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Clinical effects of external ventricular drainage system, potential complications and complication management

Eksternal ventriküler drenaj sisteminin klinik etkileri, olasi komplikasyonları ve yönetimi

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ÖZET

AMAÇ: Bu çalışmanın amacı, uygulanan eksternal ventriküler drenaj sisteminin mortalite üzerine etkisini, oluşabilecek komplikasyonları ve komplikasyonların yönetiminin ortaya konmasıdır

GEREÇ VE YÖNTEM: Ocak 2016 – Kasım 2018 ayları arasında Afyon Kocatepe Üniversitesi Beyin Cerrahisi Kliniğinde eksternal ventriküler drenaj sistemi takılmış toplam 128 hasta geriye dönük olarak tarandı. Hastalar yaş, cinsiyet, endikasyon, başvuru anındaki bilinç düzeyleri, sistemik enfeksiyon varlığı, sekonder komplikasyonlar açısından araştırıldı. Eksternal ventriküler drenaj uygulamasının klinik sonlanım üzerine etkileri değerlendirildi.

BULGULAR: Çalışma boyunca 128 hastaya toplamda 176 kez ventrikülostomi uygulandı. Yaş aralığı 1-88 arasında olan 73 erkek, 55 kadın hasta vardı. Hastaneye başvuru anında ortalama GKS değeri 64 hastada 7'nin altında idi. Toplam 38 hastada ventrikülit gelişti. Başvuru anında 8 hastada sistemik enfeksiyon ve antibiyotik kullanım öyküsü tespit edildi. 52 hasta takipler sonucunda kaybedildi.

SONUÇ: Eksternal ventriküler drenaj sistemi acil şartlarda kafa içi basıncı düşürmek amacıyla uygulanan ve klinik sağ kalım üzerine olumlu etkileri bulunan bir sistemdir. En sık ve en ölümcül komplikasyon enfeksiyon gelişimidir. Drenaj sistemi sadece kesinlikle gerekli olan durumlarda ve belirli protokollere göre yapılmalı, ventrikülostomi gerekli süre boyunca tutulmalı ve 5 gün sonra enfeksiyondaki üssel artış göz önüne alınarak hastalar yakın takip edilmelidir.

Anahtar Kelimeler: eksternal ventriküler drenaj sistemi, ventrikülit, mortalite

ABSTRACT

OBJECTIVE: The aim of this study is to reveal the effect of external ventricular drainage system on mortality, potential complications and management of complications.

MATERIALS AND METHODS: Data of 128 patients undergoing external ventricular drain placement procedure at Afyon Kocatepe University Department of Neurosurgery between January 2016 and November 2018 were screened retrospectively. Age, sex, indication, level of consciousness at the time of admission, presence of systemic infection, and secondary complications of the patients were examined. The effects of external ventricular drainage on clinical outcome were evaluated.

RESULTS: A total of 176 ventriculostomies were performed in 128 patients during the study. There were 73 male and 55 female patients with an age range of 1-88 years. The mean Glasgow Coma Scale at admission was ⩽7 in 64 patients. Ventriculitis developed in a total of 38 patients. Systemic infection and antibiotic use history were detected in eight patients at admission. Fifty-two patients died during the follow-up period.

CONCLUSION: External ventricular drainage is a system applied to reduce intracranial pressure under emergency conditions and has positive effects on clinical survival rate. Infection is the most common and most mortal complication. The drainage should only be applied in cases where it is absolutely necessary and in accordance with certain protocols. Furthermore, ventriculostomy should be kept only for the required period of time, and patients should be followed closely considering the exponential increase in infection after five days.

Keywords: external ventricular drainage system, ventriculitis, mortality

INTRODUCTION

External ventricular drainage (EVD) is a method used for the treatment of intraventricular hemorrhage (IVH) caused by the spread of intracerebral hemorrhage (ICH) and subarachnoid hemorrhage (SAH) to the ventricular system and the treatment of acute hydrocephalus. The aim of EVD

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is to lower the volume by draining the bleeding and cerebrospinal fluid (CSF), to administer the fibrinolytic drugs directly into the ventricle, to reduce the destructive effects of blood within the ventricle, and to reduce intracranial pressure.

In neurosurgery practices, ventricular catheter placement approach for CSF drainage is increasing gradually in both acute hydrocephalus treatment and clinical situations requiring temporary treatment [1- 8]. Frequent mechanical complications such as dislocation and obstruction can be listed as the disadvantages of EVD system [5, 9, 10]. Furthermore, infective complications resulting in ventriculitis and meningitis, which cause serious morbidity and are responsible for most adverse sequelae, are seen [4, 10-15]. These complications, which are very difficult to treat, increase the length of hospital stay and therefore, increase the cost of treatment [11, 16, 17].

Although there are highly effective antibiotics and closed drainage systems, the infection rate of ventricular catheters is still high and infection rates have been reported to be 0-40% [4, 10-12, 14, 18-21]. There is still no consensus on the time required for periodic replacement of optimal ventricular catheters and the use of intraventricular antibiotics. In some studies, infection has been reported to be independent of catheter duration [4, 19-21]. Therefore, a functioning ventricular catheter is recommended to remain until it gets infected or blocked and to be removed if it is ensured that it is no longer necessary [3]. There are also studies in the literature showing that infection rates increase with increasing duration of ventricular catheters [8, 14, 15, 17, 18, 22, 23]. In the present study, the effects of ventricular catheters on survival, its complications, and treatments for the management of complication were discussed.

MATERIALS & METHODS

Patients undergoing percutaneous ventriculostomy at Afyon Kocatepe University Faculty of Medicine Department of Neurosurgery between January 2016 and November 2018 were prospectively enrolled in the study. The operation was typically performed in an operating room with an aseptic environment. In some patients with a poor general condition, who were on a ventilator, the procedure was performed in the neurosurgical intensive care unit. All patients received prophylactic antibiotic treatment before the intervention and systemic antibiotic treatment for five days after the intervention. In patients with a suspicion of postoperative ventriculitis, the catheter was changed and the removed part was sent for culture analysis.

Age, sex, underlying disease, secondary complications, other concomitant infections, antibiotic treatment, and ventriculostomy duration were collected from each patient. Cerebrospinal fluid assays were performed at least once every 48 hours and included cytology, culture and biochemical analyzes.

Infection criteria were determined before the study accordingly, positive CSF culture or CSF glucose of <15mg/dL and a combination of at least 50 leukocytes and polymorphs more than 25 in direct examination were interpreted in favor of infection.

Patients who had IVH after trauma, had previously undergone shunt placement or EVD for any reason, and those who showed signs of cranial infection before EVD placement were excluded from the study.

Brain computed tomography (CT) was performed in all patients. Brain CT was repeated when there was no additional neurological deficit, decrease in GCS score and CSF drainage eight hours after EVD placement.

Statistical analysis was performed using Statistix version 4.0 and standard database techniques from which all data were later converted to numeric format (Analytical Software, Tallahassee, Florida, USA) (variance, frequency distribution, and test of significance and BDMP survival analysis, univariate, and multivariate analysis).

RESULTS

The mean age of 128 patients was 42.6 years (1 to 88 years). Of these patients, 73 (57.3%) were male and 55 (42.7%) were female patients. Sixty patients had hydrocephalus, 58 patients had ICH, and 10 had SAH. The number of cases with a hemorrhage volume of less than 30mL and more than 30mL was 22 and 36, respectively (Table 1). Majority of hemorrhage was observed to be localized in lobar and thalamus (Table 2). When the localization and volumes of hemorrhage were examined, the mean volume of lobar hemorrhage was found to be 38 mL whereas the mean volume of thalamic hemorrhage was

20mL. Of the patients, 64 had a GCS score of ≤7, 28 had a GCS score of 8-12, and 36 had a GCS score of 13-15 at the time of admission. Of the 128 patients included in the study, 52 (40.6%) died, 42 of them had a GCS score of ≤7 (Table 3).

Table 1. *ICH Volume Frequency*

Haemorrhage Volume	Case	Percentage
0-10 mL	6	11 %
11-30 mL	16	28 %
31-60 mL	22	37 %
60 mL & above	14	24 %

Table 2. *Frequency of ICH by Location*

Location	Case	Percentage
Lobar	26	44 %
Thalamic	22	38 %
İntraventricular	3	5 %
Serebellar	3	5 %
Basal ganglion	2	4 %
Brainstem	2	4 %

Table 3. *EVD infection and death in various GCS categories*

	GCS 3-7	GCS 8-12	GCS 13-15
Total patients	64	28	36
EVD infection	20	12	6
Death	42	6	4
Death due to ventriculitis	18	2	-

Patients with signs of increased intracranial pressure or progression to hydrocephalus underwent EVD procedure. The catheter was removed in patients who had improvement in neurological status and hydrocephalus. A ventriculoperitoneal shunt was inserted in 12 patients who developed obstruction. Of the patients, 76 survived and their scores increased from Grade 3–5 to Grade 2-4. The morbidity of the patients was evaluated and they were grouped as moderate disability, severe disability, and vegetative state based on GCS criteria. Moderate disability was observed in 12 patients, severe disability was observed in eight patients, and vegetative state was observed in three patients.

Ventriculostomy infection was seen in a total of 38 patients and culture was positive in 22 of them. The most common causative agents were found to be gram negative bacilli. Systemic infection findings were detected in eight patients during ventriculostomy. Chest and urinary tract infections were the most common infections. No ventriculostomy catheter change was required in 90 patients. However, it had to be changed once in 20 patients, twice in 16 patients, four times in eight patients and five times in two patients. Infection was developed in 18 of these patients in the first week, 12 patients in the second week, six patients in the third week, and two patients in the fourth week and the catheter was changed. The total duration of catheter was 4-32 days (mean: 11.6 and median: 8 days). The duration of catheter was 4-10 days in the group with the highest number of patients (n=62). Catheters were kept for more than 30 days in only eight patients. The day of onset of infection varied from four to 22 days.

Mortality was high in lobar hemorrhage with high volume despite EVD whereas survival rates were found to be higher in thalamic hemorrhage opening to a ventricle with a low volume (figure 1, 2).

Figure 1. *Intracerebral Haemorrhage*

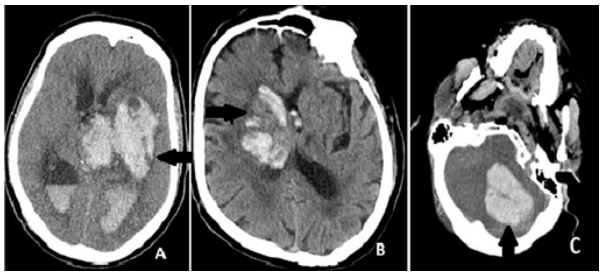

Figure 1 A: *Intracerebral hemorrhage with high-volume ventricular.*

Figure1 B: *Low-volume intracerebral hemorrhage with left thalamic-seated ventricle.*

Figure 1 C: *Bleeding from the left cerebellar-settled ventricle.*

Figure 2. *Intracerebral Hemorrhage*

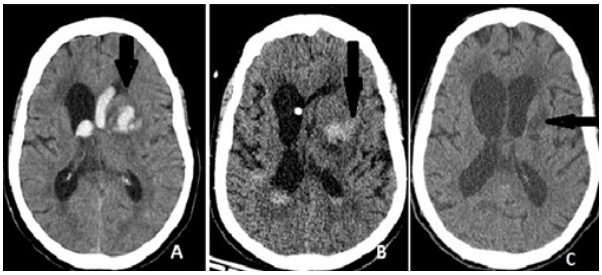

Figure 2 A: *59 years of age female patient with hypertension-induced ventricular thalamic bleeding.*

Figure 2 B: *Post-EVD application 15th day check CBT.*

Figure 2 C: *CBT from 3rd month control of the patient where the EVD was extracted after the bleeding was resorbed.*

Survival and ventriculitis rates were lower in patients undergoing EVD for hydrocephalus.

Evaluation of the results revealed that mortality rate was high both during and after the acute period (n:52). Forty-two of the 64 patients with GCS ≤7, six of 28 patients with GCS 8-12, and four of 36 patients with GCS 13-15 died prior to EVD placement. Infected EVD was most common in patients with GCS ≤7 and ventriculitis was the leading cause of death (Table 3).

DISCUSSION

The external ventricular drainage system is used to reduce intracranial pressure in the treatment of acute hydrocephalus and ventricular hemorrhage due to ICH and SAH. The aim of this treatment is to eliminate the increase in cerebral edema and intracranial pressure caused by the mass effect of ICH and to prevent rapidly developing obstructive hydrocephalus. Sudden death occurs due to the congestion in CSF absorption and communicating hydrocephalus caused by an inflammatory response and scar tissue formation following arachnoid contact with blood destruction products. In these patients, intracranial pressure should be lowered by inserting EVD urgently. The EVD system should be continued until the blood clot in the ventricle is dissolved and CSF circulation is normal [24].

Intracerebral hemorrhage is mostly localized in lobar and putamen [25]. In a study by Eroğlu et al. [26], lobar hemorrhage was reported in 41% of the cases and putaminal hemorrhage was reported in 36% of the cases. Albayrak et al. [27] reported that the most common localization was in the thalamus and lobar. In the present study, IVH was found to be localized in lobar in 44% of the cases and in the thalamus in 38% of the cases. A hemorrhage volume of 30mL is accepted as a critical threshold in ICH cases [28]. Tuhrim et al. [29] reported an increase in mortality rate when hemorrhage volume exceeded 30mL. In a study by Davis et al. [30], 1mL increase in bleeding volume was reported to lead to a 55% increase in mortality. In the present study, the hemorrhage volume of 26 (68%) of 38 patients who died was higher than 30mL.

The most common complication in patients undergoing EVD is catheter-related infection and ventriculitis. Infection could not be terminated despite all the protocols [31]. In the EVD placement guidelines published by the Infectious Diseases Society of America, long-term antibiotic use has been opposed although the use of prophylactic antibiotics is recommended [32]. Factors determining susceptibility to infection may include the presence of systemic infection, the need for surgical intervention, prolonged operation time, CSF leakage, and inability to replace the catheter in risky situations [33-37]. In a multi-centered study conducted in the United States, it has been emphasized that each center has determined a protocol in their own way regarding the EVD placement and there is no common protocol in this regard [38]. Following this study, Ramanan et al. [39] published Penn EVD application protocols and prepared the patients according to this protocol. A significant decrease was observed in infection rates after the applications made following a specific protocol [40].

The infection rate of 29.6% in our patients is in the range of 0-40% in other studies [4, 10-12, 14, 18-21]. Precise identification of ventriculitis can be possible with the correlation between positive culture results and pleocytosis in CSF examination. Although Mayhall et al. [14] describe EVD-associated ventriculitis with culture positivity, it was reported in another study that low CSF glucose value and an important CSF pleocytosis could only be explained by the presence of infection [41]. In the present study, a significant difference was found between the infected and non-infected groups in terms of CSF cell number and glucose values even in culture-negative patients.

High infection rates may be associated with ventricular catheter duration which was longer than other studies [8, 19]. The mean duration of catheter was 8.6 days in infected patients. This supports the idea that catheter stay in place more than five days increases the susceptibility to infection. Intraventricular antibiotic administration for prophylactic purposes has been reported to have no effect in preventing ventriculitis but to play an important role in the treatment [8, 10, 13].

Glasgow Coma Scale score at the time of the first admission to the emergency department is of great importance in terms of prognosis. In the present study, 42 (65.6%) of 64 patients with GCS ≤7 at the time of first admission, six (21.4%) of 28 patients with GCS 8-12, and four (1%) of 36 patients with GCS 13-15 died. The higher the GCS before the procedure, the better the prognosis.

The essence of this study is to show that there is a significant relationship between the duration of a

ventriculostomy catheter being in place and ventriculitis and mortality. Duration of a catheter being in place was 8.6 days in the infected group while it was 5.2 days in the non-infected group. Prospective studies have shown a positive relationship between ventriculitis and catheter duration in general [12, 14, 23].

CONCLUSION

In conclusion, EVD applied to reduce intracranial pressure is a treatment method with positive effects on morbidity and mortality despite the complications that may occur. Patients' consciousness at the time of admission, hemorrhage volume, hemorrhage location, age and concomitant diseases and ventriculitis are important factors in terms of prognosis. External ventricular drainage is a successful method with infection risk that helps to reduce intracranial pressure in the early period and reduces sudden death caused by hydrocephalus. Prognosis is relatively better in patients with higher GCS scores and shorter catheter duration, however, infection and mortality increase as initial GCS scores decrease and duration of the catheter increases. A standard should be set for the procedures applied during EVD placement and the procedure should be performed based on a certain protocol.

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