Measurement of cerebrospinal fluid lactate levels in pediatric patients with suspected ventriculoperitoneal shunt infection. Retrospective cohort study

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Abstract

Introduction: Ventriculoperitoneal shunt (VPS) infection is a severe complication. Its early diagnosis could help to decrease morbidity and treatment costs. Lactate has been used for the diagnosis of other central nervous system infections. The aim of this study is to determine the usefulness of lactate for the diagnosis of VPS infection.

Methodology: Retrospective cohort study. Patients who consulted between May 2019 and May 2022 with VPS dysfunction had lactate measured. Means were compared according to culture results. A ROC curve was performed to determine the appropriate cut-off point.

Result: Lactate has a high negative predictive value, but low positive predictive value, for the diagnosis of ventriculitis.

Introduction

The installation of a Peritoneal Ventricular Shunt device (VPS) is one of the most frequent procedures in neurosurgery [1]. Dysfunction and infection of these devices are common complications, which add morbidity and mortality and increase treatment costs. The incidence is estimated to be between 10–20%, which varies according to the case definition, studied period, etc [2, 3]. In our center the incidence is 7.8% in the first installation and 23% in the following ones [4].

Ventricular infection should be suspected in a patient with VPS who presents with fever, usually associated with symptoms of valvular dysfunction, such as headache, nausea or compromised consciousness [5]. In addition, they may present with focal neurological deficits, nuchal rigidity, seizures and photophobia. In a patient with a peritoneal shunt, abdominal signs should raise suspicion of device infection. Demonstration of bacteremia without other cause, in a patient with Ventricular Atrial Shunt, raises suspicion of infection [6].

Routine CSF cytochemical tests are moderately useful, since some alterations may be secondary to infection or because of the shunt (elevated protein, hemorrhage). In turn, a CSF without alterations does not completely rule out a ventricular infection [7, 8].

Lactate has emerged as a marker of inflammation in CSF, which allows distinguishing an infection of the central nervous system by bacteria versus a viral infection or inflammation by another cause (aseptic meningitis) [9, 10]. In infections, lactate increases due to inflammation and cerebral ischemia, which increases anaerobic metabolism [11]. Lactate can also be used for monitoring therapy [12].

For neurosurgical patients, this relationship is less clear. In adult patients, lactate has better positive predictive value than hypoglycorrhachia or pleocytosis for the diagnosis of post neurosurgical meningitis [13, 14]. A cut-off point close to 3.45 mmol/L lactate has a sensitivity close to 90% and a specificity over 85%[15], and is not altered by the presence of blood in the CSF[16]. Recent studies in ventriculostomy
users have shown low sensitivity and specificity [17], but with a good negative predictive value [18] (if it is low, bacterial infection can be ruled out).

In pediatrics the current evidence is less. In external ventricular drainage, one study found no significant difference (although the mean lactate in infection was higher)[19].

Meanwhile, another study found a higher mean lactate level in patients with suspected infection of the peritoneal ventricular drainage, positive culture and a negative predictive value of 96% with a cut-off point of 2.95 mmol/L[20]. There is a good correlation between lactate taken from a lumbar puncture to the sample obtained directly from the ventricle [21].

Currently the evidence of the usefulness of lactate as a marker of infection in children with ventriculoperitoneal shunts is scarce. Our objective is to provide evidence on the usefulness of lactate as a marker of ventricular infection secondary to VPS.

**Patients And Methods**

Retrospective study of diagnostic test. All pediatric patients (0–18 years old), with suspected infection associated with Ventricular Peritoneal or Ventricular Atrial Shunt, admitted to the Pediatric Neurosurgery service or Pediatric Intensive Care Unit of the Asenjo Neurosurgery Institute, in Santiago, Chile, between May 2019 and May 2022 were included.

The suspicion of infection was given by the history of being a carrier of ventricular shunt (regardless of whether it leads to the peritoneum, cardiac atrium or other location), with fever and/or symptoms or signs of valvular dysfunction: compromised consciousness, headache or seizures.

According to institutional protocol, a sample of CSF is taken by direct puncture of the valve or directly from the cerebral ventricle in the ward during the revision of the VPS, to all patients with suspected dysfunction. In addition, CSF culture is requested in every patient who has a taken sample.

Information on patients with suspected ventriculitis was obtained from the service's own records. The electronic laboratory system of the patients under study was retrospectively reviewed. The following data were recorded in a Google Spreadsheet file: identification number (in order to anonymize), patient age, diagnosis, CSF lactate level (in mmol/L) on admission, previous ATB use and CSF culture results. In addition, other results of CSF cytochemical analysis such as glucose level, cellularity and differential count and protein level were recorded. In addition, it was recorded whether the sample was taken by puncture or from the ventricle in the ward. The diagnosis of ventriculitis was made with a positive CSF culture, in a patient with compatible clinics or if the treating team determined an infection, given the clinical condition of patient and other laboratory parameters.

Data were analyzed with R statistical software [22] and RStudio[23]. A descriptive analysis was performed, estimating means and standard deviation. These means were compared using a Student's t-test, assuming independence, considering a significance of 0.05.
Since there is no established cut-off point for lactate, for the diagnosis of ventriculitis an estimation of this will be made using a ROC (Receiver Operating Characteristic) curve, evaluating the best sensitivity and specificity. A positive cerebrospinal fluid culture for any agent will be considered the gold standard for diagnosis.

Ethics

This project was approved by the Medical Direction of the Hospital and the Human Research Ethics Committee of the University of Chile.

The authors have no conflict of interest and receive no external funding.

Results

During the period studied, 130 cases of patients who consulted for ventriculoperitoneal shunt dysfunction were rescued. CSF was only studied in 88 cases, having complete available information for analysis in 86 cases. The mean age was 71.9 months (5.5 years). The distribution of age and sex is shown in Table 1.

<table>
<thead>
<tr>
<th>Gender</th>
<th>Age(month)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>6.36(81.5)</td>
<td>38.3%</td>
</tr>
<tr>
<td>Female</td>
<td>4.98(66.0)</td>
<td>61.6%</td>
</tr>
</tbody>
</table>

Twenty-three positive cultures (26.74%) were diagnosed in the sample studied. In a first analysis, a mean lactate of 3.63 mmol/L was found in the positive cases and 2.25 mmol/L in the culture-negative patients (Graph 1), this difference being significant, but with a p = 0.02. There was no difference in the means between men and women. The database was reviewed, finding 1 patient who had undergone surgery for another cause (cranioplasty), prior to the onset of symptoms. The researchers decided to perform a second analysis removing this extreme case. The mean difference was maintained, being significant with a p < 0.05.

A ROC curve was used to try to estimate an appropriate cut-off point, with an area under the curve of 0.651. With a cut-off point of 3.0 mmol/L, a specificity of 90% is achieved, but a sensitivity of 50%. With this value, a negative predictive value of 83% is achieved. As the cut-off point increases, specificity increases only marginally.

Conclusions
Infection of ventriculoperitoneal shunt is a complication that occurs relatively frequent. Its early diagnosis allows effective treatment and could reduce neurological sequelae. Lactate has been used for the diagnosis of other infections of the central nervous system, such as post-surgical meningitis in adult patients.

Our findings are consistent with those previously published for pediatric patients with VPS, but there are differences in patients with external drainage. Lactate as a unique marker of ventriculitis, has a high specificity and a high negative predictive value, which would allow it to be used to rule out ventricular infection, with a cut-off point of 3.0 mmol/L. But its sensitivity is low, so it is not recommended to use it as a single parameter for the diagnosis of ventriculitis.

**Declarations**

- Ethics approval and consent to participate: This project was approved by the Medical Direction of the Hospital and the Human Research Ethics Committee of the University of Chile.

- Availability of data and material: No applicable

- Competing interests: The authors declare that they have no conflict of interest and do not receive funding for this project.

- Authors' contributions: JP Fernández: Design, data, statistical analysis, manuscript writing. /N Acosta and T. Flores: Design, Data /G. Flores: Data

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**References**


**Figures**

![Image 1: Average lactate](image_url)

**Figure 1**

See image above for figure legend.