



Outcomes and Predictors of Outcome with Cisternostomy in the Management of Traumatic Brain Injury—A Prospective Observational Study at a Tertiary Centre

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Abstract

Background Traumatic brain injury (TBI) is a major cause of morbidity and mortality in young individuals. Goal of management in TBI patients is mainly focused on the secondary injury. Since the cisterns and the brain communicate, it would be possible to decrease the pressure in both these compartments by opening the cisterns to the atmospheric pressure.

Objective To study the outcomes and predictors of outcome with cisternostomy in the management of TBI.

Methods A single tertiary care center's prospective observational study of outcomes with cisternostomy with intraoperative intracranial pressure (ICP) monitoring. Patients were evaluated clinically and radiologically with Marshall CT score. They were categorized into mild, moderate, and severe head injury groups based on Glasgow coma scale (GCS) score. Outcomes were evaluated with Glasgow outcome scale (GOS) score.

Results A total of 25 patients with TBI were enrolled in this study. They underwent cisternostomy with intraoperative ICP monitoring. They were categorized into 4 groups based on the age. In our study, mortality rate was 32%. As much as 48% had good recovery at 3 months follow-up with GOS 4 and 5. Mean ICP after cisternostomy was 6.36 ± 1.91 mm Hg. In our study, there was decrease in ICP after cisternostomy.

Conclusion Age, time interval from trauma to surgery, and ICP showed prognostic importance on outcomes. Cisternostomy can efficiently decrease the ICP in the TBI patients and reduce postoperative complications.

Keywords

- ▶ Cisternostomy
- ▶ head injury
- ▶ recent advances in neurotrauma
- ▶ surgery for neurotrauma
- ▶ traumatic brain injury

Introduction

Traumatic brain injury (TBI) is a major cause of morbidity and mortality in young individuals. Worldwide, for the past

30 years, it does not show any significant change in its epidemiology.¹

Brain insults with TBI were divided into primary and secondary brain injury. The primary brain injury

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mainly depends on the impact and mechanical forces. The secondary brain injury is the result of brain swelling and causes increase in intracranial pressure (ICP).² Goal of treatment for TBI is meticulous control of ICP.³ Despite medical interventions, till now there are no drugs available which can effectively control the secondary damage.

Decompressive hemicraniectomy is the surgery of choice in the management TBI for the past 100 years.⁴ However, decompressive hemicraniectomy itself has many complications.⁵

As proven by the glymphatic system, cerebrospinal fluid (CSF) from the cisterns communicates with the brain parenchyma through the Virchow–Robin spaces (VRS).⁶ Evacuation of the CSF by opening the basal subarachnoid cisterns is a well-recognized method for decreasing ICP.⁷

Cherian et al in 2009 described cisternostomy as a new method for the control of ICP in TBI. This technique incorporates knowledge of the skull base and microvascular surgery.⁸

In this study, we studied prospectively outcomes and effectiveness of the cisternostomy in management of TBI patients.

Aims and Objectives

To study the outcomes and predictors of outcomes with cisternostomy in the management of TBI patients.

Materials And Methods

Patients: All the patients presented to the Department of Neurosurgery at Sri Venkateswara Institute of Medical Sciences (SVIMS), Tirupati, with TBI who need surgical management

Study period: May 2019 to December 2020.

Design of the study: Prospective observational study.

Inclusion Criteria

1. Age > 18 years and < 65 years.
2. Glasgow coma scale (GCS) score \geq 4.
3. Brain parenchymal contusions with mass effect and midline shift.
4. Acute subdural hematoma (SDH) with mass effect and midline shift.
5. Traumatic subarachnoid hemorrhage (SAH) with mass effect and midline shift.
6. Posttraumatic diffuse edema with mass effect and midline shift.

Exclusion Criteria

1. Age < 18years and age > 65years.
2. GCS score = 3
3. Extradural hemorrhage (EDH).
4. Nontraumatic SAH.
5. Nontraumatic intraparenchymal bleed.
6. Acute infarcts with mass effect.

Regulatory Approvals

The study was conducted after approval by the institutional “Thesis Protocol Approval Committee” and

“Institutional Ethical Committee.” Written informed consent from patients or their attendants were obtained before the study

Methodology

All these patients were classified into mild, moderate, and severe injury groups, based on clinical findings, GCS score, and computed tomography (CT) findings. They were assessed for requirement of surgical management, and patients requiring surgical management were enrolled for the study. Cisternostomy with intraoperative ICP monitoring was done in all these patients

Postoperatively, they were monitored for the following:

1. Number of days of ventilator support needed.
2. Number of days of intensive care unit (ICU) care.
3. Number of days of hospital stay.
4. Complications.
5. Outcome assessment with Glasgow outcome scale (GOS) score at 3 months follow-up.

Sample Size

A pilot study of 25 cases prospectively studied who had TBI and who underwent cisternostomy as the surgical method of management.

Surgery Method

Cisternostomy

The patients were placed in the reverse Trendelenburg position. The head was turned to facilitate exposure of the hemicranium. After hair clipping, the hemicranium was prepared, marked, and injected with 1% lidocaine with epinephrine to facilitate hemostasis before draping. A standard large question mark or reverse question mark incision was made (as we faced problem of blood in subdural space interfering with the cisternostomy, we chose to perform large craniotomy and evacuation of hematoma before doing cisternostomy in spite of small craniotomy, as proposed by Cherian). Musculocutaneous flap was elevated. Bone flap was removed after properly placing burr holes as done for decompressive craniectomy. Durotomy was performed. Hematoma or contusion was evacuated.

After this, under the microscope, the Sylvian fissure was gently dissected with microscissors. Gentle subfrontal retraction was applied using brain spatula. Olfactory nerve was identified, which helps in leading to the optic nerve and the interoptic cisterns. Interoptic cistern was opened by gentle suction. After CSF starts to flow out, the brain becomes much laxer. Later, opening of the opticocarotid, lateral carotid, and interhemispheric cisterns were performed. Then, with adequate brain retraction, the lamina terminalis was opened. Later, membrane of Lilliquist was opened after widening of the opticocarotid window or the lateral carotid window. Basilar artery and the pons were visualized, which ensures the opening of most of the CSF spaces. The cisterns were gently irrigated for any residual blood clots, and cisternal drain was placed, which was kept for the next 3 to 5 days after surgery, allowing

removal of residual clots. Adequate hemostasis was maintained, followed by duroplasty. The bone flap was replaced and fixed. This was followed by the closure of the musculocutaneous flap, galea, and skin in layers.

►Fig. 1 described the important steps with intraoperative images in cisternostomy.

Results

In this study, 25 patients underwent cisternostomy. Of these, 25 cases, 21 (84%) were male and 4 (16%) were female patients. All the patients in this study were diagnosed to have acute SDH with brain parenchymal contusions and mass effect and midline shift. Out of these, 11 patients (44%) had head injury on right side and 14 patients (56%) had injury on left side.

Demographic data is shown in ►Table 1.

In our study, patients were categorized into four groups as follows: 18 to 30 (20%), 31 to 40 (16%), 41 to 50 (36%)

and > 50 (28%) years. They were assessed for severity of head injury with GCS as mild (GCS—14–15) and moderate (9–13%). In this study, 7 (28%) patients had moderate head injury and 18 (72%) patients had severe head injury. No patients were with mild head injury. In this study, patients belong to age group of > 50 years had a low mean GCS score of 5.71 ± 0.95 at the time of presentation.

In this study, all the patients were evaluated with CT brain and given Marshall CT score. In our study, most of the patients were found to have a Marshall CT score of 4 (in 44%) and 6 (in 28%).

In our study, intraoperative ICP (intraparenchymal) monitoring was done. There was a significant decrease in ICP measured after placement of first burr hole (27.92 ± 2.13 mm Hg) to ICP measured after craniotomy (15.32 ± 3.17 mm Hg), with average decrease of 12.60 ± 3.20 mm Hg (p 0.000).

There was further decrease of ICP from craniotomy to cisternostomy, with average decrease of 8.96 ± 2.99 mm Hg (p 0.000).

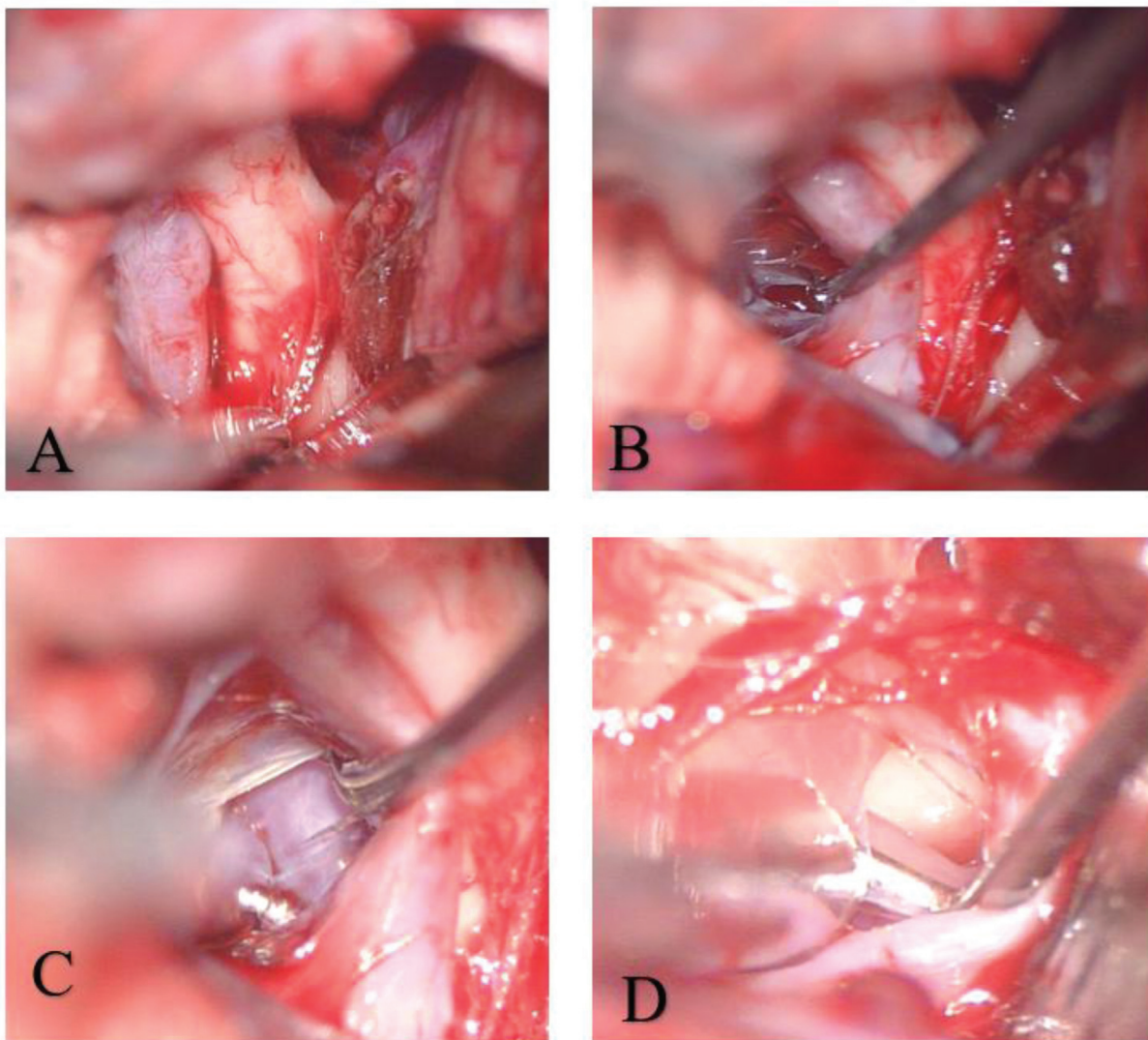


Fig. 1 Intraoperative images. (A) Opening of inter optic and opticocarotid cistern. (B) Opening of later carotid cistern. (C) Opening of Lillquist's membrane and basilar artery seen. (D) Opening of lamina terminalis

Table 1 Demographic data in this study

	Mean value
Age	44.48 ± 12.48 years
GCS	6.88 ± 1.87
Marshall CT score	4.16 ± 1.34
Time interval from trauma to surgery	13.56 ± 9.15 hours
Duration of surgery	3.28 ± 0.52 hours
Blood loss	334.00 ± 87.46 mL
ICP After first burr hole	27.92 ± 2.13 mm Hg
ICP after craniotomy	15.32 ± 3.17 mm Hg
ICP after cisternostomy	6.36 ± 1.91 mm Hg
Days on MV support	5.68 ± 3.80 days
Duration of ICU	7.12 ± 3.93 days
Duration of hospital stays	9.76 ± 5.17 days

Abbreviations: GCS, Glasgow coma scale; ICP, intracranial pressure; ICU, intensive care unit; MV, mechanical ventilation.

So, overall, there was significant decrease of ICP from first burr hole to ICP measured after cisternostomy, with average decrease of 21.56 ± 2.69 mm Hg. (*p* 0.000) (► **Table 2**).

GOS score was assessed after 3 months of follow-up. Out of the 25 patients, 7 (28%) had score of 5, 5 (20%) patients had score of 4, 5 (20%) patients with score of 3, and 8 (32%) patients had score of 1.

In this study, the average GOS score was 5 in patients who underwent surgery in less than 6 hours after trauma and 1 in patients who underwent surgery after 24 hours of trauma. (► **Table 3A**).

In this study, average GOS score in patients with moderate head injury was 4.57 ± 0.78, and it was 2.56 ± 1.54 in patients with severe head injury (► **Table 3B**).

In our study, mean ICP measured after placement of first burr hole was comparable in all the patients irrespective of their outcomes (*p* 0.026). However, mean ICP after cisternostomy was high in patients with GOS score 1 (7.25 ± 1.39 mm Hg) (*p* 0.000) (► **Table 4**).

In this study, 7 patients were associated with other major injuries. Out of the 7 patients, 3 patients were associated with hemothorax and rib fractures, 3 patients with long bone fractures, and 1 patient had both hemothorax with long bone fracture in association with head injury. Out of these 7 patients, 4 patients (57.14%) had mortality in the postoperative period with GOS score 1.

Table 2 Intraoperative ICP

	Mean decrease in ICP (in mmHg)	<i>p</i> -Value
From first burr hole to craniotomy	12.60 ± 3.20	0.000
From craniotomy to cisternostomy	8.96 ± 2.99	0.000
From first burr hole to cisternostomy	21.56 ± 2.69	0.000

Abbreviation: ICP, intracranial pressure.

Table 3 Relation of time interval from trauma to surgery and grade of head injury

	Mean GOS
A. Time interval from trauma to surgery	
< 6 hours	5 ± 0
7–12 hours	3.40 ± 1.43
13–24 hours	2.80 ± 1.68
> 24 hours	1 ± 0
B. Grade of head injury	
Mild (GCS 14 to 15)	0
Moderate (GCS 9 to 13)	4.57 ± 0.78
Severe (GCS < 9)	2.56 ± 1.54

Abbreviations: GCS, Glasgow coma scale; GOS, Glasgow outcome scale.

Table 4 Relation of ICP with GOS

GOS	Mean ICP after first burr hole (in mm Hg)	Mean ICP after cisternostomy (in mm Hg)
5	27.71 ± 2.98	5.71 ± 1.60
4	28.40 ± 2.30	6.40 ± 3.36
3	27.20 ± 1.48	5.80 ± 0.84
2	0	0
1	28.25 ± 1.75	7.25 ± 1.39

Abbreviations: GOS, Glasgow outcome scale; ICP, intracranial pressure.

In this study, out of the 25 patients, 7 (28%) patients developed seizures in the postoperative period, 1 (4%) patient developed pseudomeningocele, and 1 (4%) patient developed bed sore in the post-operative period. One patient (4%) developed osteomyelitis in the follow-up period, which was managed conservatively.

Discussion

Management of TBI is mainly focused on controlling the damage caused by secondary brain injury, which occurs mainly on account of raised ICP. Decompressive craniectomy is the most commonly used surgical procedure in the management of TBI. However, it requires second surgery in the form of cranioplasty. Both

these procedures are associated with many complications and morbidity.

Cherian et al in 2009 described cisternostomy for the control of ICP in TBI.⁹ Cisternostomy, by opening the brain cistern to atmospheric pressure, has been shown to decrease the intracranial pressure due to a backshift of CSF throughout the VRS.

Goyal et al described the pathophysiology behind the cisternostomy in controlling ICP.¹⁰

Herein, we performed 25 cases of cisternostomy in the TBI patients with intraoperative ICP monitoring.

In our study, 48% (12 cases) had good GOS score (4 and 5) after 3 months of follow-up. As much as 20% (5 cases) had GOS score of 3.

In a study done by Partiban et al, basal cisternostomy (BS) alone had a favorable GOS as compared with BS combined with decompressive craniotomy (82% vs. 62%).¹¹

Mortality rate in this study is 32% (8 patients), which was higher than in the study by Cherian et al in 2019, that is, 10%, but it was comparable to the mortality rate in a study by Youssef et al (32%) in 2020.^{12,13}

Prognostic Factors for Outcome in this Study

Age

In this study, all the patients > 50 years age (7 patients) and presented with severe head injury with mean GCS score of 5.71 ± 0.95 . Overall, out of the 18 patients with poor GCS in this study, 12 (66%) patients were with age > 40 years.

The patients with age more than 50 years had lowest average GOS score of 2.75 ± 2.06 .

This suggests that the age has an independent prognostic value in the outcome of the patients. These results were consistent with the previous studies, which stated that age is a good prognostic indicator.¹⁴

Presenting GCS

In this article, all the patients > 50 years age (7 patients) presented with severe head injury with mean GCS score of 5.71 ± 0.95 . Overall, out of the 18 patients with poor GCS in this study, 12 (66%) patients were with age > 40 years

Average GOS score in patients with moderate head injury was 4.57 ± 0.78 , and it was 2.56 ± 1.54 in patients with severe head injury.

This suggests that the patients with severe head injury at the time of presentation had poor outcome.

Intracranial Pressure

As far as we know, this was the only study where ICP was measured before opening, after craniotomy, and after cisternostomy. No study till now has compared the ICP after craniotomy with ICP after cisternostomy.

There was a significant decrease in the ICP after cisternostomy, with a mean change of 8.96 ± 2.99 mm Hg from craniotomy to cisternostomy.

Goyal et al published a cohort of 9 patients who underwent both BS and decompressive craniotomy. They demonstrated a significant difference between opening and

closing parenchymal pressures. Their study supported the CSF-shift edema and suggested that both BS and decompressive craniotomy should be provided for head injuries with severe edema.¹⁵

Giammattei et al in a study of 40 cases showed that implementation of cisternostomy as adjuvant to decompressive craniectomy had lower ICP values and better outcomes when compared with craniectomy alone.¹⁶

In our study, patients with average low ICP after cisternostomy (5.71 ± 1.60 mm Hg) had good outcome at 3 months follow-up. Patients with high average ICP after cisternostomy (7.25 ± 1.39 mm Hg) had poor outcome.

In our study, ICP measured after first burr hole was comparable in all the patients irrespective of their Marshall CT score.

Time Interval from Trauma to Surgery

In this study, patients were categorized into four groups based on the time interval between trauma to the time of surgery. As SVIMS is a tertiary care center, patients were usually referred from other hospitals after initial evaluation. So, in this study, patients were usually presented between 7 to 12 hours after trauma (40% cases) and between 13 to 24 hours after trauma. Only 3 (12%) cases were presented within 6 hours after trauma, and 2 patients underwent surgery after 24 hours from trauma.

All the patients who underwent surgery before 6 hours after trauma had good outcome (GOS score 5) and all the patients who operated after 24 hours of trauma had mortality in the postoperative period (GOS score 1).

This result supports the results of Surgical Trial in Traumatic intracranial hemorrhage (ICH) (STITCH) by Mendelow et al in 2015, which showed good outcome in early surgery group.¹⁷

Association with Other Major Injuries

In our study, out of the 7 patients who had other major injuries in association with head injury, 57.14% had a high mortality rate (4 patients). This shows the presence of other major injuries in association with head injury had an impact on outcome

Postoperative Hospital Stays

The mean duration of hospital stay was 9.76 days and mean duration on ventilator support was 5.68 days. Mean duration on ventilator support in this study was more when compared with a study done by Cherian et al in 2013.¹²

The mean duration of ICU care in this study was 7.12 days. The mean duration of ICU care in this study was more in this study compared with a study done by Cherian et al (4 days) in 2019.¹²

Chandra in a publication stated that BS seems like a promising procedure and multicentric randomized studies were needed to be conducted to solve the problem of potential danger of "having too much optimism" initially, followed by an equally "low pessimism," if the procedure does not produce optimal results.¹⁸

Conclusion

We recommend ICP monitoring in head injury patients irrespective of the Marshall CT score, as low score patients also showed high ICP. Since the cisterns and the brain communicate, it would be possible to decrease the pressure in both these compartments by opening the cisterns to atmospheric pressure. Cisternostomy can effectively decrease the ICP in TBI. Cisternostomy has less postoperative complications, hospital stay, and mortality. However, the opening of the cisterns in a swollen traumatic brain is challenging and requires thorough anatomic knowledge and adequate surgical experience

Conflict of Interest

None declared.

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