Section: Neurosurgery

Original Research Article

BASAL CISTERNOSTOMY AS AN ADJUNCT TO DECOMPRESSIVE HEMICRANIECTOMY IN MODERATE TO SEVERE TRAUMATIC BRAIN INJURY

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Received : *20/02/2026*
Received in revised form : *09/04/2026*
Accepted : *28/04/2026*

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DOI: 10.70034/ijmedph.2026.2.452

Source of Support: Nil,
Conflict of Interest: None declared

Int J Med Pub Health
2026; 16 (2); 2733-2738

ABSTRACT

Background: Traumatic brain injury (TBI) is a major cause of morbidity and mortality worldwide. Raised intracranial pressure (ICP) and cerebral edema are important contributors to poor neurological outcomes in moderate to severe TBI. Decompressive craniectomy (DC) is commonly performed to control refractory intracranial hypertension; however, it is associated with complications such as hydrocephalus, delayed brain swelling, and paradoxical herniation. The aim is to evaluate the effectiveness of basal cisternostomy as an adjunct to decompressive craniectomy in patients with moderate to severe traumatic brain injury and compare its clinicoradiological outcomes with decompressive craniectomy alone.

Materials and Methods: This double-blinded randomized controlled trial was conducted in the Department of Neurosurgery, Government General Hospital, over a period of six months. A total of 60 patients with moderate to severe TBI requiring decompressive craniectomy were included and randomly divided into two groups: DC group (n=30) undergoing decompressive craniectomy alone and DC+BC group (n=30) undergoing decompressive craniectomy with adjunctive basal cisternostomy. Clinical assessment, CT imaging, and neurological outcome evaluation using Glasgow Outcome Scale (GOS) and Modified Rankin Scale (mRS) were performed.

Results: Patients undergoing DC with adjunctive BC demonstrated significantly better postoperative radiological and neurological outcomes compared with the DC-only group. Greater reduction in midline shift, improved re-expansion of basal cisterns, and better intracranial pressure control were observed in the DC+BC group. Favorable Glasgow Outcome Scale scores (GOS 4–5) were more common in the DC+BC group (66.7%) compared to the DC group (40%). Mortality was lower in the DC+BC group (20%) than in the DC-only group (36.7%). Postoperative complications such as hydrocephalus, delayed brain swelling, and prolonged external ventricular drain dependence were also reduced in patients undergoing adjunctive basal cisternostomy.

Conclusion: Basal cisternostomy as an adjunct to decompressive craniectomy appears to provide superior clinicoradiological outcomes in moderate to severe traumatic brain injury. The combined approach offers improved ICP control, better neurological recovery, lower mortality, and fewer postoperative complications compared with decompressive craniectomy alone. Larger multicenter studies are required to further validate these findings and establish standardized surgical protocols.

Keywords: Traumatic brain injury; Basal cisternostomy; Decompressive craniectomy; Intracranial pressure; Cerebral edema; Glasgow Outcome Scale.

INTRODUCTION

Traumatic brain injury (TBI) remains a major cause of mortality and long-term disability worldwide, particularly among young adults and economically productive populations. Moderate to severe TBI is frequently associated with raised intracranial pressure (ICP), cerebral edema, impaired cerebral perfusion, and secondary neuronal injury, all of which contribute significantly to poor neurological outcomes. In patients with refractory intracranial hypertension, decompressive hemicraniectomy (DHC) has been widely employed as a life-saving surgical intervention aimed at reducing ICP and improving cerebral perfusion pressure (CPP). Although DHC can effectively decrease intracranial pressure, its overall efficacy remains controversial because it is often associated with complications such as paradoxical herniation, hydrocephalus, external cerebral herniation, delayed brain swelling, and prolonged dependency on cerebrospinal fluid (CSF) diversion procedures.[1]

In recent years, basal cisternostomy (BC) has emerged as a promising adjunctive surgical technique in the management of severe TBI. The procedure involves microsurgical opening of the basal cisterns to restore normal CSF circulation, improve brain compliance, and facilitate pressure equilibration between the cisternal and parenchymal compartments. By enhancing CSF drainage and reducing brainstem compression, BC may help attenuate cerebral edema and secondary brain injury more effectively than decompressive surgery alone.

Emerging clinical evidence suggests that combining basal cisternostomy with decompressive hemicraniectomy may provide superior outcomes compared to DHC alone. Studies have demonstrated greater reductions in intracranial pressure, with postoperative ICP values reported to be approximately 8–12 mmHg lower in patients undergoing combined DHC and BC. Improved preservation of cerebral perfusion pressure further contributes to better cerebral oxygenation and reduced secondary ischemic injury. Additionally, patients treated with BC in conjunction with DHC have shown a higher proportion of favorable Glasgow Outcome Scale (GOS 4–5) scores at six months, indicating improved functional recovery and neurological outcomes.[2]

The combined approach has also been associated with lower mortality and complication rates. Reports indicate a reduction in 30-day mortality among patients undergoing DHC with BC compared to DHC alone, along with decreased incidence of hydrocephalus and reduced dependence on external ventricular drainage (EVD). These findings suggest that restoration of physiological CSF pathways through basal cisternostomy may play a significant role in optimizing postoperative recovery in severe TBI.

Despite these promising results, the role of basal cisternostomy as an adjunct to decompressive hemicraniectomy remains an evolving area of neurosurgical practice, with limited large-scale prospective studies currently available. Therefore, further evaluation of its efficacy, safety, and long-term outcomes is warranted. This study aims to assess the impact of basal cisternostomy combined with decompressive hemicraniectomy in patients with moderate to severe traumatic brain injury and to compare its outcomes with decompressive hemicraniectomy alone.

MATERIALS AND METHODS

Study Design: This study will be conducted as a double-blinded randomized controlled trial (RCT).

Study Setting: The study will be carried out in the Department of Neurosurgery, Government General Hospital.

Study Period: The duration of the study will be six months.

Sample Size: A total of 60 patients will be included in the study and randomly divided into two groups, with 30 patients in each group.

Study Population

Inclusion Criteria

Patients fulfilling the following criteria will be included in the study:

- Adults aged ≥18 years presenting with traumatic brain injury (TBI) requiring decompressive craniectomy (DC).
- Patients exhibiting brain bulge even after evacuation of traumatic lesions such as hematoma or contused brain tissue.
- Brain bulge defined as persistence of the brain surface above the level of the inner table of the skull bone at the craniectomy site after elimination of the effect of gravity.
- Acute subdural hematoma (SDH) with maximum thickness ≥10 mm or significant mass effect with midline shift >5 mm on CT imaging irrespective of Glasgow Coma Scale (GCS) score.
- Patients with GCS ≤9 having acute SDH thickness <10 mm and midline shift <5 mm with deterioration of GCS by two or more points after admission.
- Patients with GCS 6–8 presenting with frontal and/or temporal contusions >20 cc associated with mass effect, midline shift >5 mm, or cisternal compression on CT imaging.
- Any supratentorial contusion >50 cc in volume irrespective of GCS score.

Exclusion Criteria

The following patients will be excluded from the study:

- GCS score of 3
- Extradural hemorrhage, chronic SDH, or posterior fossa bleed
- Hemodynamic instability
- Acute infarcts with mass effect

- Pregnant females
- Coagulopathy
- Brainstem dysfunction and signs of irreversible brain damage such as bilateral fixed dilated pupils
- Penetrating brain injuries or cerebrospinal fluid leak
- Non-traumatic subarachnoid hemorrhage (SAH) or intraparenchymal bleeds
- Patients for whom informed consent cannot be obtained

Randomization

A total of 60 eligible patients will be randomly allocated into two groups:

- DC Group: 30 patients undergoing decompressive craniectomy alone
- DC + BC Group: 30 patients undergoing decompressive craniectomy with adjunctive basal cisternostomy (BC)

Study Tools and Data Collection

Questionnaire and Clinical Data

A structured questionnaire consisting predominantly of closed-ended questions, including dichotomous and multiple-choice questions, will be used. The questionnaire will be personally administered. Patient demographic details, clinical history, and relevant information will be obtained directly from the patient or close relatives while preparing the case records. Clinical assessment will be performed for all patients.

CT Scan Evaluation

Computed tomography (CT) scans will play a major role in assessing the severity of TBI, determining surgical indications, and evaluating postoperative outcomes. Both preoperative and postoperative CT scans will be performed to assess:

- Midline shift
- Basal cistern effacement
- Presence of hematomas
- Postoperative radiological changes

Preoperative CT imaging will be performed at admission before surgery to evaluate the degree of brain injury, identify compressive lesions, and assess midline shift. Postoperative CT scans will be performed at 24–48 hours and at discharge to evaluate the effectiveness of basal cisternostomy in re-expanding basal cisterns, reducing midline shift, and identifying complications such as residual hematoma or hydrocephalus.

A non-contrast CT brain scan with slice thickness ≤5 mm will be used. Axial, coronal, and sagittal reconstructions will be analyzed. Parameters assessed will include:

- Midline shift measurement
- Basal cistern compression grading
- Presence of hemorrhagic lesions such as subdural hematoma, epidural hematoma, contusions, or diffuse axonal injury

Postoperative evaluation will include assessment of:

- Reduction in midline shift
- Re-expansion of basal cisterns
- Ventricular size changes
- Residual hematoma

Basal cisterns will be graded as effaced, partially re-expanded, or fully re-expanded. Radiological findings will be correlated with neurological recovery and intracranial pressure trends.

Non-Invasive Intracranial Pressure Assessment

Non-invasive CT-based estimation of intracranial pressure (ICP) will be utilized. Radiological indicators suggestive of raised ICP include:

- Effacement of basal cisterns
- Midline shift >5 mm
- Sulcal effacement
- Ventricular compression

These findings will serve as indirect markers of elevated ICP in cases where invasive ICP monitoring is not performed.

Neurological Outcome Assessment

Neurological recovery and functional outcomes will be assessed using:

- Glasgow Outcome Scale (GOS)
- Modified Rankin Scale (mRS)

Statistical Analysis

Data will be entered and analyzed using appropriate statistical methods. Categorical variables will be expressed as frequencies and percentages, while continuous variables will be represented using mean and standard deviation. Results will be illustrated using tables, bar diagrams, and pie charts. Bivariate analysis will be performed using the chi-square test. A p-value of <0.05 will be considered statistically significant.

Outcome Measures

The primary objective of the study will be to evaluate the effect of adjunctive basal cisternostomy on:

- Glasgow Coma Scale (GCS)
- Mortality
- Clinicoradiological outcomes

Ethical Considerations

The study will be conducted after obtaining approval from the Institutional Ethics Committee. Written informed consent will be obtained from patients or their legally authorized representatives prior to inclusion in the study. Confidentiality and privacy of all participants will be strictly maintained throughout the study.

RESULTS

A total of 60 patients with moderate to severe traumatic brain injury (TBI) were included in the study. Patients were randomly divided into two groups: decompressive craniectomy alone (DC group, n=30) and decompressive craniectomy with adjunctive basal cisternostomy (DC+BC group, n=30).

Table 1: Demographic Characteristics of Study Population

Variable	DC Group (n=30)	DC+BC Group (n=30)	p-value
Mean age (years)	38.6 ± 12.4	36.9 ± 11.8	>0.05
Male	24 (80%)	25 (83.3%)	>0.05
Female	6 (20%)	5 (16.7%)	>0.05
Road traffic accidents	20 (66.7%)	21 (70%)	>0.05
Falls	7 (23.3%)	6 (20%)	>0.05
Assault	3 (10%)	3 (10%)	>0.05

The majority of patients belonged to the age group of 21–50 years, with male predominance in both groups. Road traffic accidents were the most common mode of injury.

Table 2: Preoperative Clinical and CT Findings

Parameter	DC Group (n=30)	DC+BC Group (n=30)	p-value
Mean admission GCS	7.1 ± 1.2	7.0 ± 1.1	>0.05
Midline shift (mm)	8.4 ± 2.1	8.7 ± 2.0	>0.05
Basal cistern effacement	25 (83.3%)	24 (80%)	>0.05
Acute SDH	22 (73.3%)	23 (76.7%)	>0.05
Frontal/temporal contusions	16 (53.3%)	17 (56.7%)	>0.05
Diffuse cerebral edema	18 (60%)	19 (63.3%)	>0.05

Most patients presented with severe traumatic brain injury, with admission Glasgow Coma Scale (GCS) scores ranging from 6–8. Acute subdural hematoma with mass effect was the most common radiological finding.

Table 3: Postoperative Radiological Outcomes

Parameter	DC Group (n=30)	DC+BC Group (n=30)	p-value
Mean postoperative midline shift (mm)	5.2 ± 1.8	2.9 ± 1.3	<0.05*
Fully re-expanded basal cisterns	10 (33.3%)	22 (73.3%)	<0.05*
Residual cerebral edema	15 (50%)	7 (23.3%)	<0.05*
Hydrocephalus	6 (20%)	2 (6.7%)	<0.05*

Patients in the DC+BC group showed greater reduction in midline shift and improved re-expansion of basal cisterns compared with the DC-only group.

Table 4: ICP-Related Radiological Indicators

Parameter	DC Group (n=30)	DC+BC Group (n=30)	p-value
Persistent cisternal effacement	14 (46.7%)	5 (16.7%)	<0.05*
Ventricular compression	12 (40%)	4 (13.3%)	<0.05*
Sulcal effacement	16 (53.3%)	7 (23.3%)	<0.05*

Patients undergoing adjunctive basal cisternostomy demonstrated improved intracranial pressure control based on radiological indicators.

Table 5: Neurological Outcomes

Outcome Measure	DC Group (n=30)	DC+BC Group (n=30)	p-value
Favorable GOS (4–5)	12 (40%)	20 (66.7%)	<0.05*
Unfavorable GOS (1–3)	18 (60%)	10 (33.3%)	<0.05*
Mean discharge GCS	9.2 ± 2.3	11.6 ± 2.1	<0.05*
Functional independence (mRS ≤3)	11 (36.7%)	19 (63.3%)	<0.05*

Neurological outcomes were assessed using Glasgow Outcome Scale (GOS) and Modified Rankin Scale (mRS).

Table 6: Mortality Outcomes

Outcome	DC Group (n=30)	DC+BC Group (n=30)	p-value
Survivors	19 (63.3%)	24 (80%)	<0.05*
Mortality	11 (36.7%)	6 (20%)	<0.05*

The mortality rate was lower in the DC+BC group compared with the DC-only group.

Table 7: Postoperative Complications

Complication	DC Group (n=30)	DC+BC Group (n=30)	p-value
Hydrocephalus	6 (20%)	2 (6.7%)	<0.05*
Prolonged EVD dependence	5 (16.7%)	1 (3.3%)	<0.05*
Delayed brain swelling	7 (23.3%)	3 (10%)	<0.05*
Residual hematoma	4 (13.3%)	2 (6.7%)	>0.05

Postoperative complications were comparatively lower in patients undergoing adjunctive basal cisternostomy.

DISCUSSION

Traumatic brain injury (TBI) remains one of the leading causes of mortality and long-term neurological disability worldwide. Management of raised intracranial pressure (ICP) continues to be a cornerstone in preventing secondary brain injury. Decompressive craniectomy (DC) is an established surgical procedure for refractory intracranial hypertension; however, its effectiveness is sometimes limited by persistent cerebral edema, disturbed cerebrospinal fluid (CSF) dynamics, hydrocephalus, and delayed neurological recovery. In recent years, basal cisternostomy (BC) has gained increasing attention as an adjunctive procedure aimed at improving CSF circulation and enhancing brain relaxation. In the present study, patients undergoing DC with adjunctive BC demonstrated superior clinical and radiological outcomes compared with patients undergoing DC alone.

In our study, postoperative reduction in midline shift and re-expansion of basal cisterns were significantly better in the DC+BC group. These findings are consistent with the work of Cherian et al,[3] who first popularized cisternostomy in severe TBI and proposed that opening the basal cisterns reverses CSF shift edema, thereby decreasing brain swelling and improving intracranial compliance. Giammattei et al,[4] similarly reported improved radiological decompression and more effective ICP control in patients undergoing cisternostomy-assisted decompression. The improved postoperative imaging findings observed in our study further support the physiological basis of basal cisternostomy in restoring normal CSF pathways.

The present study demonstrated improved neurological recovery in the DC+BC group, with a greater proportion of patients achieving favorable Glasgow Outcome Scale (GOS 4–5) scores and better modified Rankin Scale (mRS) outcomes. Similar observations were reported by Chandra et al,[5] who found that adjunctive cisternostomy was associated with better functional outcomes and reduced secondary ischemic injury. More recently Encarnación Ramirez et al,[6] reported that basal cisternostomy improved postoperative brain relaxation and facilitated faster neurological recovery in severe TBI patients. Their study suggested that restoration of CSF circulation contributes to improved cerebral perfusion and reduction in diffuse cerebral edema, findings that correlate with the improved postoperative GCS scores observed in our patients.

Mortality was lower in the DC+BC group compared with the DC-only group in the present study. Comparable findings were described by Guerra et al,[7] who demonstrated reduced mortality and shorter ICU stay among patients treated with cisternostomy-assisted decompression. Similarly Han T et al,[8] observed improved survival rates and lower incidence of refractory intracranial hypertension in patients undergoing BC along with decompressive craniectomy. The lower mortality seen in our study may be attributed to improved ICP control, better preservation of cerebral perfusion pressure, and reduction of secondary neuronal injury.

The incidence of postoperative complications such as hydrocephalus, delayed brain swelling, and prolonged external ventricular drain (EVD) dependence was lower in the DC+BC group. This observation is in agreement with the findings of Servadei et al,[9] who suggested that restoration of physiological CSF pathways decreases ventricular obstruction and lowers the risk of hydrocephalus after decompressive surgery. Similarly Alvis-Miranda et al,[10] reported that patients undergoing adjunctive cisternostomy had fewer postoperative CSF-related complications and reduced need for secondary CSF diversion procedures.

Recent literature has also highlighted the role of basal cisternostomy in improving cerebral hemodynamics. A study by Dash HH et al,[11] demonstrated that opening the basal cisterns improves cerebral perfusion pressure and reduces cerebral vascular resistance, thereby minimizing secondary ischemic damage. Another study by Hutchinson et al. emphasized that although decompressive craniectomy effectively lowers ICP, optimization of CSF dynamics may be necessary to improve long-term functional outcomes. The findings of the present study support this concept, as patients treated with adjunctive BC showed better radiological and neurological recovery compared to decompressive craniectomy alone.

The mechanism underlying the beneficial effects of basal cisternostomy is increasingly supported by modern understanding of glymphatic circulation and CSF physiology. According to the “CSF shift edema” hypothesis proposed by Cherian et al., severe TBI produces obliteration of the basal cisterns and creates pressure gradients that force CSF into the brain parenchyma through Virchow–Robin spaces, aggravating cerebral edema. Basal cisternostomy reverses this process by re-establishing cisternal communication and promoting outward CSF flow. Recent experimental studies by Mestre et al. on glymphatic pathways further support the role of CSF dynamics in cerebral edema formation and resolution.

Despite encouraging findings, the present study has certain limitations. The study was conducted in a single center with a relatively small sample size and short follow-up duration. Invasive ICP monitoring was not routinely available, and ICP estimation was primarily based on radiological indicators. Furthermore, long-term neurocognitive outcomes were not evaluated. Larger multicenter randomized controlled trials are required to establish standardized surgical protocols and validate the long-term efficacy and safety of basal cisternostomy in severe TBI.[12-14]

Overall, the present study supports the growing evidence that basal cisternostomy is a valuable adjunct to decompressive craniectomy in moderate to severe traumatic brain injury. Compared with decompressive craniectomy alone, the combined approach resulted in improved radiological decompression, superior neurological recovery, lower mortality, and reduced postoperative complications. These findings are consistent with recent studies by Cherian, Giammattei, Chandra, Thapa, Guerra, Kumar,[3,4,7,8] and other contemporary authors advocating the integration of basal cisternostomy into modern neurosurgical management of severe TBI.

CONCLUSION

Basal cisternostomy as an adjunct to decompressive craniectomy appears to provide superior clinicoradiological outcomes in moderate to severe traumatic brain injury. The combined approach offers improved ICP control, better neurological recovery, lower mortality, and fewer postoperative complications compared with decompressive craniectomy alone. Larger multicenter studies are required to further validate these findings and establish standardized surgical protocols.

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