Case Report

Bilateral External Ventricular Drainage (EVD) for Evacuation of Bilateral Intraventricular Hemorrhage (IVH) with Hydrocephalus: An Evidence-Based Case Report

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Objective: To compare between single and dual external ventricular drainage (EVD) on patients with intraventricular hemorrhage (IVH) using Glasgow Coma Scale (GCS).

Materials and Methods: Literature searches were performed on PubMed, Cochrane, CINAHL, and ScienceDirect according to the clinical questions. The selection of titles and abstracts was based on the inclusion and exclusion criteria with multiple filters. The journals were thoroughly read. In the present study, a randomized control trial (RCT) was critically appraised for quality based on validity, importance, and applicability.

Results: The present study analyzed five journals. Dual EVDs accelerate IVH drainage with the same duration as single EVD. However, dual EVDs have a higher infection risk. It is recommended to install dual EVD starting from the ipsilateral side.

Conclusion: The use of dual EVD improves GCS, accelerates IVH drainage, and prevents hydrocephalus in IVH patients.

Keywords: Bilateral IVH; Ventriculomegaly; EVD Running Head: EVD for Evacuation of IVH with Hydrocephalus; CT scan

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Hemorrhagic stroke is a brain hemorrhage that has a high mortality and morbidity rate compared to other types of strokes. The prevalence of hemorrhagic stroke due to head trauma is estimated at 1.7 million individuals in the United States[(1)]. The prevalence of intraventricular hemorrhage (IVH) is estimated at approximately 11.9% of all types of head trauma[(2)]. IVH refers to bleeding confined to the ventricular system within the brain, and it has a 50% to 80% mortality rate[(3)]. Primary IVH happens when the bleeding occurs within the brain ventricles, from an intraventricular source or a lesion adjacent to the ventricle, reaching nearly 30% of IVH cases. Secondary IVH occurs after primary hemorrhage in the brain parenchyma or subarachnoid hemorrhage enters the ventricular chambers, which occurs in about 70% of IVH cases[(4)]. After the blood is in the ventricles, the blood will mix with the cerebrospinal fluid (CSF) and circulate to the subarachnoid space, thus, it can cause obstructive hydrocephalus and increased intracranial pressure (ICP)[(5)]. In IVH, cases may produce mass pressure effects, early hydrocephalus, late hydrocephalus, and neurotoxicity due to oxidative stress. This is increasing patient mortality and morbidity[(5)].

IVH management can be performed using several surgical techniques, including mini-craniotomy[(6)], endoscopic surgery[(7)], and external ventricular drainage (EVD) with and without recombinant tissue plasminogen activator (rt-PA)[(8)]. EVD, known as ventriculostomy or EVD, is used in patients with IVH as an emergency procedure to decrease ICP and short-term mortality[(9)]. EVD is a surgical technique for IVH with a minimally invasive method. It is

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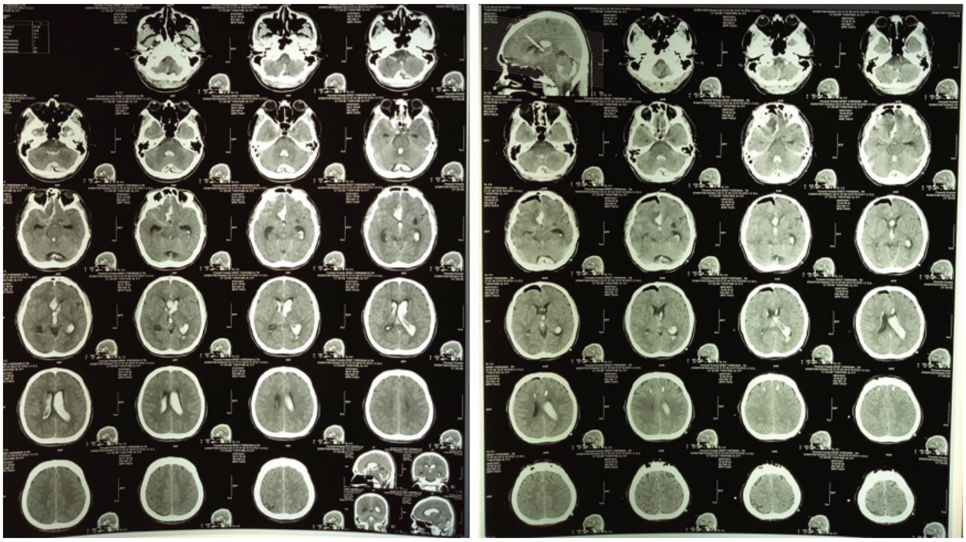

Figure 1. (a, left) Initial CT scan before EVD, (b, right) CT scan day 1 after EVD.

easily performed and requires simple tools[10]. EVD installation can be done using a single or dual port. Previous studies with dual EVD insertion showed significantly reduced IVH volume over a single EVD[11].

Although dual EVD insertion has a higher IVH volume-decreasing effect, the evidence for IVH volume reduction and prognosis is limited. The purpose of the present evidence-based case report (EBCR) is to critically analyze the effect of dual EVD insertion in improving the Glasgow Coma Scale (GCS) and hydrocephalus in patients with IVH.

Clinical question

A 41-year-old man was brought by his family to the emergency department due to sudden loss of consciousness and seizures. Loss of consciousness occurred three hours before he was admitted to the emergency department. He had seizures three times, and the duration of each seizure lasted for three minutes. Based on physical examination, blood pressure was 180/120 mmHg, 84x/minute HR, 20x/minute RR, and GCS 114. On the initial CT scan, bilateral IVH, subarachnoid hemorrhage (SAH), and subdural hemorrhage (SDH) were found (Figure 1a). Therefore, the patient underwent dual EVD insertion. The postoperative evaluation showed that the computerized tomography (CT) scan image had improved. On the CT scan, no hydrocephalus was found, and reduced IVH was seen (Figure 1a).

In the present case, the dual EVD installation used a 12-Fr catheter in the left ventricle and a 10-Fr catheter in the right ventricle. Clot aspiration was carried out using a 20-cc syringe and followed by irrigation and aspiration simultaneously and alternately. The EVD was placed 15 cm above the mean of absolute error (MAE), the average production of CSF with blood was 150 cc/24 hours. EVD was kept for four days because the patient's GCS had improved and continued with a CT scan examination on day five with the catheter positioned in a clamp for 24 hours.

The CT scan on day five (Figure 2a) showed reduced blood in IVH but with widened ventricles compared to the first postoperative CT scan. The initial left ventricular width of 3.4 mm and right ventricular width of 7.2 mm were enlarged to 5.2 mm and 11.2 mm, respectively because CSF drainage was stopped for 24 hours.

On the eighth day of evaluation, there was an improvement in the CT scan (Figure 2b). Decreased bleeding in the ventricles was proven by decreasing blood density and no ventricular width enlargement. On the fifteenth postoperative day, a control CT scan was also performed to ensure that hydrocephalus did not occur (Figure 3).

Materials and Methods

The literature search on four journal databases was completed on August 17, 2021. They were PubMed, Cochrane, CINAHL, and ScienceDirect. The results of the three journal databases were screened for titles and abstracts according to inclusion and exclusion criteria, filtered for duplicated journals,

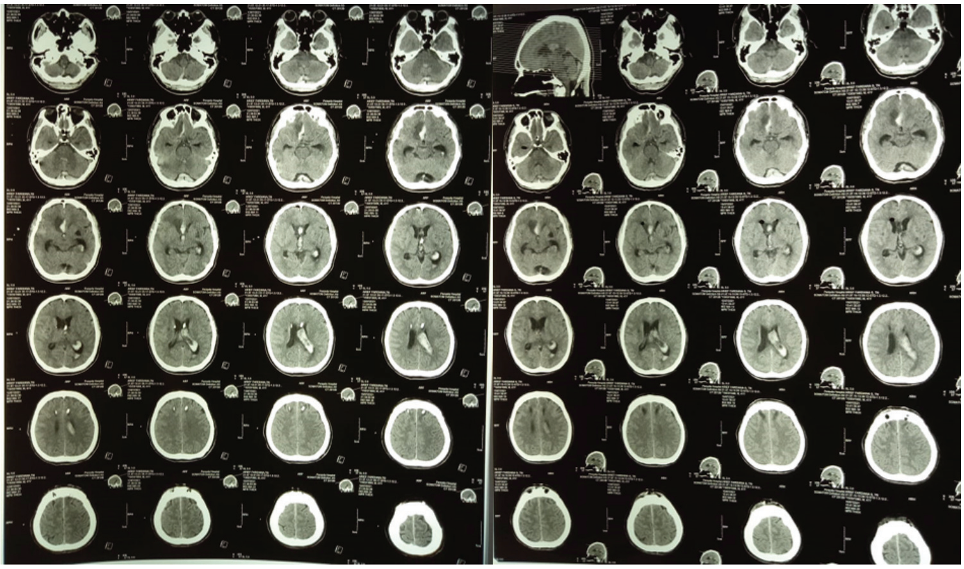

Figure 2. (a, left) development of the CT scan image of IVH patient on day five evaluation, (b, right) CT scan image on day seven evaluation postoperative EVD.

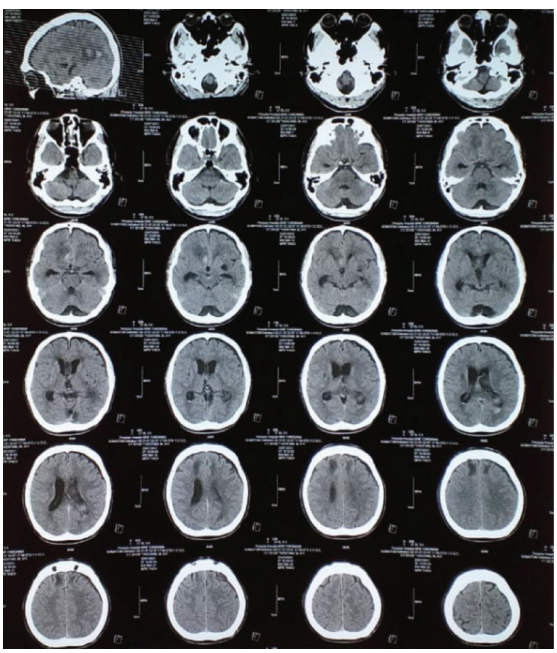

Figure 3. Evaluation of CT scan on postoperative EVD day 15.

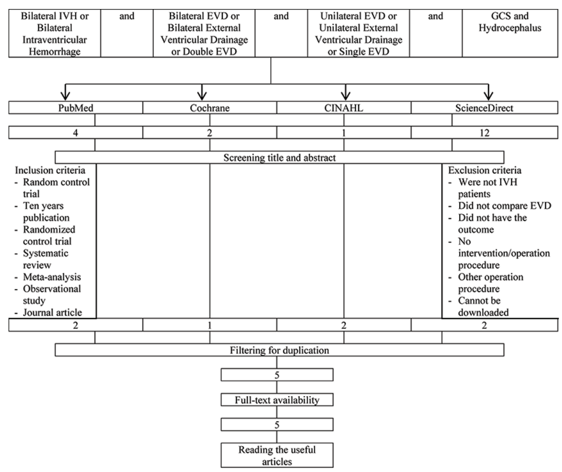

Figure 4. Flowchart of journal search strategy for EBCR.

and full-text accessibility. A critical study was carried out after reading the articles (Figure 4).

Results

There were two articles used for EBCR with randomized control trial (RCT). The bias analysis of the two articles is shown in Table 1. Based on the bias analysis, the RCT was valid and had a scientific evidence level of 1b. The study aimed to compare single and dual EVD for patients with IVH (Table 2).

Discussion

A critical review was carried out on the two RCTs regarding their validity, importance, and application. Several reasons to support the validity of the present study were that the selected journals focused on answering the research questions and were based on inclusion and exclusion criteria.

Dual EVD installation is a necessary procedure. The articles on the two studies showed that the average duration of either single or dual EVD insertion was five days ($p<0.05$). Another conclusion was that the

Table 1. A critical study using the CEBM tool from the University of Oxford

Author	CEBM tool						
	Clear PICO	Randomized (1a)	Homogenic (1b)	Treat equally (2a)	Loss follow up (2b)	Blinding (3)	Results
Hussain et al., 2018	Yes	Yes	Unclear	Yes	No	Double blind	IVH volume reduction is higher in dual EVD than single EVD (p=0.0034, <0.050; t-test=3.0519; df=58)
Hinson et al., 2010	Yes	Yes	Yes	Yes	No	Double blind	IVH volume reduction was significantly higher in dual EVD than single EVD (52.1 [31.7 to 81.1] mL) compared to single EVD (34.5 [13.1 to 73.9] mL) (p=0.004)
Du et al., 2014	Yes	Yes	Yes	Yes	No	No blinding	IVH volume reduction was significantly higher in dual EVD than single EVD (t=6.17; p=0.000). No differences in GCS between dual EVD and single EVD (F=0, 727; p=0,578).
Zheng et al., 2018	Yes	Yes	Yes	Yes	No	No blinding	Dual EVD causes an increased risk of VAI (odds ratio 4.211; p=0,031)
Wang et al., 2013	Yes	Yes	No	Yes	No	No blinding	There was no significant difference in complications between the two groups. Ipsilateral EVD insertion has higher intracranial pressure than contralateral (18.0% and 10.9%; p<0.001).

IVH=intraventricular hemorrhage; EVD=external ventricular drainage; GCS=Glasgow Coma Scale; VAI=ventriculostomy-associated cerebrospinal fluid infection

Table 2. Summary

Author	Population	EVD	Measured Results	Research result
Hussain et al., 2018	Single EVD (n=30) Dual EVD (n=30)	In the single EVD group, the EVD was attached for 24 hours and could be removed if the CT scan proved no blood clot. However, it is generally removed five days after surgery.;In the dual EVD group, one of the EVDs was removed when the CT scan proved clot loss in the third and fourth ventricles.	Decreased IVH volume	IVH volume reduction is higher in dual EVD than single EVD (p=0.0034, <0.050; t-test=3.0519; df=58)
Hinson et al., 2011	Single EVD+rTpa (n=4) Single EVD+Placebo (n=3) Dual EVD (n=7)	The second EVD was inserted 22 hours after the first EVD was inserted. On average, the insertion was carried out for five days after surgery.	Graeb score, IVH volume, IVH decrease percentage	IVH volume reduction is significantly higher in dual EVD than single EVD (52.1 [31.7 to 81.1] mL) compared to single EVD (34.5 [13.1 to 73.9] mL) (p=0.004)
Du et al., 2014	Single EVD (n=22) Dual EVD (n=25)	Installation of dual EVD and single EVD was performed in each group. Removal of the EVD was performed if the intracranial pressure was below 20 mmHg and no ventricular enlargement on a CT scan.	IVH volume, EVD complications	Dual EVD volume reduction is faster than single EVD (t=6.17; p=0,000). Both groups do not experience complications of infection and rebleeding.
Zheng et al., 2018	VAI group (n=26) Non-VAI group (n=58)	EVD was placed in patients with IVH and hydrocephalus. The minimum duration of EVD insertion was 48 hours.	Factors that cause VAI	Dual EVD causes an increased risk of VAI (odds ratio 4.211; p=0,031)
Wang et al., 2018	Ipsilateral EVD (n=28) Contralateral EVD (n=17)	The EVD between the ipsilateral and contralateral was placed less than 24 hours after the patient underwent IVH using CT scan.	Complications and decrease in intracranial pressure	There is no significant difference in complications between the two groups. It is recommended that dual EVD placement starts on the ipsilateral side of IVH rather than contralaterally because it reduces intracranial pressure more rapidly (18.0% and 10.9%; p<0.001).

IVH=intraventricular hemorrhage; EVD=external ventricular drainage; CT=computerized tomography; VAI=ventriculostomy-associated cerebrospinal fluid infection

decrease in IVH volume was higher in dual EVD than in single EVD (p<0.05).

Head injuries that independently exhibit IVH features have a poor prognosis[9]. Primary and secondary IVH is caused by the blood clots in the brain that can lead to the release of neurotoxic effects from the hematoma[12]. Acute IVH can cause hydrocephalus due to CSF drainage blockage in the

Table 3. Changes in patient's IVH volume

Date	7 July	8 July	12 July	15 July	22 July
Volume (modified Graeb scale)	28	21	25	23	18
Evan's ratio	0.26	0.24	0.26	0.28	0.28
Cupping of frontal horn lateral ventricle (frontal horn ratio)	Rt. 0.34 Lt. 0.58	Rt. 0.28 Lt. 0.4	Rt. 0.41 Lt. 0.51	Rt. 0.33 Lt. 0.42	Rt. 0.38 Lt. 0.54
Frontal horn angle (degree)	127.2	121.3	122.2	106	115.2
Periventricular edema (present/not)	Present	Present	Present	Present	Present
Degree of edema (scale 1-5), Lietke, 2020	3	2	3	2	1
Temporal horn enlargement (mm)	Dex=8,35 mm Sin=9,31 mm	Dex=2,57 mm Sin=10,1 mm	Dex=9,3 mm Sin=11.4 mm	Dex=7,99 mm Sin=9,51 mm	Dex=9,6 mm Sin=6,9 mm

aqueduct or the fourth ventricle[5]. Increased ICP due to IVH can be measured using a CT scan since a CT scan can help perform grading to predict ICP and prognosis of head trauma, IVH, and SAH[13] (Table 3).

Modified Graeb Score (mGS) is one of the scorings used to predict IVH volume and its prognosis. Another possible approach to manage IVH secondary to spontaneous intracerebral hemorrhage is the clot removal by neuroendoscopy in combination with EVD placement[14]. Research by Morgan et al[15] showed that this scoring is used to assess semi-quantitatively in IVH and to measure patient prognostic score. In this case, the patient suffered from bilateral IVH with ICH and SAH, so the treatment carried out was the installation of dual EVD to reduce IVH rapidly to prevent early obstructive hydrocephalus. Furthermore, the installation of dual EVD also prevents late communicating hydrocephalus due to arachnoid villi obstruction[15].

In this case, dual EVD was installed to accelerate IVH drainage. This allowed a rigorous comparison of the efficiency of dual versus single catheter drainage in comparable cases during similar time periods[9]. Several previous studies support the use of dual EVD to accelerate drainage. In a study by Hussain et al, the installation of dual EVD accelerated the drainage of IVH patients. In their research, the release from the EVD was carried out after proving that there were no blood clots in the third and fourth ventricles based on a CT scan[15]. The exact mechanism was also done by Du et al[16] that the release of the EVD was carried out if the ICP was below 20 mmHg, and there was no ventricular enlargement based on CT scan. In this case, EVD was removed after five days because the GCS has improved, and the 24-hour clamped EVD did not show significant hydrocephalus based on the CT scan on day five (Figure 2a). In this case, the first EVD was inserted using a 12-Fr ventricular catheter on the wide IVH side and a second 10-Fr catheter on the minimal IVH side simultaneously. This is consistent with the study by Wang et al[17] that EVD placement is preferable to the ipsilateral side of the IVH lesion first compared to the contralateral side of the lesion. This process is different from a study by Hinson et al[9] that the installation of the first and second EVD was 22 hours apart, although it had the same result, namely rapid IVH drainage. Necrotic area of neuronal and glial cells is concentrated at the coup with compromised blood supply, causing the occurrence of hematoma, epidural, subdural, and intracerebral hemorrhages at confined layers of the brain[18]. In this case, the patient was not given r-tPA to accelerate the breakdown of the blood clot. This process is supported by the previous research that r-tPA administration was not significantly different compared to the control[19]. In this case, the patient underwent clot aspiration followed by irrigation with simultaneous irrigation and aspiration. This technique is in line with a previous study that aspiration and irrigation with Hartmann's fluid are carried out to reduce blood clots[20], It is suggested that a longer duration of bilateral EVDs may lead to a greater reduction in IVH volume[21] but in this case, it was preceded by clot aspiration. As generally considered, more catheters would result in higher rates of infection, but for patients with large intraventricular blood volume, dual tubes will accelerate blood drainage, which can shorten the duration of catheter placement[22].

Dual EVD insertion also increases the patient's GCS from 1-1-4 into 4-5-6. The decreasing GCS is caused by axon damage in brain tissue, which causes impaired axonal transport and degradation of the cytoskeleton; thus, reducing the patient's GCS. In addition, decreased GCS can also be affected by excitotoxicity, mitochondrial dysfunction, oxidative stress, lipid peroxidation, inflammation in neurons, and neuronal cell death[21]. The use of dual EVD decreases blood volume rapidly, which is the cause of brain tissue damage.

Conclusion

IVH has a high risk of morbidity and mortality in patients. Dual EVD use improves GCS, accelerates IVH drainage, and prevents hydrocephalus development in patients.

What is already known on this topic?

EVD reduces the risk of functional loss in IVH patients, hence in setting associated with poor outcome.

In the recent published CLEAR III trial, EVD decreased the risk of death with severe IVH but not improve functional outcomes.

What this study adds?

Current trends describe specification in dual EVD. This report presents the sequential stocking attached to dual EVD.

This study reports out experience with IVH patients who have severe IVH that result in improvement in the CT scan, decreasing blood density and no ventricular width enlargement.

Conflicts of interest

The authors declare no conflict of interest.

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