



## External Ventricular Drain–Related Infection in Spontaneous Intracerebral Hemorrhage

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■ **OBJECTIVE:** We aimed to analyze infection rates in patients with spontaneous intracranial hemorrhage who underwent surgical external ventricular drain (EVD) placement.

■ **METHODS:** This prospective study included 94 consecutive patients who required an EVD for spontaneous intracranial hemorrhage at the Neurosurgery Department of Hospital Cristo Redentor, Porto Alegre, Rio Grande do Sul, Brazil.

■ **RESULTS:** The mean duration of EVD use was 7 days. Overall sample mortality was 45%, and overall infection rate was 36%. Patients who had an EVD in place >10 days had higher odds of infection than patients who had an EVD in place ≤10 days (odds ratio = 3.1, 95% confidence interval, 1.1–8.7). Culture positivity rate was 5.3%.

■ **CONCLUSIONS:** Our findings suggest that EVD infection is a very common complication, occurring in 36.2% of cases. We adopted ventriculitis as the standard diagnosis, as advocated by the U.S. Centers for Disease Control and Prevention. Considering the high lethality associated with intracranial hemorrhage, use of a more aggressive treatment protocol for this patient population might improve morbidity and mortality rates.

### INTRODUCTION

External ventricular drains (EVDs) are used in neurosurgery to drain cerebrospinal fluid (CSF) from patients with increased intracranial pressure caused by various

conditions (tumors, trauma, meningitis, spontaneous intracranial hemorrhage). An EVD can serve both as a therapeutic measure for CSF drainage and as a tool for intracranial pressure monitoring. The main complication of this procedure is infection (meningitis and/or ventriculitis), with infection rates of 0%–27% reported in the literature.<sup>1–3</sup> Risk factors for increased EVD infection rate include duration of catheter use, spontaneous intracranial hemorrhage secondary to intraparenchymal hemorrhagic stroke (particularly with concomitant intraventricular hemorrhage), subarachnoid hemorrhage (SAH), open and depressed skull fractures, basilar skull fracture with CSF leak, systemic infection, and other neurosurgical procedures.<sup>1–4</sup> The present study analyzes infection rates in a series of patients with spontaneous intracranial hemorrhage who required EVD placement, compares these rates with the presence of risk factors for meningitis and/or ventriculitis as described in the literature, and evaluates the mortality rate.

### MATERIALS AND METHODS

This prospective study included 94 consecutive patients who required an EVD for spontaneous intracranial hemorrhage from January 2010 to July 2011 at the Neurosurgery Department of Hospital Cristo Redentor, Porto Alegre, Rio Grande do Sul, Brazil. All EVD procedures were performed by one of the surgeons of Cristo Redentor Neurosurgery Department and an assistant using standard Codman catheters (Codman Neuro, Raynham, Massachusetts, USA). Most procedures (60%) were emergency surgeries. Cases with intracranial hemorrhage but without SAH were identified by computed tomography scans, and cases without SAH on the baseline computed tomography scan were considered as having only intracranial hemorrhage. This study was approved by the hospital Research Ethics Committee and has been performed in accordance with the ethical standards in the 1964 Declaration of Helsinki and its later amendments. Although inclusion was prospective, this was a purely observational chart review study, all

### Key words

- Cerebral hemorrhage
- Cerebral ventriculitis
- Ventriculostomy

### Abbreviations and Acronyms

**CDC:** Centers for Disease Control and Prevention  
**CSF:** Cerebrospinal fluid  
**EVD:** External ventricular drain  
**SAH:** Subarachnoid hemorrhage

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**Table 1.** General Characteristics of Study Sample

Characteristics	Value
Sex	
Female	51 (54%)
Male	43 (46%)
Age, years, mean ( $\pm$ SD)	56 $\pm$ 14
Duration of EVD use, day, mean ( $\pm$ SD)	7 $\pm$ 5
Mortality	42 (45%)
Overall infection rate	34 (36%)
Underlying disease	
SAH	59 (63%)
Hemorrhagic stroke	35 (37%)
Known malignancy	4 (5%)
Concomitant systemic infection	59 (64%)
Other neurosurgical procedures	26 (28%)
Bloody CSF	91 (97%)
Diabetes	18 (19%)
Systemic hypertension	57 (61%)
Antibiotic prophylaxis	65 (76%)
Emergency surgery	56 (60%)

Values are presented as number and percentage (%) and as mean and standard deviation. EVD, external ventricular drain; SAH, subarachnoid hemorrhage; CSF, cerebrospinal fluid.

data were anonymized, and no patients were identified. Thus, the requirement for informed consent was waived.

The following patient data were collected: age, sex, duration of EVD placement, mortality, infection rate, type of spontaneous intracranial hemorrhage, preexisting infection, length of hospital stay, underlying disease, criteria for infection, known malignancy, concomitant systemic infection, prior central nervous system surgery, bloody CSF, diabetes mellitus and hypertension status, and preoperative antimicrobial prophylaxis (Table 1). In all 94 patients, CSF samples were drawn directly from the EVD at the time of surgery or later at bedside (under rigorous aseptic technique) and analyzed by an infectious diseases specialist (L.W.L.) from the Hospital Cristo Redentor infection control committee, using U.S. Centers for Disease Control and Prevention (CDC) criteria for diagnosis of meningitis and/or ventriculitis as a reference (Table 2).<sup>5</sup>

IBM SPSS Statistics for Windows version 20.0 (IBM Corporation, Armonk, New York, USA) was used for initial statistical analysis. Data were expressed as absolute (n) and relative (%) frequencies. The Kolmogorov-Smirnov test was used to assess the normality of numerical variables. Normal variables were expressed as mean and SD, and non-normally distributed variables were expressed as median and interquartile range. The  $\chi^2$  test was used to evaluate differences between the groups (infection vs. no infection). Odds ratios were used to evaluate the association

**Table 2.** Centers and Disease Control and Prevention Criteria for Diagnosis of Meningitis and/or Ventriculitis

Criterion 1
Organisms cultured from CSF (growth in 2 different culture media or twice in the same medium)
Criterion 2
Patient has at least 1 of the following signs or symptoms with no other recognized cause: fever ( $>38^\circ\text{C}$ ), headache, stiff neck, meningeal signs, cranial nerve signs, or irritability
Patient also has at least 1 of the following:
a. Increased white blood cells, elevated protein, or decreased glucose in CSF
b. Organisms seen on Gram stain of CSF
c. Organisms cultured from blood
d. Positive antigen test of CSF, blood, or urine
e. Diagnostic single antibody titer (immunoglobulin M) or 4-fold increase in paired sera (immunoglobulin G) for pathogen
CSF, cerebrospinal fluid.

between variables that exhibited differences between the infection and no-infection groups.

Data on duration of EVD placement were dichotomized into 2 categories ( $<10$  days and  $>10$  days) for analysis. These data were then divided into 2 groups (hemorrhagic stroke and SAH) and paired comparatively for epidemiologic analysis of the outcome of interest (infection), as shown in Table 3. Logistic regression analysis was performed for the same outcome, through a model including only variables with  $P < 0.2$  in the univariate analysis (EVD use  $>10$  days and length of hospital stay  $>30$  days). Only the variable that had a significance level  $<0.5$  remained in the backward logistic regression model (EVD use  $>10$  days) (Table 4).

## RESULTS

The series comprised 43 men (45.7%) and 51 women (54.3%). Mean age across the sample was 56.1 years. The mean duration of EVD use was 7 days. Overall sample mortality was 45%, and overall infection rate was 36%. Of the 34 patients who had infections, only 5 met criterion 1 (Table 2), and the remaining patients met criterion 2. When the sample was stratified by underlying disease that prompted surgery, SAH was found to account for 63% of cases. The rate of systemic infection concomitant with ventriculitis (particularly urinary tract infection and pulmonary infection) was 64%. Most patients had bloody CSF. The mean length of hospital stay was 19 days ranging from 11 to 35 days. In 56 cases (60%), EVD was performed urgently. All ventriculostomies were performed in the operating room, and 76% of patients received antibiotic prophylaxis (1 dose 30 minutes before the procedure). Only 5 patients (5.3%) had positive cultures. Patients who had an EVD in place  $>10$  days had higher odds of infection than patients who had an EVD in place  $\leq 10$  days (odds ratio = 3.1, 95% confidence interval, 1.1–8.7), which is consistent with the literature.<sup>2–6</sup> The other

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