenges in diagnosing ventriculitis, notably in cases related to catheters, and the vital role of cerebrospinal fluid cultures and advanced brain imaging in verifying the diagnosis. The link between steroid use and worse outcomes, along with the protective effect of normal glucose levels, further illustrates the importance of cautious management. Additional research and comprehensive analyses are vital to enhance our comprehension of this condition, which includes the creation of standardized diagnostic guidelines and better treatment strategies. Such initiatives will contribute to optimizing clinical results and enhancing care for pediatric patients suffering from ventriculitis.

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