Pre-operative External Ventricle Drainage Improves Neurological Outcomes for Patients with Traumatic Intracerebellar Hematomas

Bao Wang (✉ bob616@fmmu.edu.cn)

Fourth Military Medical University <https://orcid.org/0000-0001-9689-3891>

Shun-nan Ge

Tangdu Hospital Fourth Military Medical University: Air Force Medical University Tangdu Hospital

Hao Guo

Tangdu Hospital Fourth Military Medical University: Air Force Medical University Tangdu Hospital

Fei Gao

Tangdu Hospital Fourth Military Medical University: Air Force Medical University Tangdu Hospital

Ying-wu Shi

Tangdu Hospital Fourth Military Medical University: Air Force Medical University Tangdu Hospital

Wen-xing Cui

Tangdu Hospital Fourth Military Medical University: Air Force Medical University Tangdu Hospital

zhi-hong Li

Tangdu Hospital Fourth Military Medical University: Air Force Medical University Tangdu Hospital

Yan Qu

Tangdu Hospital Fourth Military Medical University: Air Force Medical University Tangdu Hospital

Research article

Keywords: Traumatic intracerebellar hematoma, external ventricular drainage, hydrocephalus, neurological outcomes, Glasgow Outcome Scale

Posted Date: December 30th, 2020

DOI: <https://doi.org/10.21203/rs.3.rs-136557/v1>

License: © ⓘ This work is licensed under a Creative Commons Attribution 4.0 International License.

[Read Full License](#)

Abstract

Background: Traumatic intracerebellar hematoma (TICH) is a very rare entity but with high morbidity and mortality rate, and there is no consensus on its optimal surgical management. In particular, whether and when to place external ventricle drainage in TICH patients without acute hydrocephalus pre-operation is still controversial.

Methods: A single-institutional, retrospective analysis of total 47 TICH patients with craniectomy hematoma evacuation in a tertiary medical center from January 2009 to October 2020 was performed. Primary outcomes were mortality in hospital and neurological function evaluated by GOS at discharge and 6 months after the ictus. The special attention was paid to the significance of external ventricular drainage (EVD) in TICH patients without acute hydrocephalus on admission.

Results: Analysis of the clinical characteristics of the TICH patients revealed that the odds use of EVD was seen in patients with IVH ($p=0.03$), fourth ventricle compression ($p=0.02$), and acute hydrocephalus ($p<0.01$). Placement of EVD at the bedside can significantly improve the GCS score before craniotomy ($p=0.02$), as well as the neurological score at discharge ($p=0.045$) and 6 months ($p=0.04$). Compared with the only hematoma evacuation (HE) group, there is a trend that EVD can reduce hospital mortality (27.6% vs. 38.9%) and decrease the occurrence of delayed hydrocephalus (4.8% vs. 18.2%), although the difference is not statistically significant. In addition, EVD can reduce the average NICU stay time ($p=0.04$, 4.9 ± 5.1 vs. 9.4 ± 6.3), but has no effect on the total length of stay. Moreover, our data showed that EVD did not increased the risk of associated bleeding and intracranial infection. Interestingly, in terms of neurological function at discharge and 6-month after the ictus ($p=0.01$), even though without acute hydrocephalus on admission, the TICH patients can still benefit from EVD insertion.

Conclusion: For TICH patients, EVD is safe and can significantly improve neurological prognosis. Especially for patients whose GCS dropped by more than 2 points before operation, EVD can significantly improve the patient's GCS score, reduce the risk of herniation, and gain more time for surgical preparation. Even for TICH patients without acute hydrocephalus on admission CT scan, EVD placement still has positive clinical significance. However, future studies with larger sample size are warranted to confirm whether EVD can reduce in-hospital mortality and the risk of delayed hydrocephalus in TICH.

Introduction

Compared with traumatic brain injury, traumatic intracerebellar hemorrhage (TICH) has only a few small series of cases being reported[1-5]. Although TICH is a rare entity, it is associated with high morbidity and mortality. Given the lack of sufficient experience of individual neurosurgeons or single medical center in the management of TICH, there is an urgent need to explore the optimal treatment strategy for it.

The current surgical methods for TICH mainly include craniotomy, minimally invasive hematoma aspiration or external ventricular drainage (EVD) only[6]. The guidelines on craniocerebral trauma suggest that different surgical plans should be flexibly adopted based on the amount and location of the

hematoma, combined with the patient's consciousness and general condition[7]. there is no consensus on its optimal surgical management. It remains unclear whether preoperative placement of EVD is beneficial for neurological outcome in TICH patients.

It is generally believed that if the patient has acute obstructive hydrocephalus or large ventricular hemorrhage on admission, pre-operation external ventricular drainage (EVD) is required[7]. However, for patients whose admission CT showed no acute hydrocephalus, due to the physiological characteristics of the posterior fossa, the probability of hydrocephalus after admission was high and can progressed quickly[8]. Once hydrocephalus has occurred, it is probable to miss the best opportunity to rescue the patients by placing EVD. However, if the EVD is placed in advance, it may increase the risk of infection and supratentorial hemorrhage[9-12]. Therefore, there is still debate about when to place the EVD on TICH. Therefore, for patients without hydrocephalus on admission CT scan, the significance and indications of EVD placement are worth exploring.

The present study retrospectively evaluated 47 TICH patients surgically managed in a single tertiary medical center to determine whether preoperative placement of EVD is beneficial for neurological outcome in TICH patients, with special attention paid to the significance of EVD in TICH patients without acute hydrocephalus on admission CT scan.

Method

Study population and Data source

A total of 47 consecutive TICH patients surgically managed in a tertiary care academic hospital (Tangdu hospital, affiliated to the Air Force Military Medical University) from January 2009 to October 2020 were enrolled in the present study. Patients with supratentorial lesions that require surgery and those with fatal hemorrhages whose therapy did not aim to treat the condition were excluded in the present study. Medical and nursing records, including demographic information, clinical evaluation, imaging and procedure notes were retrospectively reviewed. Discharge reports from the rehabilitation facility as well as standardized telephone interviews were used to evaluate the neurological function at 6-month after the ictus. The consents with ethical clearance of the study were obtained from the patients' surrogate. The present study complies with the Health Insurance Portability and Accountability Act of 1996.

Treatment groups and EVD insertion

All TICH patients were managed according to the Chinese Guidelines for Traumatic Surgery (2015 Edition). A decompressive suboccipital craniectomy on the midline, or ipsilateral to the hematoma, with evacuation of the hematoma as well as the necrotic hemorrhagic tissue, was performed in all 47 patients.

According to whether EVD was placed before operation, these patients were divided into 2 groups: (1) hematoma evacuation combined with preoperative EVD placement (HE+EVD), (2) hematoma evacuation only and no preoperative EVD placement (HE). The decision to place a pre-operation EVD at the bedside

was based on the presumed benefit to the patients and up to the discretion of the attending neurosurgeon after discussion of potential benefits, risks and possible complications with the patients' surrogates. All the EVD was placed into the right frontal horn at the Kocher point, unless there is a fracture on the right frontal bone, in which case a left EVD was inserted. Gradual EVD weaning was performed after the patient meets the following conditions: improved neurological examination, no need to continue ICP monitoring, and continuous post-operative CT scans showing that intraventricular blood clearance or obstructive hydrocephalus is improved.

Study variables and outcomes

Presence of TICH, IVH, fourth ventricle involvement as well as occlusive hydrocephalus was established by CT scan on admission. The volume of hematoma was calculated using the ABC/2 method as already described by Kothari[13]. Glasgow Coma Scale (GCS) was applied to evaluate the level of consciousness pre-EVD, post-EVD, and before craniectomy. The primary outcomes were in-hospital mortality and neurological function evaluated by GOS at discharge and 6 months after the ictus. An GOS ≥ 4 was considered a favorable functional outcome as described previously[1]. The secondary outcomes of interest mainly include length of stay in the NICU, total length of hospital stay, EVD puncture tract bleeding, intracranial infection, pneumonia, and delayed hydrocephalus.

Statistical analysis

Statistical analyses were conducted with SPSS statistics software package (IBM Corporation, Armonk, New York, USA). Means with standard deviations or median with ranges were calculated for continuous variables and counts with percentages for categorical variables. Student's *t*-test was used for continuous data and Chi-square test for categorical data to compare the demographic and clinical characteristics among patients with and without preoperative EVD. A Wilcoxon rank-sum test was used to compare continuous data that were not normally distributed and fisher exact tests for categorical events whose expected cell count was less than 5. $P < 0.05$ was considered statistically significant.

Results

A total of 47 TICH patients was included in this study by retrospective screening and reviewing of their medical records, imaging data and operative notes. According to whether the EVD was placed before operation, these patients were divided into 2 groups: (1) hematoma evacuation combined with preoperative EVD placement (HE+EVD), (2) hematoma evacuation only and no preoperative EVD placement (HE).

The demographic and clinical characteristics were summarized in **Table 1**. The average age of the patients was 44.6 ± 17.8 years old, of which 59.6% were male. There was no statistical significance in age, gender, hematoma volume and GCS score between HE+EVD and HE groups. Notably, the odds use of EVD was seen in patients with IVH ($p=0.03$), fourth ventricle compression ($p=0.02$), and acute hydrocephalus ($p<0.01$).

In **Table 2**, compared with the time of admission, the GCS scores of the two groups both decreased to a certain extent before operation. However, placement of EVD at the bedside could significantly improve the preoperative GCS score ($p=0.02$). There was a trend that EVD could reduce hospital mortality (27.6% vs. 38.9%), however the difference was not statistically significant. Importantly, compared with HE group, EVD significantly improved the neurological outcome at discharge ($p=0.045$) and 6 months ($p=0.04$) after ictus.

Table 3 revealed that preoperative EVD could reduce the average NICU stay time ($p=0.04$, 4.9 ± 5.1 vs. 9.4 ± 6.3), but had no effect on the total length of hospital stay. It seemed that EVD tended to decrease the occurrence of delayed hydrocephalus (4.8% vs. 18.2%), although the difference is not statistically significant. In terms of EVD related hemorrhage, intracranial infection as well as pneumonia, there was no statistical difference between the two groups.

Furthermore, we extracted the patients without acute hydrocephalus on admission CT scan for comparison and divided them into two groups: (1) hematoma evacuation combined with preoperative EVD placement (EVD) ($n=14$), (2) hematoma evacuation only and no preoperative EVD placement (non-EVD) ($n=18$) (**Table 4**). Interestingly, in terms of neurological function at discharge ($p=0.01$) and 6-month after the ictus ($p=0.01$), even though without acute hydrocephalus on admission CT scan, the TICH patients could still benefit from EVD insertion. 0 patients in the EVD group had delayed hydrocephalus, while 2 patients (18.2%) in the non-EVD group had delayed hydrocephalus. There was no statistical difference in hospital mortality between the two groups (14.3% vs. 38.9%).

Discussion

In this retrospective study, we examined the impact of EVD placement before craniectomy on in-hospital mortality and neurological function for patients with TICH. Our data revealed that preoperative EVD at the bedside can significantly improve the preoperative GCS score, ameliorated the neurological score at discharge and 6 months after the ictus and reduced the average NICU stay time, without increasing the risk of associated bleeding and intracranial infection. In addition, there is a trend that EVD can reduce in-hospital mortality and decrease the occurrence of delayed hydrocephalus. Interestingly, in terms of neurological function at discharge and 6-month after the ictus, even though without acute hydrocephalus, the TICH patients can still benefit from EVD insertion.

The application of EVD in severe craniocerebral trauma, aneurysmal subarachnoid hemorrhage and intraventricular hemorrhage has been reported and has achieved good clinical results[14-17]. Especially, for patients whose intracerebral hematoma broke into the ventricular system, placing EVD can significantly improved the patient's prognosis[17, 18]. However, there are few reports on the application of EVD in TICH.

Consistent with previous literature reports, the current study revealed the odds use of EVD in TICH patients with IVH, fourth ventricle compression, and acute hydrocephalus[19-23]. Due to the special anatomical position of the cerebellum, it is easy to form acute obstructive hydrocephalus, and the

compensation space is narrow, making the traumatic intracerebellar hemorrhage (TICH) become extremely dangerous. The patient's condition can change rapidly, even before the consciousness and pupil changes, breathing and heartbeat can suddenly be stopped, giving no chance of rescue. Therefore, For TICH patients with admission CT showing IVH, fourth ventricle compression and acute hydrocephalus, we prefer to place EVD as soon as possible before surgery.

Previous studies showed that EVD use was associated with a trend towards decreased mortality but greater modified Rankin Scale score for functional outcomes in spontaneous intracerebral hemorrhage[9]. Similarly, our results demonstrated that placement of EVD significantly improved the neurological score at discharge and 6 months, regardless of the presence or not of acute hydrocephalus. We believe that preoperative placement of EVD can improve the prognosis mainly from the following aspects: (1) Patients who need cerebellar hematoma evacuation generally have different degrees of intracranial hypertension. Preoperative EVD should be performed first to relieve intracranial hypertension, and then hematoma evacuation. Otherwise, the cerebellum will become acutely bulged after cutting the dura mater, which has obvious negative effects on surgical operation. (2) If EVD is performed after the hematoma is eliminated, the morphology of the lateral ventricle changes due to the outflow of cerebrospinal fluid, which increases the difficulty of successful puncture. (3) If the postoperative cerebellar edema is obvious and the hematoma remains, the continuous drainage by EVD can help patients through the peak period of edema.

Studies have shown that EVD can increase the risk of bleeding and infection in patients with traumatic brain injury. However, the current research has not found that preoperative EVD can increase the chance of bleeding and intracranial infection. Furthermore, the results showed a trend that EVD can decrease the occurrence of delayed hydrocephalus, which may be due to the continuous drainage of bloody cerebrospinal fluid by EVD, reducing subarachnoid adhesions.

Conclusion

For TICH patients, EVD is safe and can significantly improve neurological prognosis. Especially for patients whose GCS dropped by more than 2 points before operation, EVD can significantly improve the patient's GCS score, reduce the risk of herniation, and gain more time for surgical preparation. Even for TICH patients without acute hydrocephalus on admission CT scan, EVD placement still has positive clinical significance. However, future studies with larger sample size are warranted to confirm whether EVD can reduce in-hospital mortality and the risk of delayed hydrocephalus in TICH.

Abbreviations

1. EVD

External ventricular drainage

2. HE

Hematoma evacuation

3. GCS

Glasgow coma scale

4. GOS

Glasgow Outcome Scale

5. TICH

Traumatic intracerebellar hematoma

Declarations

1. Ethics approval and consent to participate

This study obtained the approval by the Ethics Committee of Tangdu Hospital, Fourth Military Medical University and the informed consents to participate from all patients or their legal guardians.

2. Consent for publication

This consents for publication of this work was obtained from all patients or their legal guardians.

3. Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

4. Competing interests

The authors declare that they have no competing interests.

5. Funding

This work was supported by National Natural Science Foundation of China (Grant No. 81801256) (B.W.), Shaanxi Provincial Association of Science and Technology Youth Talents Lifting Plan (Grant No. 20190302) (B.W.) and Tangdu Hospital Youth Talent supporting Plan (B.W.).

6. Authors' contributions

Yan Qu and Bao Wang proposed and designed this study. Shun-nan Ge and Bao Wang completed all the surgical operations. Hao Guo, Fei Gao and Ying-Wu Shi collected the data. Wen-xing Cui and Zhi-hong Li analyzed the patients' data. Zhi-hong Li and Bao Wang were the major contributors in writing the manuscript. All authors read and approved the final manuscript.

7. Acknowledgements

Not applicable

References

1. d'Avella D, Servadei F, Scerrati M, Tomei G, Brambilla G, Angileri FF, Massaro F, Cristofori L, Tartara F, Pozzati E, et al. Traumatic intracerebellar hemorrhage: clinicoradiological analysis of 81 patients. *Neurosurgery*. 2002;50:16–25. discussion 25 – 17.
2. Harsh V, Prakash A, Barry JM, Kumar A. Traumatic intracerebellar haematoma: To operate or not to operate? *Br J Neurosurg*. 2015;29:353–7.
3. D'Avella D, Cacciola F, Angileri FF, Cardali S, La Rosa G, Germano A, Tomasello F. Traumatic intracerebellar hemorrhagic contusions and hematomas. *J Neurosurg Sci*. 2001;45:29–37.
4. Takeuchi S, Wada K, Takasato Y, Masaoka H, Hayakawa T, Yatsushige H, Shigeta K, Momose T, Otani N, Nawashiro H, Shima K. Traumatic hematoma of the posterior fossa. *Acta Neurochir Suppl*. 2013;118:135–8.
5. Takeuchi S, Takasato Y, Masaoka H, Hayakawa T. Traumatic intra-cerebellar haematoma: study of 17 cases. *Br J Neurosurg*. 2011;25:62–7.
6. Mitchell P, Gregson BA, Vindlacheruvu RR, Mendelow AD. Surgical options in ICH including decompressive craniectomy. *J Neurol Sci*. 2007;261:89–98.
7. Carney N, Totten AM, O'Reilly C, Ullman JS, Hawryluk GW, Bell MJ, Bratton SL, Chesnut R, Harris OA, Kissoon N, et al: Guidelines for the Management of Severe Traumatic Brain Injury, Fourth Edition. *Neurosurgery* 2017, 80:6–15.
8. Sumer MM, Acikgoz B, Akpınar G. External ventricular drainage for acute obstructive hydrocephalus developing following spontaneous intracerebral haemorrhages. *Neurol Sci*. 2002;23:29–33.
9. Lovasik BP, McCracken DJ, McCracken CE, McDougal ME, Frerich JM, Samuels OB, Pradilla G. The Effect of External Ventricular Drain Use in Intracerebral Hemorrhage. *World Neurosurg*. 2016;94:309–18.
10. Gardner PA, Engh J, Atteberry D, Moossy JJ. Hemorrhage rates after external ventricular drain placement. *J Neurosurg*. 2009;110:1021–5.
11. Dorresteyn K, Jellema K, van de Beek D, Brouwer MC. Factors and measures predicting external CSF drain-associated ventriculitis: A review and meta-analysis. *Neurology*. 2019;93:964–72.
12. Champey J, Mourey C, Francony G, Pavese P, Gay E, Gergele L, Manet R, Velly L, Bruder N, Payen JF. Strategies to reduce external ventricular drain-related infections: a multicenter retrospective study. *J Neurosurg* 2018:1–6.
13. Kothari RU, Brott T, Broderick JP, Barsan WG, Sauerbeck LR, Zuccarello M, Khoury J. The ABCs of measuring intracerebral hemorrhage volumes. *Stroke*. 1996;27:1304–5.
14. Chung DY, Olson DM, John S, Mohamed W, Kumar MA, Thompson BB, Rordorf GA. Evidence-Based Management of External Ventricular Drains. *Curr Neurol Neurosci Rep*. 2019;19:94.
15. Chung DY, Mayer SA, Rordorf GA. External Ventricular Drains After Subarachnoid Hemorrhage: Is Less More? *Neurocrit Care*. 2018;28:157–61.

16. Thabet AM, Kottapally M, Hemphill JC. 3rd: Management of intracerebral hemorrhage. Handb Clin Neurol. 2017;140:177–94.
17. Dey M, Jaffe J, Stadnik A, Awad IA. External ventricular drainage for intraventricular hemorrhage. Curr Neurol Neurosci Rep. 2012;12:24–33.
18. Herrick DB, Ullman N, Nekoovaght-Tak S, Hanley DF, Awad I, LeDroux S, Thompson CB, Ziai WC. Determinants of external ventricular drain placement and associated outcomes in patients with spontaneous intraventricular hemorrhage. Neurocrit Care. 2014;21:426–34.
19. Jaffe J, Melnychuk E, Muschelli J, Ziai W, Morgan T, Hanley DF, Awad IA. Ventricular catheter location and the clearance of intraventricular hemorrhage. Neurosurgery. 2012;70:1258–63. discussion 1263 – 1254.
20. Kakarla UK, Kim LJ, Chang SW, Theodore N, Spetzler RF. Safety and accuracy of bedside external ventricular drain placement. Neurosurgery. 2008;63:ONS162–166. discussion ONS166-167.
21. Hanak BW, Walcott BP, Codd PJ, Jones PS, Nahed BV, Butler WE, Asaad WF. Fourth ventricular neurocystercercosis presenting with acute hydrocephalus. J Clin Neurosci. 2011;18:867–9.
22. Roitberg BZ, Khan N, Alp MS, Hersonskey T, Charbel FT, Ausman JI. Bedside external ventricular drain placement for the treatment of acute hydrocephalus. Br J Neurosurg. 2001;15:324–7.
23. Muralidharan R. External ventricular drains: Management and complications. Surg Neurol Int. 2015;6:271–4.

Tables

Table 1. The demographic and clinical characteristics of patients with traumatic intracerebellar hemorrhage stratified by surgical strategy (n=47)

	Overall	HE + EVD	HE	<i>p</i> value
Number of patients (%)	47 (100)	29 (61.7)	18 (38.3)	
Male (%)	28 (59.6)	17 (58.6)	11 (61.1)	>0.99
Age	44.6 ± 17.8	43.4 ± 18.3	45.7 ± 13.2	0.64
Volume of hemotoma	17.8 ± 8.1	18.2 ± 7.6	17.4 ± 6.9	0.71
median GCS (range)	7 (3-15)	7 (3-14)	8 (3-15)	0.83
Presence of IVH (%)	17 (36.2)	14 (48.3)	3 (16.7)	0.03*
Fourth ventricle involvement (%)	21 (44.7)	17 (58.6)	4 (22.2)	0.02*
Acute hydrocephalus (%)	15 (31.9)	15 (31.9)	0 (0)	<0.01**
Hypertension	23 (48.9)	11 (37.9)	12 (66.7)	0.08
Diabetes	16 (34.0)	8 (27.6)	8 (44.4)	0.34
Heavy drinking	27 (57.4)	15 (51.7)	12 (66.7)	0.37
Warfarin	11 (23.4)	7 (24.1)	4 (22.2)	>0.99
Any antiplatelet drug	18 (38.3)	11 (37.9)	7 (38.9)	>0.99

HE: hemotoma evacuation; EVD: external ventricle drainage;

GCS is defined as the lowest Glasgow coma scale before EVD insertion;

*and **: statistically significant

Table 2 Primary outcomes for traumatic intracerebellar hemorrhage managed surgically with or without EVD						
	GCS			In-hospital	Favorable GOS $\geq$ 4 (n, %)	
	Admission	Before EVD	Before Surgery	Mortality (n, %)	Discharge	6 months
HE+EVD(n=29)	10.0 $\pm$ 3.8	5.3 $\pm$ 2.3	8.6 $\pm$ 3.3	8 (27.6)	15 (51.7)	17 (58.6)
HE (n=18)	10.4 $\pm$ 3.2	~	6.4 $\pm$ 2.5	7 (38.9)	4 (22.2)	5 (27.8)
<i>p</i> value	ns		0.02*	0.41	0.045*	0.04*

HE: hemotoma evacuation; EVD: external ventricle drainage;
GOS: Glasgow Outcome Scale
ns: statistically non-significant
*and **: statistically significant

Table 3. Secondary outcomes for traumatic intracerebellar hemorrhage managed surgically with or without EVD

	HE + EVD	HE	<i>p</i> value
Mean length of stay (d)			
NICU, survivors	4.9 $\pm$ 5.1	9.4 $\pm$ 6.3	0.04*
Hospital, survivors	12.4 $\pm$ 8.1	13.7 $\pm$ 7.2	0.66
EVD related hemorrhage (n,%)	0	~	ns
Intracranial infection (n,%)	5 (17.2)	3 (16.7)	>0.99
pneumonia (n,%)	16 (55.2)	7 (38.9)	0.37
delayed hydrocephalus, survivors (n, %)	1 (4.8)	2 (18.2)	0.27

HE: hemotoma evacuation; EVD: external ventricle drainage;
*: statistically significant

Table 4. outcomes for EVD in traumatic intracerebellar hemorrhage without acute hydrocephalus

	EVD (n=14)	non-EVD (n=18)	<i>p</i> value
In-hospital Mortality (n, %)	2 (14.3)	7 (38.9)	0.23
Favorable GOS $\geq$ 4 (n, %)			
Discharge	10 (71.4)	4 (22.2)	0.01*
6 months	11 (78.6)	5 (27.8)	0.01*
delayed hydrocephalus, survivors (n, %)	0	2 (18.2)	0.21

HE: hemotoma evacuation; EVD: external ventricle drainage;
GOS: Glasgow Outcome Scale
*: statistically significant