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Clinical Analysis of External Ventricular Drainage Related Ventriculitis

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Objective : The aim of this study is to analyze on the external ventricular drainage (EVD) related ventriculitis, especially on their risk factors, management, and prevention.

Methods : From January 2003 to December 2005, a total of 174 EVD catheters were placed in 112 patients at our institution. Of these patients, EVD-related ventriculitis were developed in 15 cases. Clinical variables such as age, sex, prior clinical diagnosis, placement of EVD insertion, duration of EVD, total numbers of EVD per person, and outcome were analyzed in theses cases to verify the risk factors, causative agents and outcomes.

Results : Fifteen cases of EVD related ventriculitis were noted presenting infection incidence of 13.39 % per patient and 8.62% per procedure. Of these, five patients died from sepsis, seven patients were recovered from infection but neurological complications remained and three patients were recovered without any complications. Microbes were obtained from cerebrospinal fluid only in six patients. Acinetobactoer baumanii was the most common pathogen in our study (4 cases). Among the various risk factors, only the prior clinical diagnosis showed the statistical significance. Patients who underwent decompressive craniectomy after severe brain trauma showed unfavorable outcome because of possible contaminative environment compared with other cases.

Conclusion : EVD is considered as a safe procedure with good control of intracranial pressure if meticulous care is provided for EVD procedure and maintenance. With regards to risk factors and prevention, the higher incidence and unfavorable outcome was seen especially in patients with severe head trauma. Thus, special attention is required in these clinical settings.

KEY WORDS : External ventricular drain · Ventriculitis · Risk factors · Management · Prevention.

Introduction

External ventricular drainage (EVD) is a useful neurosurgical diagnostic and therapeutic tool that provides for continuous intracranial pressure (ICP) control with monitoring in severe head trauma patients, and also for control of secondary hydrocephalus of various causes. Although it has been a useful method, its benefits have always been tempered by complications associated its use. The most important and serious complication is infection that ranges from 0 to 40% of patients, with a mean value of approximately about 10%[2-5,7,8,12,14,15].

Although many studies of EVD-related ventriculitis have been investigated extensively and several factors that contribute to EVD related ventriculitis have been identified[2,7,11] (e.g, craniotomy, systemic infection, depressed cranial fracture, IVH), some factors are still remained controversies[1,8,9,16,17,20,24] (e.g, duration of EVD catheter, use of antibiotics, and etc.). Also, gram positive microbes in the past traditionally have been predominant because EVD is taken by percutaneous procedure, but gram negative infections have been recently reported with EVD insertion with high mortality rates up to 58%[14, 17].

The main objective of this study was to analyze EVD-related ventriculitis on their incidences, risk factors, managements, and outcomes in recently treated cases compared with previous reported studies.

Materials and Methods

We retrospectively reviewed the medical records and analyzed the patients who underwent EVD between

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January 2003 and December 2005 at our institution. A total of 174 EVD catheters were placed in 112 patients during this period. The duration of catheter was determined on the basis of clinical status of the patients and necessity of intracranial pressure (ICP) monitoring.

Date were collected according to the sex, age, prior clinical diagnosis, previous medical history, placement of EVD catheter, duration of EVD, total numbers of EVD per person, microbiologic results, and clinical outcomes. In cases of verified infection, more detailed clinical findings were added to database with regards to possible factors related to infection, anti-microbial susceptibility, types of treatment provided, and outcomes of patients. Baseline characteristics of all patients and patients with EVD-related infections are separately listed in Table 1, Table 2, and Table 3.

Table 1. Baseline characteristics of patients

Characteristics	
Age (mean, years)	1-82 (48.5)
Sex (male : female)	71: 41
Placement of EVD insertion (OR / ICU)	23 : 89
Duration of EVD insertion (mean)	4-23 days (8.3)
Number of EVD catheter	1-4 (1.55)
Diagnosis of Patients	Total = 112 patients
Trauma	71 (63.39%)
Tumor	4 (3.57%)
Vascular Disease	30 (26.78%)
Hydrocephalus	7 (6.25%)

EVD : external ventricular drain, OR : operation room, ICU : intensive care unit

Table 2. Baseline characteristics of patients with ventriculitis

Characteristics	
Age (mean, years)	1-80 (37.7)
Sex (male : female)	12 : 3
Placement of EVD insertion (OR / ICU)	3 : 12
Duration of EVD insertion (mean)	6-18 days (10.6)
Number of EVD catheter	1-3 (1.86)
Diagnosis of Patients	Total = 15 patients
Trauma	10 (66.66%)
Tumor	1 (6.66%)
Vascular Disease	3 (20%)
Hydrocephalus	1 (6.66%)

EVD : external ventricular drain, OR : operation room, ICU : intensive care unit

EVDs were inserted in the operation room (OR) or Intensive Care Unit (ICU) under sterile conditions. The patient's scalp was shaved and prepared with standard sterile technique. The skin incision was made centered on at Kochor's point and the catheter was inserted into frontal horn of ventricle. The catheter was inserted about 5cm untill CSF was obtained. Then the catheter was tunneled under scalp laterally about 5cm and connected using 3 way stopcocks to an external CSF drainage system. The catheter was securely fixed with suture and sterile dressing applied and prophylactic antibiotics were administrated before catheter insertion and during the period of EDV-in place in all patients.

All patients were monitored in the ICU and EVD catheter dressing was done in daily basis. The closed drainage system was strictly followed. Elevation of the catheter was forbidden to prevent backflow of CSF. If CSF drainage stopped, a computed tomography (CT) scan of brain was performed to determine the proper maintenance of catheter system and to verify any intracranial abnormalities. Routine CSF analysis was done everyday and culture was performed every other day. During the period of EVD maintenance, 1.5g of first-generation cephalosporins were intravenously administrated every 8 hours. If CSF analysis was abnormal, EVD catheter was removed and its tip was sent for culture. Repeated EVD catheter insertion was done at alternate sites when necessary.

Although there have been several different definitions of

Table 3. Summary of patients with EVD related ventriculitis

	Sex	Age	Diagnosis	Placement	Duration(day)	No. of EVD/person	CSF culture	Outcome
1	4	M	ICH Lt corpus callosum c IVH	OR	7	1	x	Fair
2	22	M	EDH Rt-T, SDH Lt F-T-P	SICU	8	1	A. baumanii	Poor
3	3	M	Dermoid cyst	SICU	13	3	E. faecalis,	Poor
4	18	M	H.contusion, T.ICH	SICU	9	2	S. hominis	Poor
5	51	M	SDH Rt F-T-P, acute	SICU	11	2	x	Poor
6	44	F	Moyamoya Disease c IVH	SICU	6	1	x	Poor
7	1	F	Hydrocephalus	OR	18	3	x	Fair
8	60	M	EDH Lt F-T-P, H.contusion	SICU	16	2	A. baumanii	Expire
9	41	M	ICH Lt BG c IVH	SICU	8	1	x	Fair
10	39	M	A1 An Rt c SAH	OR	5	1	A. baumanii,	Poor
11	60	F	Basilar tip An c SAH	SICU	10	2	A. baumaniii	Expire
12	80	M	ICH Rt thalmus c IVH	SICU	11	3	x	Expire
13	61	M	SDH cbll, acute, SAH c IVH	SICU	15	2	x	Expire
14	47	M	T.SAH, SDH Rt F-T-P	SICU	9	2	x	Poor
15	35	M	H. contusion, bilateral	SICU	13	2	x	Expire

EVD : external ventricular drain, OR : operation room, ICU : intensive care unit, ICH : intracranial hemorrhage, EDH : epidural hematoma, SDH : subdural hematoma, An : aneurysm, Cbll : cerebellum, T.SAH : traumatic subarachnoid hemorrhage

"ventriculitis", we used the term "nosocomial ventriculitis" according to Martinez[13] and Mayhall[12] which defined as; 1) a febrile conditions with temperature above 38.5 C' at the time of more than 2 days after EVD catheter insertion, and 2) a positive CSF culture. However, when CSF cultures were negative, the term "suspicious ventriculititis" was used if CSF pleocytosis (above 15cells/mm3) and CSF/plasma glucose ratio of less than 0.5 were noted in CSF laboratory results. We excluded the following patients who have other detectable sources for infection; 1) CSF leakage unrelated with EVD, 2) concurrent bacteremia with the same pathogens, and 3) penestrating injury of the brain.

When EVD-related ventriculitis was diagnosed as mentioned earlier, following treatment protocols were applied. First, CSF sample was obtained for chemical and culture study. Second, EVD catheter was removed and its tip was also sent to laboratory for culture. But if EVD was necessary because of ICP control, EVD catheter was changed to other remote site. Third, when CSF culture study revealed positive result, selective antibiotics (third-generation cephalosporins) were administrated in addition to intra-ventricular vancomycin if necessary. Also, combined antibiotic therapies, based on culture study results, were given for 4-8 weeks. Finally, serial serologic studies were performed.

Data were analyzed by Chi-square test or Fishers's exact test. The difference was considered statistically significant when the p value was less than 0.05.

Results

Between January 2003 and December 2005, 174 EVD catheters were placed in 112 patients (Table 1). Of these, fifteen cases of EVD related ventriculitis were noted presenting infection incidence of 13.39% per patients and 8.62% per procedure (Table 2, 3). The mean age of all patients was 48.5 years (range; 1-82 years), and that of infected patients was 37.7 years (range; 1-80 years). Twelve of 71 (16.90%) males and 3 of 41 (7.31%) females developed infections. There were 5 patients (4.46%) died due to sepsis after average 35 days, 7 patients (6.25%) were recovered from infection but neurological complications remained, and 3 patients (2.67%) were recovered without any complications. Other ventriculitis induced complicatios found in our patients were two patients of brain abscess, and 7 patients with hydrocephalus. All patients with abscess died despite aggressive surgical management with high dose antibiotics.

Each patient had 1-4 EVD catheters, and 38 patients had more than 2 EVD catheters. And 12 patients of 89 and 3 patients of 23 patients who underwent EVD catheter insertion in ICU and operation room developed infections. But the location of placement of EVD insertion SICU or OP and mean numbers of EVD catheter did not add the risks for nosocomial ventriculitis (p=0.12, 0.18). However, the longer the duration of EVD catheter, the more likely the patient seemed to develop an infection. In comparing with the uninfected patients group (mean : 8.3 day, range : 4-23 days), the infected patients group had longer duration of EVD in place (mean : 10.6 day, range : 6-18 days). But the duration of EVD catheter was not clearly associated with the risk of developing ventriculitis in our study (p=0.08) (Table 4).

Table 4. Statistical significances of clinical variables

Clinical variables	*p*-value
Age	0.45
Sex	0.37
Placement of EVD insertion (OR / ICU)	0.12
Duration of EVD insertion	0.08
Number of EVD catheter	0.18
Diagnosis of Patients	0.03*

EVD : external ventricular drain, OR : operation room, ICU : intensive care unit

Table 5. Results of CSF culture

Characteristics	
Culture Positive patients	6
Culture negative patients	9
Organisms of CSF culture	Total = 6 patients
Acinetobacter baumanii (All resisitant)	4
Enterococcus faecium (Ceftriaxone suscepitility)	1
Staphylococcus hominis (Vancomycin susceptility)	1

The patient's underlying diagnosis was associated with the risk of developing ventriculitis, especially in trauma patients. Of all patients, 71 patients underwent EVD after severe head trauma because of ICP control and monitoring. Of these patients, 10 patients (14.08%) developed EVD related ventriculitis.

Six patients showed positive CSF culture and other nine patients who did not show any organisms did not meet the criteria of 'suspicious ventriculitis'. Five cases were caused by gram negative organisms. The microbes which were obtained from CSF culture were Acinetobacter baumanii in 4 cases, Enterococcus faecium in 1 case, and Staphylococcus hominis in 1 case (Table 5).

Discussion

External ventricular drain (EVD) remains a very useful mean in acute hydrocephalus due to IVH and tumors. It can also be considered as the ICP monitoring tool in severe head trauma. However, its benefits have always been tempered by complications associated with their use especially the infections.

The true incidence of EVD-related ventriculitis is difficult

to assess from the literature, because most studies were retrospective and diagnosis usually relied on a positive culture without consideration of clinical and CSF findings. This may lead to an inadequate estimation of infection incidence as shown in studies differentiating infection from contamination. The incidence has been reported as high as 40%, but more commonly, between 10 and 17%[2,3,7,12,21,23] (Table 5). The rate of EVD-related infections at our hospital - 15 cases occurring during of 3 years (infection incidence of 13.39% per patients and 8.62% per procedure) was similar to theses reported in the literatures.

With regard to various possible risk factors studied, neither age nor sex increased the risk of developing infections in our hospital that is consistent with findings previously reported in the literature[7,12,23] (Table 5). Although some authors report an association between infection and various risk factors such as either placement of EVD insertion, duration of EVD, or number of EVD insertion per person[2,3,10,12,15,20], their contributions were not evident in our study. A trend toward the development of infection in patients who had longer duration of EVD insertion was noted, but this trend did not achieve statistical significance in our study (p=0.08) (Table 5). However, there was a significant relation with diagnosis which resulted in EVD insertion especially after head trauma patients. These patients, including intracranial hemorrhages and cerebral contusions, were indicated for EVD insertion to control ICP and to continuously monitor the intraventricular pressure. Because these patients underwent operations with EVD insertion in urgent situation, they seemed to be exposed more contaminated environment than in patients with other elective operations.

Hemorrhage and CSF leakage related to trauma may play an important role causing infection as following mechanisms[2,12]; 1) those that promote bacterial growth, and 2) those that promote bacterial access to the CSF. Several authors[2-5,7,12,18,20-22] also reported causes of EVD related infection as follows; 1) CSF leakage, 2) infection of other site, 3) the use of antibiotics, 4) artificial devices, 5) incomplete closure of dura or skin, and 6) prolonged operation time.

Among various causative etiologic agents associated with EVD-related ventriculitis, the predominant ones are Staphylococcus species, and coaulase-negative staphylococci (CoNS) originated from normal skin flora[12,14,21,23]. The preponderance of gram-negative infections was also notable in our study. Because gram-negative infections are associated with a higher mortality rate, approaching 58% in some studies[14,17], this finding is very important in EVD-related ventriculitis. Several authors[11,14] have described possible clinical settings of the preponderances of gram-negative infections; trauma with open head injury may predispose the patient to gram-negative infection, and prolonged hospitalization result in gram-negative microbial colonization in patients. In our series, open trauma patients were the most vulnerable for EVD-related ventriculitis group. As some authors[11,16] insist to use prophylactic antibiotics for covering gram-positive organisms, we also administrated prophylactic antibiotics before and during procedure. However, prolonged hospital stays, coupled with administration of prophylactic antibiotics may predispose to gram-negative infections. Therefore, the use of broad spectrum prophylactic antibiotics may remain as controversy.

Although many authors and studies have been reported about EVD-related infections, there are still many controversies on the issue of relationship between the duration of EVD insertion and occurrence of infection. In 1984, Mayhall[12] and co-workers reviewed the Medical College of Virginia's database and reported an increased risk of infection in patients with ventriculostomy in place for more than 5 days. They recommended, if monitoring is required for more than 5 days, the catheter should be removed and inserted at different sites. In contrast, in 1996, Holloway[7] and colleagues found a non-linear relation between duration of EVD placement and ventriculitis. The risk of infection increased during the first 10 days, but infections then became unlikely and these authors found no support for the routine exchange of catheters when ICP monitoring is required for more than 5 days[7-9]. In our study, a trend toward the development of infection in patients who had longer duration of EVD insertion was seen, but this did not achieve statistical significance. Although these results support that EVD duration is not a risk factor for EVD-related ventriculitis, more research should be needed for justification.

Another controversy about ventriculitis is the usefulness of prophylactic antibiotics. It has been recommended that prophylactic antibiotics be administered at the time of insertion only, or throughout the entire EVD duration. But, recent studies reported doubtful role of prophylactic antibiotics. Prabhu[17] et al. reported that the role of prophylactic antibiotics with EVD remain unclear. And, several authors[1,10,11] found that antibiotic administration did not decrease the incidence of CSF infection, and moreover, prolonged antibiotic use may predispose for the resistant microbes as mentioned earlier. As our study was not designed to validate this factor with outcome, it should be included in future work.

As for the summary of our study, results and from the review of literature, we emphasize followings to keep in mind for the successful management of EVD; 1) more meticulous care is needed, especially open head injury patients with dirty wounds, 2) when patients were suspected EVD-related infection, prompt evaluation should be performed for differentiate other disease causing febrile conditions, and 3)

selective antibiotics should be started as soon as possible, if CSF culture result is positive or in cases suspicious ventriculitis.

Conclusion

EVD is considered as a safe procedure that provides good intracranial pressure control and monitoring method when meticulous care in taken for EVD procedures and its maintenance. However, ventriculitis may occur in considerable number of patients and when it occurs it may be associated with substantial morbidity and mortality even in modern era of medical practice. Every attempt to reduce its occurrence and prevention is mandatory and when suspected, prompt evaluation and treatment should be initiated and carefully monitored.

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Commentary

The authors retrospectively reviewed the risk factors and prevention of infection after placement of ventricular drains. The ventriculostomy is an important adjunct used for management of hydrocephalus, intraventricular hemorrhage, intracranial hypertension, and central nervous system infections. But the ventriculostomy infection remains the main morbidity associated with this procedure despite the use of prophylactic antibiotic medications, meticulous external drainage care. The risk factors that frequently accompany infections after external ventricular drainage (EVD) are systematic infection, neurosurgical procedure, depressed skull fracture, and intraventricular hemorrhage. Also, the duration and number of EVD and placement of EVD insertion are said to trigger infections as well. Severe techniques have been used to minimize the risk of infection associated with ventriculostomy. The techniques used to reduce the risk of infection include short tunneling of the drainage tube, use of prophylactic antibiotic, reinsertion of a new ventriculostomy catheter after a certain time, use of valve regulated system, minimizing manipulations, and use of a long tunnel catheter. The author reported that infections occur more frequently in case of severe head trauma. However, such assumption is controversial because it is easy to predict high probabilities of infection when CSF leakage occurs as a consequence of severe head trauma. Nevertheless, the author's emphasis on reviewing risk factors to reduce infection rate after EVD deserves attention.

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