DOI: 10.5137/1019-5149.JTN.24714-18.1
Received: 06.09.2018 / Accepted: 02.10.2018
Published Online: 10.12.2018

Turk Neurosurg 29(2):275-278, 2019

Original Investigation

Shunt Tapping Versus Lumbar Puncture for Evaluating Cerebrospinal Fluid Infections in a Pediatric Population

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ABSTRACT

AIM: To compare the results of lumbar puncture (LP) and shunt tapping in pediatric patients with suspected ventriculoperitoneal shunt infection.

MATERIAL and METHODS: Medical records of pediatric patients with suspected shunt infections were retrospectively analyzed. All patients had cerebrospinal fluid samples obtained either via shunt tapping, LP or both. The diagnosis of infection was made when at least one cerebrospinal fluid had positive culture results. The patients with negative cerebrospinal fluid culture results were followed up for at least 6 months to monitor the occurrence of central nervous system infection.

RESULTS: There were 20 patients in the study (12 males, 8 females). Cerebrospinal fluid was obtained by shunt tapping in 11, by lumbar puncture in 9 and by both methods in one patient. Thirteen patients [Shunt tapping: 5/11 (45%), LP: 7/9 (78%), Both: 1)] were diagnosed with shunt infection on the basis of cerebrospinal fluid culture. Seven patients with negative cerebrospinal fluid culture were found to have infections unrelated to shunts and did not show evidence of cerebrospinal fluid infection during the follow-up period. Although the percentage of detecting the infection was higher in LP group, both groups showed negative predictive value of 100%.

CONCLUSION: Both shunt tapping and LP are effective in establishing the diagnosis of shunt infection in suspected patients.

KEYWORDS: Shunt, Infection, Lumbar puncture, Cerebrospinal fluid

INTRODUCTION

Although ventriculoperitoneal shunting (VPS) is the most effective and straightforward neurosurgical procedure for hydrocephalus treatment, it has the highest rate of revision (5,16). One of the most fearsome complications of VPS is infection which occurs in a considerable proportion of patients (6,14,24,25). Several recommendations have been proposed to reduce the rate of infection (2,8,13,20,26,31,35), but a permanent solution remains elusive. Common bacteria that cause shunt infections include *Staphylococcus epidermidis*, *Staphylococcus aureus*, *Streptococcus faecalis*, gram-negative bacteria, and other organisms (4,7,9,12,15,17, 19,23,27,29,30). The diagnostic approach for shunt-associated infections is not straightforward, and can be challenging because clinical manifestations vary greatly depending on the location of the infection source in the central nervous system (CNS), and along the shunt itself as well as the virulence of the organism. To further complicate the clinical picture, cerebrospinal fluid (CSF) infection (meningitis or ventriculitis) can mimic shunt failure because both conditions usually present with signs and symptoms of increased intracranial pressure (11). Prompt diagnosis is of essence because a delay in treatment can have catastrophic consequences.

The most reliable method for infection assessment is identifying the causative organism. Specific antimicrobial antibodies have been reported to help in establishing the

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diagnosis (1), but serological findings are generally of limited value in these situations. The most common method for isolating the underlying organism involves obtaining a CSF sample for microscopic and culture analyses. This is usually accomplished by either shunt reservoir tapping or lumbar puncture (LP) (19,23,29,33). There is very little information in the scientific literature comparing the effectiveness of the aforementioned methods. In the present study, we aimed to retrospectively compare the results of LP and shunt tapping in pediatric patients with suspected shunt infection. We believe that this study will be helpful in filling the scientific gap as well as in designing future studies on this topic.

■ MATERIAL and METHODS

This study was approved by the Antalya Education and Research Hospital Ethics Committee (decision dated 05/04/2018 and numbered 7/13). We retrospectively analyzed the hospital records of 20 pediatric patients evaluated for suspected shunt infections. The diagnostic workup included clinical, laboratory, and imaging studies. We obtained data on the demographics, clinical presentation, laboratory and imaging studies, method of CSF collection, and culture results. The final diagnosis was based on at least one positive CSF bacterial culture result. Statistical analysis was not performed due to the small sample size.

■ RESULTS

Twenty pediatric patients (mean age: 3.2 ± 2.6 years, 12 males and 8 females) were included. Infection was detected in 13 patients with at least one positive CSF culture result. The clinical signs and symptoms for these patients are summarized in Table I. CSF was obtained using shunt tapping in 11 patients and LP in 9 patients. Five patients (45%) in the shunt tapping group and 7 in the LP group (78%) had positive culture results. The most common causative organism was *Staphylococcus epidermidis* (30%) followed by *Staphylococcus aureus* (20%), *Streptococcus pneumoniae* (15%), *Klebsiella pneumonia* (7%), *Escherichia coli* (7%), *Enterobacter faecalis* (7%), *Pseudomonas aeruginosa* (7%), and *Enterobacter cloacae* (7%). The mean CSF protein level in patients with proven infections was 103 mg/dl (range, 5–705 mg/dl), the mean CSF glucose level was 43 mg/dl (range, 1–70 mg/dl), the mean cell count was 180/mm^3 (range, 0–5000 mm^3), the mean C-reactive protein level was 28 mg/L (range, 2–286 mg/L), and the mean blood white blood cell (WBC) count was 12800 /mm^3 (range, 2800–34200 mm^3).

■ DISCUSSION

CSF shunts are associated with high infection rates because the device can get contaminated by bacteria present in the surrounding environment (1). The high infection rate is mostly attributable to the patients' skin etiology of hydrocephalus along with prematurity and young age, which can influence immunocompetence (2). Additionally, shunts, like other prosthetic catheter devices, are associated with poor leukocyte adherence and phagocytosis (3). The clinical

Table I: Clinical Presentation of Patients with Proven Shunt Infection

Symptom	n (%)
Headache	4 (30)
Vomiting	7 (54)
Lethargy	3 (23)
Fever	4 (30)
Seizure	1 (7)

symptoms in this situation do not necessarily indicate infection and include altered consciousness, headache, nausea, vomiting, and symptoms associated with increased intracranial pressure (19). The detection of infection as a cause of shunt failure is challenging. The treatment of infected shunts requires the removal of the device in the majority of cases. Unnecessary removal and delayed removal can have considerable consequences on the patient. Therefore, early and correct diagnosis is an essential part of shunt infection management as the condition is potentially life-threatening.

The bacteria that cause shunt infections are opportunistic and usually have low virulence (32). Microorganisms adhere to the device, making it difficult to identify and completely eradicate the source of infection. This phenomenon usually complicates diagnosis because the absence of evidence of infection in a CSF sample does not exclude the diagnosis of infection (32).

As in all cases of infectious disease, the ultimate diagnostic method is positive culture results. The optimal test is to remove the shunt and send it alongside a CSF sample for bacteriological analysis (10). The superiority of shunt sampling over CSF sampling has been demonstrated (34). However, for various reasons, this approach cannot be utilized as the first-line approach for management. The most common first-line option is to obtain a CSF sample and reserve shunt removal for proven CNS infection. The most widely used method for obtaining CSF is to perform a shunt reservoir puncture. This method is simple, straightforward, safe, reliable, and provides not only a fluid sample but also some information about the functional status of the shunt (21,28). For example, in the event of an obstructed ventricular catheter, no CSF can be drawn. However, there is always a question whether the CSF sample from the shunt is adequate for sampling because bacteria attach to the device and CSF is constantly flowing. LP, on the other hand, provides a sample from the lumbar cistern where the CSF is more stagnant. In addition, many hydrocephalic patients have multiple, physically (semi) isolated compartments in the CSF space, with different levels of contamination. This is particularly true for non-communicating and multi-loculated hydrocephalus. To date, the superiority of one method over the other has only been superficially addressed in the scientific literature.

Scribano et al. reported the case of a patient with a striking difference in the WBC count between the CSF obtained from shunt tapping and LP. However, both samples subsequently tested positive for the same microorganism (29). Miller et al. described a case where the initial shunt tap showed no evidence of an infection that was later detected with LP (18). Noetzel and Baker demonstrated the relative safety and effectiveness of shunt tapping. LP was only performed for three patients, with positive culture results for two. All patients with positive LP culture results also had positive culture results from CSF obtained from shunt tapping (22). Vanaclocha et al. compared the results for CSF culture and removed shunts. They reported that shunt tapping is clearly ineffective in demonstrating shunt infections and advocated shunt removal and sampling (34). Conen et al. reported a higher infection detection rate with shunt tapping than with LP (91% vs. 45%) (3). However, the difference may be attributable to the high rate of prior antibiotic treatment in the LP group (41%). To our knowledge, our study is the first to directly address this question. In most previous studies, CSF sampling was primarily performed via shunt tapping. LP was usually performed later for non-diagnostic shunt taps. By the time LP was performed, most patients had received antibiotic treatment, reducing the importance of the test. To our knowledge, ours is the only study where a comparable number of patients had undergone either shunt tapping or LP at the initial presentation.

Despite the higher rate of infection detection in the LP group, one should be careful not to interpret the results as indicating the superiority of one method over another. It is worth reiterating that the importance of the method is not determined by the rate of disease detection in suspected patients but rather by the rate of detection when the disease is actually present. For this purpose, the usefulness of the test is defined by its positive and negative predictive value. In our study, both shunt tapping and LP were demonstrated to have 100% positive and negative predictive values. This is attributable to the small sample size, and large, prospective studies with concomitant CSF sampling from different sites are needed to compare the relative value of each test.

The present study has several limitations. The retrospective design is one of the major drawbacks. CSF was not simultaneously obtained from both shunt tapping and LP. However, both methods were shown to be effective in detecting shunt infection because the patients with negative culture results were found to have no CNS infection in their follow-up.

■ CONCLUSION

Shunt tapping and LP are simple, safe, and accurate for diagnosing CSF infection in shunt-implanted pediatric patients.

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