Management of Pyogenic Cerebral Ventriculitis by Neuroendoscopic Surgery

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BACKGROUND: **Pyogenic cerebral ventriculitis is a debilitating form of intracranial infection with an unfavorable outcome as a result of lack of experience in surgical management.**

OBJECTIVE: **To study retrospectively a group of pyogenic cerebral ventriculitis patients managed by neuroendoscopic surgery (NES).**

METHODS: **The standard intraventricular protocols of NES to treat this disease included 1 or more of the following: 1) obliteration of debris, 2) evidence of microbial infection, 3) septomy, 4) incision of the septation, or 5) monitoring catheter insertion. Modified external ventricular drainage EVD (mEVD) was combined with NES when intraventricular debris and bacterial plaques could not be evacuated completely. Subsequent surgical treatment strategies depended on the clinical manifestation, cerebrospinal fluid analysis, and mEVD blockage tests approximately 3 weeks after the last NES.**

RESULTS: **Forty-one patients, who were distributed in 7 hospitals and underwent NES, were included. Five patients received 1 NES, 18 received 2, 16 received 3, and 2 received 4. mEVD was performed in all patients, and mean mEVD duration in the hospital was 27.6 days. At discharge, 15 patients were cured, 15 were cured but ventriculoperitoneal shunt dependent, 9 were mEVD dependent, and 2 died (mean modified Rankin Scale score was 2.48). Two mEVD-dependent patients died, and no other outcomes changed during postoperative follow-up (mean modified Rankin Scale score, 2.67).**

CONCLUSIONS: **The results suggest a relatively favorable outcome for management of pyogenic cerebral ventriculitis by NES. The techniques and strategies are practical and should be applied more extensively.**

INTRODUCTION

Pyogenic cerebral ventriculitis is a debilitating form of intracranial infection as well as a severe complication after surgical procedures, especially cerebral ventricular insertion.[1,2] It is uncommon, and its incidence varies significantly because of variation in diagnostic criteria. Recently, pyogenic cerebral ventriculitis has been detected by diffusion-weighted (DW) magnetic resonance imaging (MRI) and apparent diffusion coefficient (ADC) maps, which are noninvasive methods for pyogenic cerebral ventriculitis diagnosis rather than cerebrospinal fluid (CSF) sampling.[3,4] Furthermore, DW MRI and ADC maps are more sensitive than CSF analysis in pyogenic cerebral ventriculitis diagnosis.[5,6] As a result, it is possible to diagnose pyogenic cerebral ventriculitis promptly.

However, the outcome of pyogenic cerebral ventriculitis is still unfavorable because of lack of experience in surgical management,[7] even although antibiotic treatments have been discussed frequently.[8] Pyogenic cerebral ventriculitis is an intractable emergency, and complicated hydrocephalus, intraventricular debris, and pus must be treated appropriately, but surgical approaches are rarely reported and studied. Neuroendoscopic surgery (NES) seems to be the most appropriate approach for obtaining the goals. However, to our knowledge, only a few cases of pyogenic cerebral ventriculitis treated by NES have been

Key words
- Neuroendoscopy
- Prognosis
- Surgery
- Ventriculitis

Abbreviations and Acronyms
ADC: Apparent diffusion coefficient
CSF: Cerebrospinal fluid
CT: Computed tomography
DW: Diffusion-weighted
EVD: External ventricular drainage
mEVD: Modified external ventricular drainage
MRI: Magnetic resonance imaging
mRS: Modified Rankin Scale
NES: Neuroendoscopic surgery
VP: Ventriculoperitoneal

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reported.[9-11] In addition, these cases were unlikely to have been severe because almost all patients recovered relatively quickly with just 1 surgery and were independent of ventriculoperitoneal (VP) shunt. Thus, study of a large group of pyogenic cerebral ventriculitis patients who had undergone NES is required.

More than half of the cases included in this study were transferred to our center from the other 6 main hospitals in Yunnan Province once pyogenic cerebral ventriculitis was diagnosed or highly suspected. All the NES in this study was performed by the same chief neurosurgeon in our center or the other 6 main hospitals, which represents typical treatment of pyogenic cerebral ventriculitis in Yunnan Province.

METHODS

Patients and Inclusion Criteria

This study was conducted in accordance with ethics committee guidelines of Kunming Medical University and with the approval of the institutional review board. All relevant patients in this study authorized release of their medical records and information. Fifty-six consecutive patients diagnosed with cerebral ventriculitis in 7 hospitals were retrospectively evaluated from May 2011 to November 2015. These hospitals are main hospitals or the leading center in Yunnan Province, and they are as follows: First Affiliated Hospital of Kunming Medical University, People's Hospital of Yuxi City, People's Hospital of Gejiu City, People's Hospital of Mile City, People's Hospital of Qujin City, People's Hospital of Chuxiong City, and People's Hospital of Kaiyuan City. Eligible patients were enrolled in this study only if they had been diagnosed with pyogenic cerebral ventriculitis and had undergone NES to treat this disease. However, if the primary disease before pyogenic cerebral ventriculitis had been lethal, patients were excluded from this study. The criteria for pyogenic cerebral ventriculitis was as follows: 1) history of neurosurgical procedures or weakness; 2) symptoms of fever, headache, and deterioration of mental status or consciousness; 3) hydrocephalus confirmed by computed tomography (CT) or MRI as well as intraventricular debris and pus shown by DW MRI and ADC maps (a decreased ADC value and increased signal intensity of intraventricular fluid by DW MRI); and 4) pyogenic cerebral ventriculitis confirmed under surveillance of NES. All the criteria had to have been present together.

NES Techniques

The standard protocols of NES to treat pyogenic cerebral ventriculitis were 1 or more of the following: 1) to obliterate intraventricular debris and pus by intra-channel suction and forceps, 2) to observe bacterial plaques of the ventricular wall, 3) to perform septomy if the foramen Monro or third ventricle was obstructed, 4) to incise or excise the intraventricular septation, and 5) to monitor or adjust ventricular insertion for optimal external ventricular drainage (EVD) or VP shunt placement. All the procedures were performed via a single burr hole (the right Kocher point was the preferred entry site) in combination with thorough intraventricular irrigation under general anesthesia. The senior author (T.S.) is the only neurosurgeon in Yunnan Province who is eligible to perform NES on pyogenic cerebral ventriculitis patients.

Combined Surgical Procedures

The modified EVD (mEVD) protocols in this study differed from conventional EVD. Conventional EVD placed by other doctors was withdrawn under surveillance of neuroendoscopy. mEVD was performed when intraventricular debris and bacterial plaques could not be evacuated completely. The distal portion of the ventricular catheter was attached to a pressure valve that was connected to a long catheter. Ventricular catheter, pressure valve ($\approx$10 cm H_2O), and long catheter were tunneled subcutaneously according to VP shunt protocols, except that the end of the long catheter was placed ex vivo to be connected to a drainage system rather than in the peritoneal cavity (Figure 1). The 24-hour volume of CSF by mEVD was measured by a glass cylinder.

Subsequent Surgical Treatment Strategies

Subsequent surgical treatment strategies depended on the clinical status after the last NES. Clinical manifestation, CSF analysis, and mEVD blockage tests were combined for clinical status evaluation. mEVD was blocked ex vivo for 2 days to evaluate the possibility of communicating hydrocephalus prospectively, which is referred to as the mEVD blockage test. The blockage test was performed only when 2 consecutive routine CSF analyses were completely normal, at least 1 CSF culture was negative, and hydrocephalus was obliterated. If completely cured pyogenic cerebral ventriculitis and sparing from hydrocephalus were suggested, mEVD was withdrawn. In case of completely cured pyogenic cerebral ventriculitis but complicating hydrocephalus, mEVD was replaced by VP shunt. If ventriculitis was still detected approximately 3 weeks since the last NES, it was performed again, and mEVD was replaced by another mEVD. If the VP shunt did not work well because of ventriculitis relapse, it was replaced promptly by mEVD.

CSF Sampling and Cutoff for Normal Routine CSF Analysis

CSF samples were acquired from mEVD, and frequency of sampling varied with patients (usually once every 2–7 days). The cutoffs for CSF analysis were white blood cell count $<10 \times 10^6$/L, total protein level <0.25 g/L, and glucose level 2.8–4.5 mmol/L.[12]

Antibiotics Treatment

The empiric antibiotics treatment before the report of CSF culture was vancomycin (1.0 g, every 12 hours) and meropenem (1.0 g, every 8 hours).[13] CSF culture was also used to establish antibiotic treatment strategy after empiric antibiotics treatment.

Grading for Outcomes at Discharge and Long-Term Outcomes

The modified Rankin Scale (mRS) was used to grade outcomes at discharge and long-term outcomes.

Data Analysis

All analyses were performed using SPSS version 19.0 for Windows (IBM Corp., Armonk, New York, USA). Continuous variables are presented as mean $\pm$ standard deviation, and count or ranked variables are presented as mean (range, minimum–maximum).