

Characteristics of cerebrospinal fluid (CSF) among children with ventriculoperitoneal shunt infections

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ABSTRACT

A common (5%) complication of cerebrospinal fluid (CSF) shunt systems is infection. CSF cytochemical findings have been used to choose the initial empirical antimicrobial treatment. The objective was to evaluate the results of cytochemical and microbiological analyses of CSF samples obtained from children with pyogenic ventriculitis associated to ventriculoperitoneal shunt systems. This was a retrospective, descriptive and analytical study. Thirty-two cases of pyogenic ventriculitis were included; Gram-positive bacteria were predominant in 26 cases (81.25%); the rest corresponded to Gram-negative bacteria. There were no statistically significant differences for the studied outcome variables (CSF cellularity, glucose and protein levels).

Conclusion: Gram-positive bacteria were widely predominant as a cause of pyogenic ventriculitis associated to the surgical procedure. CSF characteristics show a high heterogeneity and were not associated to the type of microorganism in this studied sample.

Key words: cerebral ventriculitis, ventriculoperitoneal shunt, cerebrospinal fluid, hydrocephalus.

INTRODUCTION

Excessive production of cerebrospinal fluid (CSF) and/or obstructed CSF flow lead to hydrocephalus¹ and are the most common causes for CSF shunt placement. CSF shunts are now commonly used in pediatrics given the survival of preterm infants who suffer from intraventricular hemorrhage. Shunts are also used for other types of hydrocephalus, such as hydrocephalus secondary to central nervous system (CNS) tumors, congenital hydrocephalus, etc.

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The most feared and common complication is shunt infection associated to the surgical procedure for shunt implantation, which ranges between 0% and 20%, depending on the series.² Since a definitive CSF culture usually takes 5 to 7 days, CSF cytochemical findings have been used in clinical practice to choose the initial empirical antimicrobial treatment based on previously published studies.³⁻⁵

The objective of this study was to evaluate the results of cytochemical and microbiological analyses of CSF samples obtained from children with pyogenic ventriculitis associated to ventriculoperitoneal shunt systems (VPS) and establish the association between cytochemical findings and the type of microorganism.

MATERIAL AND METHODS

This was a retrospective, descriptive and analytical study conducted at Hospital de Pediatría "Prof. Dr. Juan P. Garrahan," a tertiary care facility located in Buenos Aires, Argentina. Medical records (case history and computer data bases) were reviewed for the period between January 2010 and December 2012. All patients diagnosed with pyogenic ventriculitis associated to the surgical procedure were selected. Ventriculitis was defined according to the criteria established by the Centers for Disease Control and Prevention's National Healthcare Safety Network (CDC/NHSN) 2014, and infections had to be diagnosed in the six months following CSF shunting surgery.⁶ All CSF samples were obtained through valve reservoir puncture; CSF physical, chemical and microbiological findings were collected at the time of the diagnosis of pyogenic ventriculitis.

Data were entered into an Excel spreadsheet and after wards processed using the S.P.S.S. statistical software package v17.0. Histograms were performed to establish the distribution of numerical outcome measures. Based on these histograms, groups were compared using a Mann-Whitney test given their non-parametric distribution. The frequency of occurrence of each microorganism was determined. They were

then grouped as either Gram-positive or Gram-negative, and CSF cellularity, glucose and protein levels were compared for both groups. A *p* value lower than 0.05 was considered the cut-off point for statistically significant differences.

RESULTS

Thirty-two cases (17 males) of documented pyogenic ventriculitis confirmed by microbiological isolation in the studied period were included. These account for approximately 5% of all VPSs placed in the same period (640 surgical procedures). Patients' age ranged between 3 months and 13 years old.

Their underlying diagnosis, which led to VPS requirement, included CNS tumors (*n*= 10), congenital hydrocephalus (*n*= 9), intraventricular hemorrhage (*n*= 5), Dandy-Walker malformation (*n*= 2), and others, such as meningitis, traumatic brain injury, etc.

In terms of microbiology, all cultures resulted monomicrobial. Gram-positive bacteria were predominant in 26 cases (81.25%); the rest corresponded to Gram-negative bacteria. No fungi were observed. The most commonly found bacteria were methicillin-resistant coagulase-negative staphylococci (*n*= 17), followed by methicillin-sensitive *Staphylococcus aureus* (*n*= 5) and methicillin-resistant *Staphylococcus aureus* (*n*= 3), and then by *Pseudomonas aeruginosa* (*n*= 3) and *Acinetobacter* (*n*= 2); the rest corresponded to other microorganisms.

Median values and ranges of dispersion for CSF glucose and protein levels and number of WBCs –classified by Gram staining– were compared (shown in *Table 1*). No statistically significant differences were observed for analyzed outcome measures.

The time elapsed between CSF shunting surgery and diagnosis of pyogenic ventriculitis was also studied. The median time in the Gram-negative group was 27 days (range: 4-139), while it was 28 days (range: 2-151) in the Gram-positive group; no statistically significant differences were observed (*p*= 0.9). The frequency of occurrence of microorganisms was analyzed for the patients in whom infection had been detected in the 15 days following VPS placement, and found that this was the case in 11 Gram-positive infections (42%) and in half of Gram-negative infections (*n*= 3); no statistically significant differences were observed (Fisher's two-tailed test= 1).

DISCUSSION

Infections are the most common complications of CSF shunts. In relation to microorganisms causative of pyogenic ventriculitis, in our hospital it was observed that Gram-positive bacteria are predominant while Gram-negative bacteria have decreased. The trends seen in other hospitals are consistent with our study, as described in the article by Kuo Wei;⁷ however, other hospitals have reported *Acinetobacter* as the most common etiologic agent (Brazil and Australia).²

The study conducted at our site by Grandi L., et al. and published in 1997³ documented a significant difference in the number of cells that stained Gram-negative, which was higher than the number observed to stain Gram-positive. This was also described for external CSF drainages.⁵ The same was observed in other published studies,⁸⁻¹⁰ although it was not confirmed in our research; however, the values observed by us show a similar trend. Such differences may be due to the fact that Gram-negative bacteria have remarkably decreased as causative agents of pyogenic ventriculitis, from 30% in the 1992-1995 period to 19% at present. In addition, the study mentioned above assumed a normal distribution of outcome measures used parametric tests for comparison; in our case, and given the highly biased distribution of studied outcome measures, non-parametric tests (Mann-Whitney) were used.

Rosanova and Paganini¹¹ pointed out that a high CSF cell count correlates with infection, but a normal cell count does not rule it out. The same has been observed in relation to CSF glucose and protein level alterations. It should also be noted that an increased CSF cellularity has been described in the 15 days following VPS placement caused by the surgical trauma itself.

As shown in *Table 1*, the CSF cellularity range for both Gram-negative and Gram-positive bacteria encompasses some cases with a CSF cellularity below 5, which is the cut-off point for normality. This is important because there may be cases of pyogenic ventriculitis with normal CSF cellularity that would require a strong diagnostic suspicion to initiate an empirical antibiotic treatment, as observed in 11% of cases included in the study published by Von der Brélie.¹²

A study conducted by Fulkerson, et al.¹⁰ reported significant differences in the CSF WBC count depending on the type of bacteria; however,

it is worth noting the high cellularity observed for both Gram-positive and Gram-negative microorganisms. As seen in our study, there is no description in relation to the time elapsed from symptom onset to infection diagnosis (given the difficulty to collect such information in retrospective studies); if a long time has elapsed, it may account as one of the causes for such significant increase in CSF cellularity.

Some series have also reported increased CSF eosinophil count in children with pyogenic ventriculitis, although such finding is rare. CSF eosinophil counts are associated to leak and presence of blood in the CSF, and allergies to silicone and other materials, in addition to infections.^{13,14} Eosinophilia is described as the presence of at least one eosinophil per field, since none should be present. In our review, no patient had eosinophilia.

Another outcome measure previously studied in order to predict the type of bacteria that may be causing pyogenic ventriculitis is the time elapsed between shunt placement and infection onset; however, its usefulness has not been demonstrated in our research. The article published by McGirt¹⁵ is consistent with our results: bacteria identified in the first 14 days following VPS placement were the same as those observed after this period.

One of the limitations of our research, also observed in published studies, is the small number of patients with this infection, resulting in a small sample size that may influence the statistical power to find group differences. Another limitation of our work is its retrospective nature, which hinders the analysis of certain outcome measures, such as patient symptoms.

TABLE 1. Characteristics of cerebrospinal fluid in pyogenic ventriculitis based on Gram staining (n= 32)

	Gram positive ¹	Gram negative ¹	P*
CSF glucose level mg/dL	49.5 (0-96)	16 (0-84)	0.14
CSF protein level mg/dL	54.5 (10-684)	117.5 (10-320)	0.17
WBC/mm ³	21 (0-1900)	70 (2-240)	0.79

* Mann-Whitney.

¹ Median (range).

CONCLUSION

Gram-positive bacteria were widely predominant as a cause of pyogenic ventriculitis associated to the surgical procedure. Unlike previous studies, CSF findings show a high dispersion and were not associated to the type of microorganism in this studied sample. At present, CSF cytochemistry may not help to guide microbiological diagnosis or be useful to decide on an initial empirical antibiotic treatment. ■

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