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Infection Rate of External Ventricular Drain in Neurosurgical Patients

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Abstract

Background: *External ventricular drain (EVD) is a common neurosurgical procedure, associated with high rates of infection and consequent morbidity and mortality.*

Objective: *The aim of the study is to analyze the EVD related infections, the risk factors, management and prevention.*

Methods: *This is a retrospective analysis from January 2011 to December 2013; a total of 160 patients having EVD inserted, sixteen patients had a primary Cerebrospinal fluid (CSF) infection and were excluded from the further analyzes of the secondary EVD infections. Hence, 144 patients were included in the study. Sets of clinical parameters were analyzed in these cases to verify the EVD infection rate and the related causes, risk factors, causative agents and outcome.*

Results: *A total of 160 patients, 182 EVD procedures, and 1016 catheter-days were evaluated. The EVD-associated CSF infection rate was 18.8%. The most common diagnosis required EVD was strokes (59.7%). (44%) of the infections were caused by Gram-negative organisms. All of the patients received antibiotic prophylaxis.*

Conclusion: *It has been found that there are a relative high percentage of EVD-related infections. After different analysis of the existing data we found that manipulation of the EVD and the duration of the drainage were the most risk factors for the EVD infections. A new EVD protocol has been proposed in our hospital to minimize such infections.*

Keywords: External Ventricular Drain, Neurosurgical Procedures, Complications, Risk Factors, Prevention, Management

Introduction

External ventricular drainage (EVD) is a common neurosurgical practice, which is used as a life-saving procedure to treat hydrocephalus associated with different types of stokes, subarachnoid hemorrhage, tumors and traumatic brain injuries. In the same time, it used to monitor and treat intracranial pressure. Unfortunately, the use of these drains is associated with a relatively high risk of infection. The reported EVD infection rates range from less than one to up to 40% [1-3]. This infection has carried high rates of morbidity and mortality for the patient and an addition burden on neurosurgical care and prolonged hospital stay. EVD infection means EVD revision, reinsertion, use of antibiotics intravenously and intrathecally, EVD blockage, irrigation and flushing, frequent CSF sampling and finally conversion to a ventriculoperitoneal shunt. Some predisposing factors may aggravate the EVD infection including systemic diseases and infection, prior neurosurgical procedures, craniotomy, IVH, and surgical technique (asepsis, extending subcutaneous tunneling, duration of ventriculostomy, EVD manipulation, CSF leak).

The objective of this study is to analyze the incidence of the EVD related infection, the length of hospitalization needed for treating it, risk factors, complications and management.

Patients and Methods

Retrospectively the medical records of the patients who underwent EVDs from January 2011 to December 2013 were reviewed at our hospital. A total of 182 EVD catheters were placed in 160 patients. The duration needed for EVD is planned according to the clinical picture of the patient and the need for the Intracerebral pressure (ICP) monitoring.

Clinical variables, which were collected, included the age, diagnosis, EVD related problems (such as insertion, infection, revision, catheter type, duration and conversion to a ventriculoperitoneal shunt), use of antibiotics (prophylactic, intravenous, intrathecal), CSF and blood analysis, comorbidities, hospital stay and outcome.

Description of all patients which were involved in the study are listed in table 1, and those patients who developed EVD infection where listed in table 2.

Table 1: Comparison of Patient Groups with and without EVD Infection

Parameter	No Infection (n=117, 81.2%)	Infection (n=27, 18.8%)	Infection Rate (%)
Age (yrs), mean (range)	41.4 (2–88)	46.7 (10–81)	—
Diagnosis Subgroups			
Intracerebral Hemorrhage (ICH), IVH	44	5	10.2
Cerebellar ICH	13	4	23.5
Cerebellar Infarction	9	0	0
Brainstem ICH	4	0	0
IVH	4	3	42.9
Subarachnoid Hemorrhage (SAH)	17	11	39.3
Tumor	18	2	10
Traumatic Brain Injury (TBI)	8	2	20
Procedures			
EVD Revisions	3 (2.6%)	13 (48.1%)	—
Converted to VP shunt	14 (12%)	8 (29.6%)	—
Duration of EVD (days)	18.0 (1–77)	30.9 (10–60)	—
Antibiotic Prophylaxis	117 (100%)	24 (88.9%)	—

Table 2: Summary of Patients with EVD Infection

No.	Age	Diagnosis	Infection Day	CSF Culture	Blood Test	IV	IT	Comorbidities	Revision	VP Shunt	Adm. Period (Days)	EVD Duration (Days)	Outcome
1	45	CB-ICH	11	Acinetobact	PC +	Y	Y	HT	N	N	21	11	Poor
2	45	SAH	93	Pseudomon	PC +	Y	Y	HT	N	Y	186	78	Poor
3	65	SAH	24	-v, WBC372	CRP +	Y	N	HT,DM, HD	N	N	46	44	Deceased
4	46	ICH,	9	Acinetobact	PC+	Y	Y	HT, DM	Y	N	45	36	Deceased
5	27	CH-ICH	5	-v, WBC450	PC +	Y	N	None	N	N	16	10	Good
6	40	ICH,	10	-v, WBC20	PC +	Y	N	HT	N	N	42	16	Deceased
7	10	Brain tumor	37	Acinetobact	PC +	Y	Y	None	Y	Y	70	60	Good
8	81	ICH	7	Staph. Epid	PC +	Y	N	HT,DM, HD	N	N	70	27	Poor
9	32	SAH	8	-v,,WBC100	PC+	Y	N	None	N	N	23	23	Deceased
10	64	SAH	11	E. Coli	Not done	N	N	HT, DM	N	N	25	19	Deceased
11	38	SAH	12	Staph. Epid	CRP +	N	N	None	N	N	117	26	Poor
12	37	SAH	9	-v, WBC240	CRP +	N	N	HT	N	N	58	18	Good
13	29	SAH	10	Enterobact	PC +	Y	N	None	Y	N	40	27	Good
14	12	Brain tumor	9	-v, WBC80	ESR 50	Y	N	None	N	N	24	24	Good
15	49	CB-ICH	17	Staph Capits	CRP +	Y	N	HT	N	N	39	22	Good
16	61	SAH	4	-v, WBC 40	PC -	Y	N	HT, DM	N	N	110	17	Poor

17	45	SAH	2	-v, WBC240	PC -	Y	N	HT	N	N	10	10	Deceased
18	48	SAH	5	-v, WBC600	PC -	Y	N	HT	N	N	19	13	Good
19	61	IVH	17	Staph .Epid	PC -	Y	N	HT, DM	N	N	72	17	Poor
20	68	ICH	36	Klebsiel. Pn	PC +	Y	Y	HT, DM	Y	Y	150	53	Deceased
21	36	TBI	37	Klebsiel. Pn	CRP +	Y	Y	Craniotomi	Y	Y	210	180	Poor
22	79	ICH	23	Staph Capits	CRP +	Y	N	HT	Y	Y	210	53	Poor
23	36	ICH	12	-v, WBC 22	PC -	Y	N	HT	N	N	24	20	Deceased
24	36	TBI	23	Klebsiel Pn	CRP +	Y	N	Craniotomi	N	Y	210	8	Poor
25	41	ICH	13	MRSA, Klebs	CRP +	Y	Y	HT, DM	Y	Y	43	30	Poor
26	68	SAH	65	Klebsiel Pn	CRP +	Y	Y	HT	Y	Y	390	133	Poor
27	63	CB-ICH	30	MRSA, Acine	CRP +	Y	Y	HT, DM	N	N	120	16	Poor

Table 3: Statistically Significant of clinical Variables

Clinical variable	p- value
Age	0.05
Diagnosis	0.05
Number of EVD catheters	0.04
Duration of EVD insertion	0.05
Number of EVD revisions	0.04

EVD Procedure

All EVDs were inserted in the operation theatre under strict aseptic measures. Hair was shaved in a localized area where the EVD is planned to be inserted. The scalp was washed initially with Saflon solution then scrubbing with Betadine solution three times. The skin incision was made at Kocher's point and catheter was inserted into the lateral ventricle usually in the right frontal horn through a 4 mm burr hole. The catheter was inserted about 5cm until CSF was drained. After insertion the EVD was tunneled under the scalp about 5cm, fixed to the scalp and connected with a 3- way stopcocks to an external CSF drainage system. The catheter connection and the stopcock were left uncovered. A sterile dressing was applied over the wound and the catheter exit wound. Prophylactic antibiotics were administered before catheter insertion and during the period of EVD-in place in all patients. A CSF sample was taken for analysis for biochemistry, cell count, Gram staining and culture. No ICP sensor line was connected to the EVD system.

EVD Maintenance

Postoperatively the patients were admitted in the intensive care unit, where the EVD is monitored and maintained. Head dressing was changed every 3-4 days. The closed EVD drainage system was frequently manipulated during patient's bed care, rising and lower the patient during positioning was not taken in consideration for CSF backflow. The drainage bag was emptied whenever there is CSF and not waiting until it was full. Routine CSF culture was not performed unless there is suspicious of infection i.e. if the patient had fever or alteration of neurological status with no other apparent cause. CSF samples were taken directly from the catheter exiting the scalp after cleaning it with alcohol swap.

If drainage stopped, a trial of flushing it with normal saline was performed, and if it was not succeeded a plain CT scan of the brain was performed. The catheter was kept in place if CT scan showed it was still inside the ventricle or the ventricles were collapsed. If the catheter was displaced or completely blocked, the EVD was revised and a new EVD was inserted, usually in the same side. If CSF analysis was abnormal (positive gram stain or increased WBC), the patient was taken to the operation theatre and the EVD was removed, and its tip was sent for culture, and a new EVD was inserted in the opposite side.

Whenever the EVD was not more required, it was removed under aseptic measures, its tip was sent for culture and its skin exit was suture.

Definition of EVD Infection

According to Martinez and Mayhall, ventriculitis was defined when there was fever (temperature above 38.5 C), positive CSF culture, CSF pleiocytosis (more than 15 cells/mm3) and CSF/plasma glucose ratio of less than 0.5 [4, 5]. The infection was considered as EVD-related if there was no other detectable source of CNS infection, sepsis, penetrating head injury, CSF leak unrelated to EVD, and post-craniotomy infection. The onset of infection was considered as the number of days after the insertion of the first EVD, regardless of whether the catheter had been changed or not.

Study Analysis

The incidence of the EVD infection was calculated from the whole population of the study period from January 2011 to December 2013 (160 patients, 16 of them were excluded because they were already infected with meningitis) and of the control period (144 patients). The analysis of the whole population (144 patients) to be treated with EVD was considered in order to compare with them the population who developed the EVD infection (27 patients) and the risk factors related to the infection.

Patients' data were collected from the operation theatre registers, operative notes, and patients' files and from on-line patients' in-

formation system "SAM" which includes all radiological, blood and bacteriological analysis and treatment charts.

The risk factors were examined during the study period using the information of the intensive care unit (ICU) charts and the patients' charts regarding the manipulations, revisions and CT scans. The criteria which were considered as risk factors included: hair shaving, EVD tunneling, wound dressing, CSF sampling, catheter flushing, CSF bag emptying and EVD sterility and manipulation.

Table 4: Characteristics of Patients for EVD

Parameter	Value
Total Patients (n)	144
Age (yrs), mean (range)	45.1 (1–88)
Diagnosis Subgroups	
ICH, IVH	49 (34.0%)
Cerebellar ICH	17 (11.8%)
Cerebellar Infarction	9 (6.3%)
Brainstem ICH	4 (2.8%)
IVH	7 (4.9%)
SAH (Aneurysmal, AVM)	28 (19.4%)
Tumors	20 (13.9%)
TBI	10 (6.9%)
EVD Procedures	182
Revisions	16
Converted to VP shunt	22
Duration of EVD insertion (days)	20.4 (1–77)

Results

In the period from January 2011 to December 2013, 164 EVD catheters were inserted, 12 of these patients were excluded because of a pre-existing infection. From the total 144 patients 27 patients had got EVD infection presenting infection incidence of 18.8% per patients and 16.46% per procedure (table 4). The mean age of all patients was 45.1 years (range 1-88 years) and that of infected patients was 46.7 years (range 10-81 years). There were 8 patients (5.36%) died due to sepsis after average 27.6 days, 12 patients (8.05%) were recovered from infection with neurological complications, and 7 patients (4.7%) were recovered without any complications. Of the 27patients 8 patients had 1-3 EVD catheters that underwent EVD revisions due to EVD malfunction and 8 patients had ended with ventriculo-peritoneal shunt due to established hydrocephalus.

For the duration of the EVD catheter, the uninfected patient's group were compared with infected patients' group; in the uninfected group the EVD catheter duration was less (mean: 19.9 days, range: 3-60 days) than in the infected patient's group (mean: 37.6-day, range: 8-133 days). Concluding the longer the duration of the EVD catheter, the more likely the patient seemed to develop an infection.

The CSF culture was positive in 17 patients of the infected cases, in the other 10 patients the culture was negative but they met the criteria of EVD infection within the CSF biochemistry. Twelve cases were caused by gram negative organisms; Acinetobacter Baumanii were in 4 cases, Klebsiella Pneumonia in 5 cases and Pseudomanas aeroginosa in one case, Enterobacter Aerogenes in one case and E. Coli in one case. Three cases had Staphylococcus Epidermis and two cases had Staph Capitis.

Table 5: CSF Analysis in 27 Patients with EVD Infection

Culture Result	Cases (n)
Culture Negative	10
Culture Positive	17
Klebsiella pneumonia	5
Acinetobacter baumanii	4
Staphylococcus epidermis	3
Staphylococcus capitis	2
Pseudomonas aeruginosa	1
Enterobacter aerogenes	1
E. Coli	1

Discussion

External ventricular drainage is considered a life-saving procedure in treating acute hydrocephalus that results from several intracranial pathologies (strokes: Iitracranial hemorrhage (ICH), Intraventricular hemorrhage (IVH), subrachanoidal hemorrhage (SAH), ischemic infarctions) tumors and head traumas. It is used as a monitor for the intracranial pressure as well. Its use carries some complication and collateral damage when these drains got infected.

According to the literature, there is no true incidence of the EVD infection as most of the studies are retrospective and depend only on positive CSF cultures without consideration of the clinical and biochemical data [6-9].

The incidence of EVD infection has been reported as high as 40%, and more commonly between 10 and 22% [10, 11]. The rate of EVD infection at our hospital (27 cases occurred within 3 years (infection incidence of 18.12% per patients and 16.46% per procedure) was within the rates of EVD infections reported in the literatures.

The age has no role to be a risk factor for developing EVD infection as per our study; no age was exempted [12, 13].

The initial diagnosis for which the EVD was required might predispose to more infected cases such as those cases with intracerebral and intraventricular hemorrhages, figure 1 [14, 15].

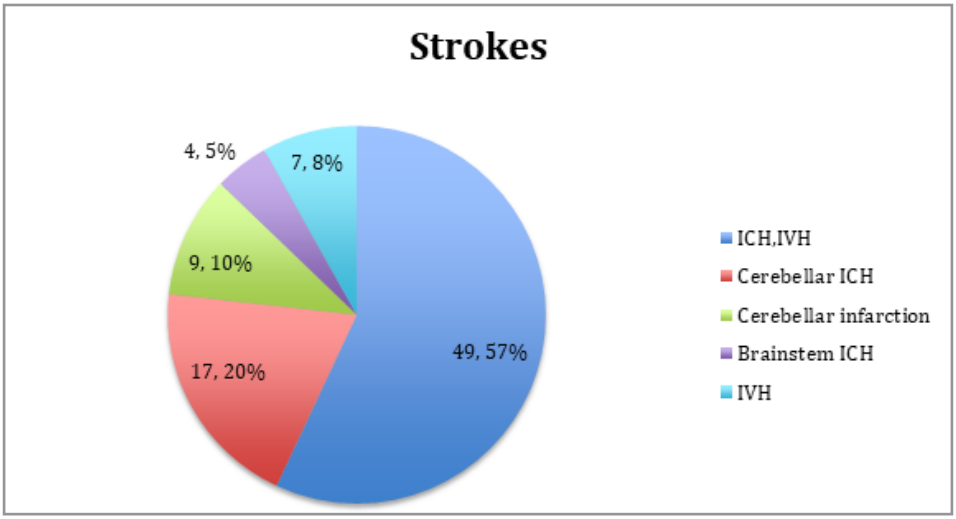


Figure 1: Pie Chart Compares Different Causes of Stroke Required EVD Insertion

Although the head injury cases had shown increased association with EDV infection in some studies, in our study the incidence was just 6% in spite some of the cases had CSF rhinorrhea or otorrhea. But the analysis of this relationship is limited by their small sample size [16].

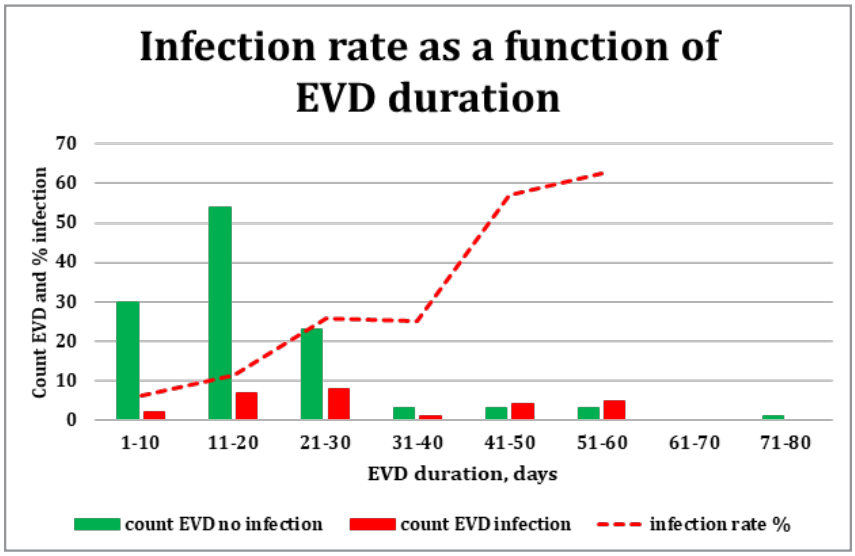
Catheter manipulations, sampling, flushing and irrigation were unavoidable when handling the EVDs, so the EVD maintenance has been suggested to be important in limiting the risk of infection, only catheter irrigation has consistently been associated with increased CSF infection rates [17-19]. In our study all EVD infected cases had been exposed to catheter manipulations in form of CSF sampling, catheter irrigation and flushing. Catheter connections were kept unprotected and not covered with sterile dressing. Strict antiseptic technique was not ensured for the closed system.

The predominant etiological agents causing the EVD infection was found to be Staphylococcus species, and coagulase-negative staphylococci originated from normal skin flora [20-22]. In our study gram-negative infections were the dominant organisms. In some studies, this preponderance of gram-negative infections was found in cases with open head injury and those cases with prolonged hospitalization. In some studies, they insist to use prophylactic antibiotics for covering gram-positive organisms. However, in our study we had prolonged hospitalization and prophylactic antibiotics were used for all patients.

The use of prophylactic antibiotics is controversy. As it decreases the incidence of CSF infection and systemic infections at the expense of predisposing the patient to infection by more resistant organisms when infection do occur. Because EVD infection has devastating consequences, in our study we advocated using prophylactic antibiotics in all patients with EVDs; at the time of insertion and throughout the entire EVD duration. Although the use of antibiotics or antibiotic-impregnated catheters is unwarranted- a positive given concerns of evolving anti-microbial resistance.

Duration of catheterization and the risk of infection is evident in the literature. In 1984, Mayhall 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. In 1996, Holloway and colleagues found a non-linear relation between duration of EVD placement and ventriculitis. The risk of infection increase within the first 10 days, but infections then became unlikely and these authors found no support for the routine exchange of the catheters when ICP monitoring is required for more than 5 days. In our study although the EVD duration was long but the development of infection was not really reflecting this relationship. This may support the result that the EVD duration is not a significant risk factor for EVD infection, although more research should be needed for justification.



To summarize our study and the results we have got from it and from the review of the literature, we recommend the followings to avoid the EVD infections: 1) there should be a defined protocol of EVD insertion and maintenance that incorporates evidence-based measures, 2) early diagnosis of suspected EVD-related infection, 3) co-management of the infected cases with infectious team 4) use of infection-resistant catheters such as antibiotic impregnated or silver impregnated catheters [23-25].

Conclusion

EVD is an important procedure in neurosurgery, although it is a simple and safe procedure, it carries a high risk being infected. EVD infection is an avoidable state; if such procedure is taken seriously and followed a strict and meticulous care with the procedure and the maintenance later on. The complications are devastating and may be associated with substantial morbidity and mortality [26, 27].

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