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Monoblock external ventricular drainage system in the treatment of patients with acute hydrocephalus: A pilot study

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Data Collection B
Statistical Analysis C
Data Interpretation D
Manuscript Preparation E
Literature Search F
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Background: Infection is a major complication in patients undergoing external ventricular drainage (EVD). Our study aimed to evaluate the incidence of infection in a series with the monoblock EVD system.

Material/Methods: 46 patients treated with EVD at our emergency department were analyzed prospectively to research the incidence of infections with a new EVD system.

Results: The average rate of infection was 8.7%. When we stratified the patients according to the exclusive use of EVD without craniotomies, we identified a reduction in the overall incidence of ventriculitis from 8.7% to 2.3%. Age, etiology, and the presence of ventricular bleeding were not statistically significant risk factors.

Conclusions: Despite the small sample examined in this study, we believe that the monoblock system is a simple, inexpensive device that reduces accidental disconnection of the system.

Keywords: **external ventricular drainage • infection • risk factors**

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Background

The first continuous drainage of external cerebrospinal fluid (CSF) was performed by Krause in 1911. Dandy first discovered the importance of dynamic CSF in animals, and Sjöquist did comparable work in humans [1].

Nowadays, it is known that ventriculostomy catheters are uniquely useful in the control of intracranial pressure by allowing the drainage of CSF [2–5]. The main drawback of these catheters is the life-threatening risk of ventriculitis associated with catheters [3]. Previous studies have shown a high incidence of infectious complications (4–20%), with an average value of about 10% [3–11]. There are few consensual guidelines on the precautions that can be used to avoid infections with the External Ventricular Drainage (EVD) system, and current precautions that are in use often rely on studies that are not based on evidence.

Modifications in surgical techniques, technological advances in shunt design, educational programs, and surgical experience have contributed to an overall decrease in shunt-related complications. However, shunt infections remain one of the most serious challenges facing neurosurgeons today. Even when successfully treated, infections are associated with reduced IQ and academic performance, increased risk of seizures, and psychomotor impairment. Moreover, shunt infections are a common cause of shunt failure, and they are associated with increased morbidity and mortality rates [12].

Conventional EVD systems usually have many connections for the cleaning and removal of debris or clots in the ventricular system, the intracranial pressure monitoring, and others that allow the infusion of drugs. The majority of these connections consist of stopcocks that allow for the opening of the system. Accidental disconnection of the EVD system is not uncommon in clinical practice. We aimed to evaluate the incidence of infections in patients who had been treated with the monoblock-type system, which is a new model of EVD that does not have stopcock connections.

Material and method

Setting

We performed a prospective pilot study from January 1, 2012 to June 30, 2012. Data were collected from 46 neurosurgical patients who were treated with EVD. The ventriculostomy catheter used was the monoblock type, a new low-cost EVD system, and it was placed under sterile conditions in the operating room. The study was conducted in the emergency ICU of our institution, an unit with 20 beds, with 10 targeted for emergency neurosurgery, and with a nursing team trained in handling ICP and EVD systems. We used a protocol adopted in our neurology ICU, described by Camacho et al. [12].

Criteria for infection diagnosis

The diagnosis of meningitis or ventriculitis in our sample was established by the criteria described by Horan et al. [13] Infection was diagnosed in serial CSF samples with bacterioscopy, culture, and biochemical exams. An infection was defined with either pleocytosis or abnormal CSF protein or glucose levels, in addition to a positive CSF culture, and it was recorded to have occurred on the day that the CSF sample was obtained. CSF was collected from all the patients during catheter removal, and it was considered to be an infection related to EVD up to 30 days after catheter removal.

Evaluated parameters

The following parameters were collected: sex, age, incidence of EVD system disconnections, admitting diagnosis, surgical procedures, presence of inflammation of the CSF, the causative organism and frequency of isolation, resistance pattern, and initiation of antibiotics for ventriculitis. The sample was composed of patients with different emergency neurosurgical pathologies, such as primary hydrocephalus, subarachnoid hemorrhage (SAH), tumors, and brain swelling.

Statistical analysis

Statistical analyses were performed using SigmaStat® (Jadel Inc, Brandon, FL) software, applied within each subgroup analysis using Fisher test to compare proportions. To evaluate the incidence of EVD-related infection system, we stratified the independent variables as dichotomous form of ventricular bleeding, age greater or less than 60 years, and time of catheterization (>5 days or <5 days). A p value of less than 0.05 was considered significant. The procedures that were performed in this study were previously approved by the ethics committee of our hospital and were in accordance with the principles of the Declaration of Helsinki.

Description of the EVD "monoblock" system

The straight radiopaque ventricular silicone catheter, the curved trocar of stainless steel, and the safety systems that prevent accidental breakage and displacement of the ventricular catheter were identical to those of conventional EVD systems. The drainage system consisted of a measuring scale of millimeters that went up to 25 cmH_2O, with a parallel scale in mmHg and a system of tubes that were connected to the collection bag fitted with a one-way valve (Figure 1). The differences in the system compared to the conventional system were the absence of stopcocks and the presence of an injection port for drug infusion that was called an "interlink", to prevent violation of the

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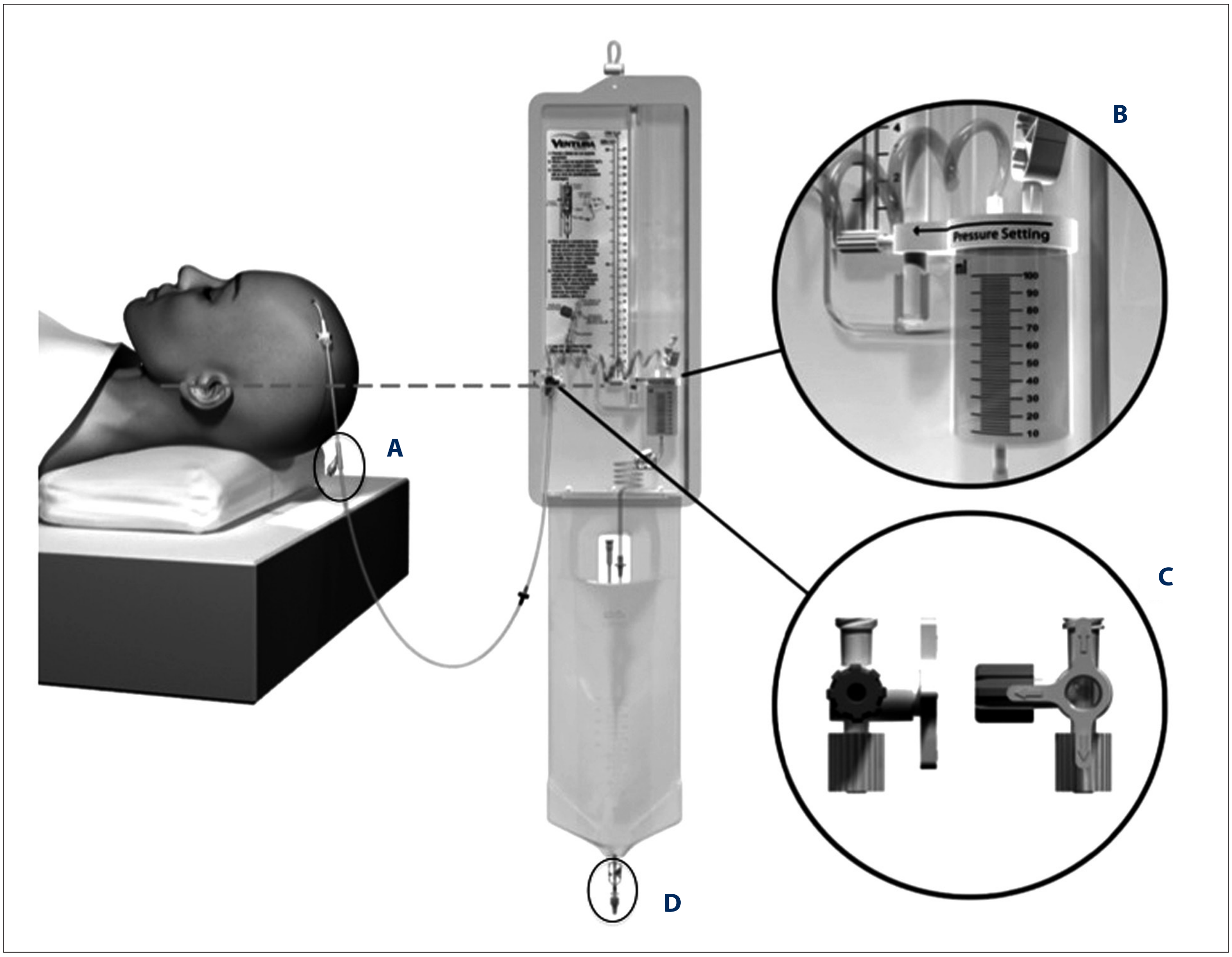

Figure 1. Schematic drawing of the external ventricular drainage monoblock system. (**A**) First interlink without connections, it allows the collection of CSF for analysis without needle. (**B**) Collector tube with level marking for proper height. (**C**) Unique connector in the external ventricular drainage system, with special locking system that serves to unstop for acute obstruction. (**D**) Second interlink that allows emptying the collection bag without needles and damage to the system.

system and disconnection. The technique used to implant the EVD system is very similar to the conventional one: the catheter is introduced after a burr-hole is made at the Kocher point until it reaches the ventricles (about 5.5 cm from the inner table of frontal bone). Once CSF is obtained, the catheter is exteriorized through a counter-opening at least 10 cm away from the incision and fixed to the skin. Since there are no stopcocks, CSF sampling is made through the interlink, keeping the system relatively closed and preventing contamination and accidental disconnections.

Results

Table 1 shows the distribution of patients according to sex, etiology, infection, and type of EVD system. The study population consisted of 46 patients (18 women [39.1%] and 28 men [60.9%]). The mean age of the patients was 41.84±21.05 years (range, 10 months to 71 years). The leading cause of EVD placement was ventricular hemorrhage in 24 patients (10 spontaneous brain hematomas, 7 patients with SAH with ventricular bleeding, and 7 patients with traumatic brain injury). The overall infection rate was 8.7% (4 cases), excluding the cases with previous ventriculoperitoneal shunts and those with endoscopic ventriculostomies. Four patients had previously confirmed infections, and 3 had undergone craniotomies for aneurysm clipping. If we consider the patients who underwent EVD placement without other neurosurgical procedures, ventriculitis was noted in only 1 patient, a poly-traumatized victim of a traffic accident, who had diffuse axonal injury with ventricular bleeding (VB). He underwent EVD placement and received a direct cerebral oximetry catheter. After 5 days, catheter infection was confirmed in the CSF that was collected at the time of catheter removal.

The average length of time the catheter was implanted was 5 days, ranging from 3 to 9 days. The microorganisms involved

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Table 1. Distribution of patients according to sex, etiology, infection and type of EVD system.

	N	%
Sex		
Male	28	61
Female	18	39
ETIOLOGY		
Stroke (brain hematoma)	10	21.7
Subarachnoid hemorrhage	7	15.2
Brain injury	7	15.2
Tumor	15	32.6
Other	7	15.2
Infection		
EVD	1 in 43	2.3
EVD + craniotomy	3 in 46	6.5
EVD system and infection		
Monoblock	4 in 46	8.7
Conventional*	22 in 119	18.3

EVD – external ventricular drainage system. * Referring data published in another paper of our institution [17].

were *Acinetobacter baumannii* complex, which was present in 2 patients (50%), followed by *Enterobacter cloacae*, present in 1 patient (25%), and *Pseudomonas aeruginosa*, present in 1 patient (25%). Age, etiology, and VB were not statistically significant risk factors. In this group, the severity of VB did not influence the outcome. We did not verify any cases of accidental disconnection of the system or catheter malfunction due to obstruction (caused by the clot), even in patients with VB.

Infection occurred in 3 of 24 patients with VB and only in 1 of 22 without this condition (12.5% *vs.* 4.5%, p=0.09). In relation to duration of catheterization, infection was present in 1 of 8 patients with EVD for less than 5 days and in 3 of 38 with EVD for 5 or more days (12.5% *vs.* 7.9%, p=0.46). Infection occurred in 3 of 36 patients younger than 60 years (8.7%) and 1 of 10 patients older than 60 years (10%), but these differences were not statistically significant (p=0.69).

Discussion

In the management of intracranial hypertension, ventricular catheters have been shown to be of considerable value. Unfortunately, despite the preventive measures, there are still complications associated with EVD. Infections are of particular concern, with reported rates ranging from 0% to 45% [4,14–26]. This wide range of infection rates is most likely attributable to many factors, including the variety of populations evaluated and the use of dissimilar methodologies in the management of ventricular catheters. Specifically, the use of antibiotic prophylaxis, the techniques of catheter placement, and the methods of CSF sampling have varied between studies, and these differences probably affected the observed infection rates. In addition, multiple studies that have evaluated ventriculostomy-associated infections have used different definitions of infection. Several studies have defined infection as either pleocytosis or abnormal CSF protein or glucose levels, in addition to a positive CSF culture [4,21], which was the criterion used in our study.

Tronnier et al. evaluated different EVD systems and concluded the following: 1) catheters should have an outer diameter of at least 3 mm and an inner diameter of 1.5 mm to avoid occlusion; 2) because catheters without length marks are often too deeply introduced into the ventricle, they should have length marks at 5, 7.5, and 10 cm to facilitate correct positioning; 3) the only acceptable procedure is fixation of the catheter to the galea with a stiff connector at the end of the silicone catheter; 4) impregnation of the ventricular catheter with antibiotics decreases the infection rate; 5) the tunneling between the burr hole and the exit of the galea should be at least 10 cm to prevent infections; 6) the presence of one-way valves prevents the reflux of CSF from the collection bag into the ventricles, preventing infection; and 7) antimicrobial filters should be integrated into air vent caps to balance atmospheric pressure without the risk of contamination, and it is necessary to replace the filter caps after they are in contact with drainage contents, which renders them useless [1].

Mayhall et al. conducted a prospective study of 172 consecutive patients who underwent a total of 213 ventriculostomies, reporting an 11% incidence of ventriculitis. They found that the risk factors for ventriculostomy-related infections were intracerebral hemorrhage with intraventricular hemorrhage, neurosurgical operations, intracranial pressure of 20 mm Hg or more, ventricular catheterization for more than 5 days, and irrigation of the system; however, a previous ventriculostomy did not increase the risk of infection in subsequent procedures. The authors suggested that, if monitoring is required for more than 5 days, the catheter should be removed and a new one inserted at a different site [14].

In the study by Holloway et al, 61 out of 584 patients with ventriculostomies developed ventriculitis, resulting in an incidence rate of 10.4% [15]. Park et al. found an overall infection rate of 8.6% in 595 patients with prolonged ventricular catheterization (duration of catheterization averaged 8.6 days, and 213

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went beyond 10 days) [16]. They found that neither age, sex, diagnosis, catheter exchange, nor CSF leakage significantly affect the infection rate. The location of the patient at the time of catheter insertion, however, did have a significant impact on the infection rate. Specifically, patients who had their ventricular catheter placed at an outside institution had a higher risk for infection – they had a hazard ratio of 3.42, which implied a significant increased risk. Unfortunately, with the limited information provided on their technique of catheter placement, little can be concluded from this finding.

Similar to our experience, another study of 58 patients with continuous intracranial pressure monitoring by ventricular catheterization reported an overall infection rate of 8.6% [17]. Another study that was performed in our institution by Camacho et al. on 119 patients who underwent EVD procedures showed an incidence of infection of 18.3%, and mortality was not significantly different between patients who were infected with Gram-negative (56%) or Gram-positive (50%) microorganisms. The species of microorganisms that were isolated from patients with EVD-related infections were the following: 6 (27.3%) strains of *A. baumannii* (3 of which were carbapenem resistant); 4 (18.2%) strains of *Klebsiella pneumoniae*; 3 (13.6%) strains of *Enterobacter spp.*; 3 strains (13.6%) of *P. aeruginosa* (1 of which was carbapenem resistant; 2 strains (9.1%) of *Staphylococcus epidermidis*; and 1 strain (4.5%) each of *Stenotrophomonas maltophilia*, *Staphylococcus aureus*, *Enterococcus faecium*, and *Micrococcus sp*. The only independent risk factor associated with infection according to the multivariate analysis was the duration of catheterization [18].

We obtained an 8.7% ventricular rate of infection in patients who underwent EVD. The monoblock system did not result in lower infection rates, which have been reported for the conventional system (with stopcocks and devoid of interlinks) [16].

All the 4 cases who presented ventriculitis have peculiarities and this seems to have affected the infection rate found. In 2 cases, patients concomitantly underwent EVD placement and craniotomies for cerebral aneurysm clipping after SAH, and, in the other case, the patient underwent a decompressive craniectomy after posterior fossa brain swelling in a postoperative attempt to clip a vertebral aneurysm, requiring EVD. In the single case with isolated EVD placement, the patient suffered severe head trauma and was subjected to the simultaneous passage of an intraparenchymal catheter to measure intracranial pressure and EVD. Thus, all the cases had at least 2 complicating factors for infection: cerebral hemorrhage and another neurosurgical procedure (craniotomy). Regarding the location of the procedure, all of our cases were subjected to EVD in the operating room with aseptic techniques. Gram-negative microorganisms were responsible for infection in about 50% of cases. Regarding to the microorganism identified in the culture, Liétard et al. [27] reported that Gram-positive agents are responsible for 75.8% of the infections; however, in Latin American hospitals, Gram-negative agents have increased incidence, mainly *Pseudomonas aeruginosa, Acinetobacter baumannii*, and *Klebsiella pneumonia* [28].

Conclusions

Despite the small sample in this pilot study, we believe that the new monoblock EVD system is a simple modification that is useful and inexpensive, with a placement technique very similar to the conventional systems, and that avoids accidental EVD system disconnections.

Disclosure

The authors report no conflicts of interest in this work

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