Research Square

Preprints are preliminary reports that have not undergone peer review.
They should not be considered conclusive, used to inform clinical practice,
or referenced by the media as validated information.

Decompressive Craniectomy for Traumatic Brain Injury: Outcomes and Predictive Factors at Ethiopian Tertiary Centers

Kedir Dekebi Guduru
kedirdekebi@gmail.com

Addis Ababa University

Selemon G. Asgedom
Addis Ababa University

Research Article

Keywords: Decompressive craniectomy, Traumatic brain injury, Glasgow Coma Scale, Functional outcome, Prognostic factors

Posted Date: February 17th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-8802278/v1

License: This work is licensed under a Creative Commons Attribution 4.0 International License. Read Full License

Additional Declarations: No competing interests reported.

Abstract

Background

Decompressive craniectomy (DC) is commonly performed to control refractory intracranial hypertension after traumatic brain injury (TBI). This study aimed to identify the clinical, radiological, and perioperative factors associated with functional outcomes following DC among patients with TBI treated at tertiary hospitals in Addis Ababa, Ethiopia.

Methods

A prospective multicenter cohort study was conducted among consecutive patients with TBI who underwent decompressive craniectomy at four teaching hospitals affiliated with the Addis Ababa University. Sociodemographic, clinical, radiological, intraoperative, and postoperative data were collected. Functional outcomes were assessed using the Extended Glasgow Outcome Scale (EGOS) at discharge, 3, and 6 months. Univariate and multivariate logistic regression analyses were performed to determine the factors associated with poor outcomes.

Results

A total of 94 patients were included (mean age 38.9 ± 15 years), with a predominance of male patients (88.3%). Road traffic accidents were the leading cause of injury (54.3%). At 6 months, mortality was 33%, whereas 59.6% of patients achieved a favorable functional outcome (EGOS 5–8). On multivariable analysis, admission Glasgow Coma Scale (GCS) independently predicted poor outcomes. Compared with patients with GCS 13–15, those with GCS < 5 (adjusted OR 8.07; 95% CI 2.25–23.7) and GCS 5–8 (adjusted OR 27.06; 95% CI 3.92–29.83) had significantly higher odds of poor outcomes (likelihood ratio test, p = 0.001). In addition, surgery performed 24–72 h after injury was independently associated with poor outcomes compared with surgery within 24 h (adjusted OR 5.98; 95% CI 1.47–30.38; p = 0.02).

Conclusion

Decompressive craniectomy provides acceptable survival and functional outcomes in patients with traumatic brain injury in resource-limited settings. Admission GCS and timing of surgical intervention were the most important independent predictors of outcome.

Introduction

Traumatic brain injury (TBI) is a leading cause of death and long-term disability worldwide and represents a significant public health burden in low- and middle-income countries (LMICS) (1,2). In Ethiopia, neurotrauma accounts for a substantial proportion of trauma-related mortalities. A retrospective hospital-based study conducted at Tikur Anbessa Specialized Hospital (TASH) between 2002 and 2006 demonstrated that head injuries were responsible for approximately 60% of trauma-related deaths among surgical inpatients (3). National data in Ethiopia indicates that 20% of trauma patients sustain TBI (4).

Globally, TBI is associated with an estimated annual mortality rate of 10.4 per 100,000 population, with more than 1.7 million new cases reported annually in the United States, resulting in approximately 52,000 deaths(5,6). Worldwide, injury-related mortality exceeds that of HIV, tuberculosis, and malaria combined, with the World Health Organization estimating 5.8 million injury-related deaths annually, 90% occur in LMICs(7–9). In Africa, up to one-third of patients with head injuries experience unfavorable outcomes, and mortality among patients with severe TBI is twice that reported in high-income countries(10,11). These disparities are attributable to limited access to prehospital care, advanced neurocritical care, and timely neurosurgical intervention(11).

Following TBI, elevated intracranial pressure (ICP) commonly results from intracranial hematomas, cerebral contusions, diffuse brain swelling, or hydrocephalus. Raised ICP compromises cerebral perfusion pressure and precipitates secondary ischemic injury and brain herniation(12). Numerous studies have demonstrated a strong association between post-traumatic intracranial hypertension and increased mortality(2,13–15) . Accordingly, effective control of ICP remains a central component of severe TBI management, despite the limited availability of level 1 evidence supporting many ICP-directed interventions(14,15).

The Brain Trauma Foundation guidelines advocate a tiered approach to ICP management(10,16). Initial measures include head elevation, optimization of ventilation, sedation, and analgesia. First-tier therapies involve hyperosmolar agents, cerebrospinal fluid diversion, and temperature control. Second-tier therapies include barbiturate coma and decompressive craniectomy (DC). When indicated, the guidelines recommend performing a large frontotemporoparietal decompressive craniectomy (≥12 × 15 cm or 15 cm diameter) to optimize ICP reduction and survival(10).

Decompressive craniectomy involves the removal of a portion of the skull with dural opening to accommodate cerebral swelling and reduce ICP(17). Although DC has demonstrated efficacy in reducing mortality among patients with refractory intracranial hypertension, its effect on long-term functional outcomes remains controversial. Pivotal randomized controlled trials, including DECRA and RESCUE-ICP, have yielded differing conclusions

regarding functional recovery despite a survival benefit, underscoring the importance of patient selection, timing of intervention, and perioperative factors (6,18,19).

Despite its widespread use, the optimal timing, patient selection, and perioperative factors influencing outcomes after decompressive craniectomy (DC) remain uncertain. Conflicting evidence from randomized trials and observational studies contributes to variability in practice, which in resource-limited settings may expose patients to surgical morbidity without clear benefit. This study aims to evaluate clinical, radiologic, and perioperative factors associated with outcomes following DC for traumatic brain injury, to inform evidence-based decision-making, develop locally applicable prognostic tools, and improve neurotrauma care in comparable LMIC settings.

Methodology

Study Design and Population

This was an institution-based prospective cohort study conducted at four teaching hospitals affiliated with Addis Ababa University: ALERT Hospital, Black Lion Hospital (BLH), Menelik II Comprehensive Specialized Hospital (MCM), and Zewditu Memorial Hospital (ZMH). The study population consisted of all consecutive patients with traumatic brain injury (TBI) who underwent decompressive craniectomy (DC) during the study period and met the predefined inclusion criteria. The source population included all TBI patients presenting to the participating hospitals with an indication for surgical intervention. Patients or their legally authorized representatives who declined to provide informed consent were excluded. All eligible patients were enrolled consecutively to minimize selection bias.

Study Variables

Outcome (Dependent Variable)

The primary outcome was functional outcome following decompressive craniectomy (DC), measured using the Extended Glasgow Outcome Scale (EGOS) and categorized as:

- Death
- unfavorable outcome (EGOS 1–4)- this includes death
- Good outcome (EGOS 5–8)

Outcomes were assessed at hospital discharge, 3 months, and 6 months postoperatively.

Exposure and Covariates (Independent Variables)

Independent variables were grouped a priori into sociodemographic, clinical, radiological, intraoperative, and postoperative factors:

- Sociodemographic and baseline factors: age, sex, comorbidities, and mechanism of injury
- Preoperative clinical and radiological factors: admission Glasgow Coma Scale (GCS), pupillary reaction, presence of motor weakness, preoperative use of osmotic diuretics, and computed tomography (CT) characteristics, including lesion type, lesion site, and Rotterdam CT score
- Intraoperative factors: type of DC (primary vs secondary), surgical site, duration of surgery, estimated blood loss, type of dural opening, use of duraplasty, and occurrence of intraoperative hypotension or vasopressor use
- Postoperative factors: intensive care unit (ICU) admission, need for mechanical ventilation, and immediate postoperative GCS

Operational Definitions

- **Primary decompressive craniectomy:** removal of the bone flap during the initial emergency surgery for hematoma evacuation or control of acute brain swelling
- **Secondary decompressive craniectomy:** DC performed after failure of maximal medical management for intracranial hypertension
- **Extended Glasgow Outcome Scale (EGOS):** an eight-point functional outcome scale ranging from death to upper good recovery
- **Rotterdam CT score:** a prognostic CT-based scoring system assessing mortality risk using midline shift, basal cistern status, presence of epidural hematoma, and intraventricular hemorrhage or traumatic subarachnoid hemorrhage

Data Collection

Data were collected **prospectively** by trained neurosurgical residents using a **pretested electronic data collection tool.** Information was obtained from patients or attendants, emergency department records, neurosurgical operative notes, and critical care charts. Follow-up assessments were conducted at **discharge and at 3 and 6 months postoperatively**. Data collectors received **two days of standardized training** before study initiation. Supervisors and the principal investigator performed **daily data review** to ensure completeness, consistency, and accuracy. Data cleaning, cross-checking, and **double data entry** were performed before analysis.

Statistical Analysis

Coded data were analyzed using R statistical software. Continuous variables were summarized using means and standard deviations, while categorical variables were presented as frequencies and percentages. Univariable analyses were performed to identify factors associated with outcome following decompressive craniectomy (DC). Variables with a p-value < 0.25 in univariable analysis were entered into a multivariable regression model to control for potential confounding.

Heterogeneity of associations across key subgroups was assessed using interaction terms, and model fit was evaluated using likelihood ratio tests. Multicollinearity among independent variables was assessed prior to multivariable modeling using variance inflation factors (VIFs), with VIF values >10 considered indicative of significant collinearity. Variables demonstrating substantial collinearity were excluded or combined based on clinical relevance. Statistical significance was set at $p < 0.05$, and results were reported as odds ratios (ORs) with 95% confidence intervals (CIs).

Results

Sociodemographic and Injury-Related Characteristics

A total of 94 patients were included, with a mean age of 38.9 ± 15 years and a male predominance (88.3%). Road traffic accident was the most common mechanism of injury (54.3%), followed by assault (21.3%) and falls (14.9%). Comorbidities were present in 4.3% of patients (Table 1).

Table 1: Sociodemographic and injury-related characteristics of patients undergoing decompressive craniectomy

Variable		Frequency	Percentage
Age of the patient (years), mean ± SD		38.9 ± 15	
Sex	Male	83	88.3
	Female	11	11.7
Mechanism of Trauma	Road traffic accident	51	54.3
	Assault	20	21.3
	Falling accident	14	14.9
	Motor vehicle accident	7	7.4
	Penetrating TBI	2	2.1
Comorbidity	Yes	4	4.3
	No	90	95.7

Perioperative Clinical, Neurological, and Radiological Characteristics

Most patients presented within 8 hours of injury (62.1%). On admission, 62.8% had mid-sized reactive pupils, while 21.3% had nonreactive pupils. Admission Glasgow Coma Scale (GCS) scores were 13–15 in 20.2%, 9–12 in 38.3%, 5–8 in 26.6%, and <5 in 14.9% of patients. Focal neurological deficits were absent in 47.9% of patients, while 37.2% presented with contralateral weakness. Hemodynamic instability at presentation was observed in 12.8% of patients, and mannitol was administered to 97.9% of them. Computed tomography demonstrated Rotterdam CT scores of classes III (30.9%) and IV (28.7%) in the majority of patients. Multiple intracranial lesions were the most common finding (51%), followed by acute subdural hematoma (29.8%), with supratentorial involvement (96.8%) (Table 2).

Table 2: Preoperative clinical and radiological characteristics of patients undergoing decompressive craniectomy

Variable		Frequency	Percentage
GCS on Admission	GCS <5	14	14.9
	GCS 5–8	25	26.6
	GCS 9–12	36	38.3
	GCS 13–15	19	20.2
Pupillary Reaction	Mid-sized and reactive	59	62.8
	Midsized and non-reactive	2	2.1
	Anisocoric and reactive	13	13.8
	Anisocoric and non-reactive	9	9.6
	Dilated and non-reactive bilaterally	11	11.7
Mannitol use	Yes	92	97.9
	No	2	2.1
Duration of trauma upon arrival			
	Less than 4 hrs.	29	30.9
	4-8hrs	35	37.2
	8-16hrs	10	10.6
	16-24hrs	12	12.8
	24-36hrs	3	3.2
	36-72hrs	2	2.1
	Greater than 72hrs	3	3.2
Weakness during presentation			
	Bilateral weakness	4	4.3
	Unilateral weakness	6	6.4
	Contralateral weakness	35	37.2
	Lower extremity weakness	4	4.3
	No weakness	45	47.9
Hemodynamic disturbance during presentation			
	Yes	12	12.8
	No	82	87.2
Rotterdam CT score	Class I	9	9.6
	Class II	25	26.6
	Class III	29	30.9
	Class IV	27	28.7
	Class V	2	2.1
	Class VI	2	2.1
Type of Lesion	ASDH	28	29.8
	Bilateral ASDH	1	1.1
	CONTUSION	10	10.6
	EDH	1	1.1
	Multiple Lesion	48	51
	TICH	6	6.4
Location of the lesion	Supratentorial	91	96.8

	Supratentorial and Infratentorial	3	3.2

Surgical intervention was performed within 24 hours in 48.9% of patients and between 24 and 72 hours in 40.4%. The duration of surgery exceeded 120 minutes in 94.7% of cases, with 50% lasting more than 180 minutes. Estimated blood loss was between 500 and 1000 mL in 50% of cases. Intraoperative hypotension occurred in 37.2%, and 24.5% required vasopressor support. A cruciate dural opening was most commonly used (73.4%), and primary decompressive craniectomy was performed in 85.1% of cases (Table 3).

Table 3: Intraoperative characteristics of patients undergoing decompressive craniectomy

Variables		Frequency	Percentage
Surgery to trauma Interval	Less than 24hrs	46	48.9
	24-72hrs	38	40.4
	Greater than 72hrs	10	10.6
Duration of surgery	Less than 90min	2	2.1
	90min- 120 min	3	3.2
	120-180min	42	44.7
	Greater than 180min	47	50
Estimated Blood Loss	Less than 500ml	10	10.6
	500-1000ml	47	50
	1000-2000ml	24	25.5
	Greater than 2000ml	13	13.8
Intraoperative hypotension	Yes	35	37.2
	No	59	62.8
Intraoperative vasopressor used	Yes	23	24.5
	No	71	75.5
Dural opening during surgery	Cruciate	69	73.4
	Stellate	22	23.4
	curvilinear	2	2.1
	Other	1	1.1
Type of decompressive craniectomy	Primary	80	85.1
	Secondary	14	14.9

Postoperative Course and Functional Outcomes

Postoperatively, 75 patients (79.8%) required intensive care unit (ICU) admission with mechanical ventilation, while 17 patients (18.1%) were managed in the ICU without mechanical ventilation. Intraoperative mortality occurred in 2 patients (2.1%). At discharge, 17 patients (18.1%) had died, and 39 patients (41.5%) had an unfavorable Extended Glasgow Outcome Scale (EGOS) outcome. At the 3-month follow-up, mortality increased to 29 patients (30.9%), with 42 patients (44.7%) experiencing an unfavorable outcome. At 6 months, 31 patients (33.0%) had died, and 38 patients (40.4%) had an unfavorable outcome. (Figure 1).

Table 4: Postoperative course and extended Glasgow Outcome Scale (EGOS) outcomes at discharge and 3-month follow-up

Factors Associated with Unfavorable Outcome

Univariate and multivariate logistic regression analyses were performed to identify factors associated with unfavorable outcomes following decompressive craniectomy. The final multivariable logistic model demonstrated a good fit, and the Hosmer–Lemeshow test was (χ^2 (8, n = 94) = 13.3, p = 0.12). Multicollinearity was not a concern, with a maximum variance inflation factor (VIF) of 4.2. On univariate logistic regression analysis, pupillary reaction was significantly associated with poor outcome (p = 0.003), with markedly increased odds observed in patients with anisocoric non-reactive pupils (OR 7.97, 95% CI 1.73–57.17) and bilaterally dilated non-reactive pupils (OR 10.25, 95% CI 2.36–71.86), compared with mid-sized reactive pupils. Admission Glasgow Coma Scale (GCS) showed a strong association with outcome (p < 0.001); patients with GCS <5 (OR 21.25, 95% CI 3.87–182.25) and GCS 5–8 (OR 26.92, 95% CI 5.69–205.32) had significantly higher odds of poor outcome compared with those with GCS 13–15.

Additional factors associated with poor outcome on univariate analysis included presence of weakness at presentation (OR 2.95, 95% CI 1.28–7.04; p = 0.01), hemodynamic disturbance at presentation (OR 4.45, 95% CI 1.23–21.21; p = 0.02), and higher Rotterdam CT score, with Rotterdam class ≥IV showing increased odds of poor outcome (OR 6.36, 95% CI 1.28–47.99; p = 0.03). Intraoperative hypotension (OR 4.04, 95% CI 1.69–10.06; p = 0.001) and intraoperative vasopressor use (OR 3.96, 95% CI 1.49–11.48; p = 0.005) were also significantly associated with poor outcome. Time from trauma to surgery showed a trend toward significance, with surgery performed at 24–72 hours associated with higher odds of poor outcome (OR 2.58, 95% CI 1.08–6.36; p = 0.09).

On multivariate logistic regression analysis, admission GCS remained an independent predictor of poor outcome (p = 0.001). Compared with GCS 13–15, patients with GCS <5 (adjusted OR, 8.07; 95% CI, 2.25–23.7) and GCS 5–8 (adjusted OR, 27.06; 95% CI, 3.92–29.83) had significantly increased odds of a poor outcome. The time from trauma to surgery was also independently associated with outcome (p = 0.02); surgery performed 24–72 hours after trauma was associated with a poorer outcome (adjusted OR, 5.98; 95% CI, 1.47–30.38). Other variables did not retain statistical significance after adjustment. (Table 4)

Table 4: Univariate and multivariate logistic regression analyses of factors associated with unfavorable outcome following decompressive craniectomy

			Univariate logistic regressions			Multivariate logistic regression		
			Poor Outcome		LRT	Poor Outcome		LRT
Variables	N	Prev (%)	OR	(95%CI)	P value	adj OR	(95%CI)	P value
Sex					0.77			
Male	83	41.0	0.82	(0.44 ; 1.07)		-	- -	
Female	11	36.4	1					
Mechanism of Trauma					0.26			
Assault	20	50.0	1					
Falling accident	14	21.4	0.27	(0.05 ; 1.19)		-	- -	
penetrating TBI	2	50.0	1.00	(0.04 ; 27.7)		-	- -	
Road Traffic Accident	58	43.1	0.76	(0.27 ; 2.12)				
pupillary Reaction					**0.009**			0.5
Mid-sized and reactive	59	30.5	1					
Midsized and non-reactive	2	50.0	2.28	(0.09 ; 59.78)		4.03	(0.03 ; 36.7)	
Anisocoric and reactive	13	53.8	2.66	(0.78 ; 9.36)		1.47	(0.27 ; 8.38)	
Anisocoric and non-reactive	9	77.8	7.97	(1.73 ; 57.17)		2.11	(010 ; 6.48)	
Dilated and non-reactive bilaterally	11	81.8	10.25	(2.36 ; 71.86)		6.60	(0.67 ; 12.06)	
GCS on Admission					**<0.001**			**0.001**
Less than 5	14	92.5	110.50	(13.06 ; 272.83)		60.60	(4.93 ; 195.15)	
5 to 8	25	64	15.11	(3.34 ; 110.24)		7.79	(1.27 ; 70)	
9 to 12	36	19.4	2.05	(0.44 ; 14.84)		1.9	(0.34 ; 15.43)	
13-15	19	10.5	1			1		
Weakness During presentation					**<0.001**			0.11
Yes	49	59.2	5.80	(2.37 ; 15.3)		3.29	(0.78 ; 15.46)	
No	45	20	1			1		
Hemodynamic disturbance during presentation					**<0.001**			0.07
Yes	12	83.3	9.64	(2.34 ; 65.61)		1.56	(0.18 ; 9.73)	
No	82	34.1	1			1		
Comorbidity					0.69			
No	90	40	1					
Yes	4	50.0	1.50	(0.17 ; 12.97)		-	- -	

Rotterdam Brain CT score								**0.02**						0.32
	Class I	9	22.2	1										
	Class II	25	24.0	1.11	(	0.20	;	8.76	)	0.75	(	0.04	;	10.65	)	
	Class III	29	37.9	2.14	(	0.42	;	16.12	)	0.67	(	0.07	;	10.44	)	
	>=Class IV	31	61.3	5.54	(	1.12	;	41.59	)	0.92	(	0.05	;	14.64	)	
Time of surgery (intraoperative)								**0.21**						0.18
	≤ 3 hours	47	38.3	1						1						
	> 3 hours	47	51.1	1.68	(	0.74	;	3.86	)	1.22	(	0.52	;	3.47	)	
Time trauma to surgery								**0.09**						**0.02**
	< 24 hours	46	34.8	1						1						
	24-72 hours	38	52.6	2.08	(	1.08	;	5.09	)	2.97	(	1.50	;	5.98	)	
	> 72 hours	10	20.0	0.47	(	0.07	;	2.15	)	0.61	(	0.05	;	5.25	)	
Estimated Blood Loss								0.26						
	Less than 500ml	9	44.4	1												
	500-1000ml	24	54.2	0.51	(	0.12	;	2.34	)	-		-		-		
	1000-2000ml	48	29.2	1.48	(	0.31	;	7.32	)	-		-		-		
	Greater than 2000ml	13	53.8	1.46	(	0.26	;	8.51	)							
Intraoperative hypotension								**<0.001**						0.4
	No	59	23.7	1						1						
	Yes	35	68.6	7.01	(	2.84	;	18.48	)	1.56	(	0.18	;	7.73	)	
Intraoperative vasopressor use								**0.001**						0.2
	No	71	31.0	1						1						
	Yes	23	69.6	5.09	(	1.90	;	14.93	)	1.16	(	0.12	;	9.55	)	
Type of decompressive craniectomy								0.43						
	Primary	80	38.8	1												
	Secondary	14	50	1.58	(	0.50	;	5.04	)	-		-		-		
Mannitol use								0.38						
	NO	2	50.0	1.80	(	0.05	;	32.10	)							
	YES	92	44.6	1												
Location of the lesion								0.8						
	Supratentorial	91	40.7	1												
	Supra and Infratentorial	3	33.3	0.73	(	0.03	;	7.89	)							

Discussion

This prospective multicenter cohort study evaluated clinical, radiological, and perioperative factors influencing outcomes following decompressive craniectomy (DC) for traumatic brain injury (TBI) in four tertiary hospitals in Addis Ababa, Ethiopia. At 6 months, the mortality rate was 33%, while 59.6% of patients achieved a favorable functional outcome (EGOS 5–8). These findings underscore both the life-saving potential of DC and the persistent burden of poor outcomes in resource-limited settings.

The observed six-month mortality rate of 33% is comparable to reports from other low- and middle-income countries (LMICs), where mortality following DC for severe TBI ranges from 25% to 45%(20–23). Similar mortality rates have been reported in Ethiopia and sub-Saharan Africa, reflecting shared challenges such as delayed presentation, limited prehospital care, and constrained neurocritical care resources(4, 24). In contrast, randomized controlled trials from high-income countries, such as the RESCUE-ICP trial, reported mortality rates of approximately 26% at six months, albeit with higher rates of severe disability among survivors (19). These differences reflect variations in patient selection, timing of intervention, postoperative rehabilitation, and intensive care capacity. The proportion of patients achieving a favorable outcome in our cohort (55.3%) is encouraging and aligns with findings from observational studies in Asia, Latin America, and Africa, where favorable outcomes after DC range between 40% and 60% (25–28). This suggests that, even in resource-constrained environments, carefully selected patients can derive meaningful functional benefit from DC.

Admission GCS emerged as the strongest independent predictor of outcome in this study. Patients presenting with GCS < 5 and 5–8 had significantly higher odds of poor outcomes compared with those with GCS 13–15. This finding is consistent with extensive literature identifying admission GCS as one of the most robust predictors of mortality and functional outcome after TBI and DC(8, 25, 27, 29). Large cohort studies and prognostic models, including the IMPACT study, have consistently demonstrated that lower admission GCS reflects the severity of primary brain injury and predicts limited neurological recovery despite aggressive surgical intervention(16, 29). Our findings reinforce the importance of admission neurological status in guiding surgical decision-making and counseling families regarding expected outcomes, particularly in settings where advanced neuromonitoring is limited.

Time from trauma to surgery was independently associated with outcome, with DC performed 24–72 hours after injury associated with poorer outcomes compared with surgery within 24 hours. This observation aligns with prior studies suggesting that delayed surgical decompression may allow progression of secondary brain injury, including cerebral edema, ischemia, and irreversible neuronal damage(1, 30, 31). Early intervention has been associated with improved intracranial pressure control and better survival in selected patients, particularly those with mass lesions or malignant cerebral swelling(23, 30). However, the optimal timing of DC remains controversial. While some randomized trials, such as DECRA, failed to demonstrate functional benefit with very early DC for diffuse injury(18), observational studies from LMICs often show improved outcomes with earlier surgery, reflecting differences in case mix and delayed access to care(25, 31, 32). In our context, delays may be attributable to referral barriers, limited imaging availability, and operating room constraints, highlighting system-level targets for improvement.

Although pupillary reactivity, Rotterdam CT score, hemodynamic instability, and intraoperative hypotension were associated with poor outcomes on univariate analysis, these factors did not retain independent significance in multivariate analysis. Pupillary abnormalities and high Rotterdam CT scores are well-established markers of severe primary brain injury and increased mortality(33, 34). The lack of independent association in our study may reflect collinearity with admission GCS, limited sample size, or heterogeneity in injury patterns. Intraoperative hypotension and vasopressor use were also strongly associated with poor outcomes on univariate analysis, consistent with evidence that secondary insults such as hypotension exacerbate cerebral ischemia and worsen prognosis(14, 19). Although these variables did not remain significant after adjustment, their high prevalence underscores the importance of meticulous intraoperative and perioperative physiological optimization, particularly in settings without advanced neurocritical monitoring.

Most patients in this cohort underwent primary DC (85.1%), reflecting common practice in LMICs where DC is frequently performed concurrently with hematoma evacuation to preempt intracranial hypertension. Consistent with previous studies, no significant difference in outcome was observed between primary and secondary DC after adjustment(35, 36). Evidence comparing primary and secondary DC remains mixed, with outcomes influenced by indication, timing, and patient selection rather than the classification alone(35, 37).

The findings of this study have important implications for neurotrauma care in Ethiopia and similar LMIC contexts. First, admission GCS and timing of surgery are practical, readily available predictors that can inform surgical decision-making and prognostication. Second, reducing delays to definitive surgical care and minimizing secondary insults such as hypotension may yield substantial improvements in outcomes. Finally, the high proportion of favorable outcomes supports the continued use of DC as a life-saving intervention when appropriately indicated, even in resource-constrained environments.

Conclusion

In this multicenter prospective cohort from a resource-limited setting, decompressive craniectomy for traumatic brain injury was associated with acceptable survival and functional outcomes at three months. Admission Glasgow Coma Scale was the most important independent predictor of outcome, and delayed surgery beyond 24 hours after injury was associated with significantly worse functional results. These findings highlight the importance of early neurological assessment and timely surgical intervention in patients undergoing decompressive craniectomy. Optimization of referral pathways and perioperative care may further improve outcomes. Larger studies with longer follow-up are needed to refine patient selection and establish context-appropriate guidelines for decompressive craniectomy in low- and middle-income countries.

Declarations

Ethical Declarations

Ethical Approval

Ethical approval for this study was obtained from the Institutional Review Board of Black Lion Hospital (Tikur Anbessa Specialized Hospital), Addis Ababa University. The study was conducted in accordance with the ethical principles of the Declaration of Helsinki. Patient privacy and confidentiality were strictly maintained, and no personal identifiers were included in the dataset.

Consent to Participate

Written informed consent was obtained from all patients or, when applicable, from legally authorized representatives or family members with power of attorney before enrollment in the study.

Consent for Publication

Not applicable.

Competing Interests

The authors declare that they have no competing financial interests or personal relationships that could have influenced the work reported in this paper.

Privacy and Confidentiality

All patient data were anonymized using coded identifiers. No names or personal identifiers were collected. Access to the data was restricted to authorized members of the research team only.

Availability of Data and Materials

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

Funding

This study was supported by institutional resources from Black Lion Hospital (Tikur Anbessa Specialized Hospital). The funding source had no role in the study design, data collection, analysis, interpretation of data, manuscript preparation, or the decision to submit the manuscript for publication. Publication fees were not covered by the funding body.

Acknowledgments

The authors would like to express their sincere appreciation to the staff of Black Lion Hospital (Tikur Anbessa Specialized Hospital) for their cooperation and support throughout the conduct of this study.

References

1. Maas AIR, Marmarou A, Murray GD, Teasdale GM, Steyerberg EW. Prognosis and clinical trial design in traumatic brain injury: The IMPACT study. Vol. 24, Journal of Neurotrauma. 2007. p. 232–8.
2. Badri S, Chen J, Barber J, Temkin NR, Dikmen SS, Chesnut RM, et al. Mortality and long-term functional outcome associated with intracranial pressure after traumatic brain injury. Intensive Care Med. 2012 Nov;38(11):1800–9.
3. Biluts H, Bekele A, Kotisso B, Enqueselassie F, Munie T. In-patient surgical mortality in Tikur Anbessa Hospital: A five-year review. Ethiop Med J. 2009 Apr 1;47:135–42.
4. Laeke T, Tirsit A, Kassahun A, Sahlu A, Debebe T, Yesehak B, et al. Prospective Study of Surgery for Traumatic Brain Injury in Addis Ababa, Ethiopia: Trauma Causes, Injury Types, and Clinical Presentation. World Neurosurg [Internet]. 2021 May 1 [cited 2026 Jan 18];149:e460–8. Available from: https://www.sciencedirect.com/science/article/abs/pii/S1878875021001844?via%3Dihub
5. Garg K, Singh P, Singla R, Aggarwal A, Borle A, Singh M, et al. Role of Decompressive Craniectomy in Traumatic Brain Injury - A Meta-analysis of Randomized Controlled Trials. Neurol India. 2019 Sep 1;67(5):1225–32.
6. Zhang Q, Li Y, Chang X. Role of Decompressive Craniectomy in the Management of Traumatic Brain Injury - A Meta-Analysis of Randomized Controlled Trials. Ann Indian Acad Neurol. 2023;26(6):966–74.

7. Schuchat A, Director A, Griffin PM, Rasmussen SA, Leahy MA, Martinroe JC, et al. Morbidity and Mortality Weekly Report Traumatic Brain Injury-Related Emergency Department Visits, Hospitalizations, and Deaths-United States, 2007 and 2013 Surveillance Summaries Centers for Disease Control and Prevention MMWR Editorial and Production Staff (Serials) MMWR Editorial Board. Vol. 66, Summ. 2017.
8. Silva ACV, De Oliveira Farias MA, Bem LS, Valença MM, De Azevedo Filho HRC. Decompressive Craniectomy in Traumatic Brain Injury: An Institutional Experience of 131 Cases in Two Years. Neurotrauma Rep. 2020 Oct 1;1(1):93–9.
9. Zhong H, Feng Y, Shen J, Rao T, Dai H, Zhong W, et al. Global Burden of Traumatic Brain Injury in 204 Countries and Territories From 1990 to 2021. Am J Prev Med [Internet]. 2025 Apr 1;68(4):754–63. Available from: https://doi.org/10.1016/j.amepre.2025.01.001
10. Hawryluk GWJ, Rubiano AM, Totten AM, O'Reilly C, Ullman JS, Bratton SL, et al. Guidelines for the management of severe traumatic brain injury: 2020 update of the decompressive craniectomy recommendations. Vol. 87, Neurosurgery. Oxford University Press; 2020. p. 427–34.
11. Mock Charles. Strengthening care for the injured : success stories and lessons learned from around the world. World Health Organization; 2010. 62 p.
12. Bratton Susan L, Chestnut Randall M, Ghajar Jamshid, McConnell Hammond Flora F, Harris Odette A, Hartl Roger, et al. VIII. Intracranial Pressure Thresholds. J Neurotrauma [Internet]. 2007 May 1;24(1_suppl):S-55-S-58. Available from: https://journals.sagepub.com/action/showAbstract
13. Nino S, R MAI. Traumatic Intracranial Hypertension. New England Journal of Medicine [Internet]. 2026 Jan 18;370(22):2121–30. Available from: https://doi.org/10.1056/NEJMra1208708
14. Hutchinson PJ, Kolias AG, Czosnyka M, Kirkpatrick PJ, Pickard JD, Menon DK. Intracranial pressure monitoring in severe traumatic brain injury. BMJ : British Medical Journal [Internet]. 2013 Feb 15;346:f1000. Available from: https://www.bmj.com/content/346/bmj.f1000.abstract
15. Balestreri M, Czosnyka M, Hutchinson P, Steiner LA, Hiler M, Smielewski P, et al. Impact of intracranial pressure and cerebral perfusion pressure on severe disability and mortality after head injury. Neurocrit Care [Internet]. 2006;4(1):8–13. Available from: https://doi.org/10.1385/NCC:4:1:008
16. Hutchinson PJ, Kolias AG, Tajsic T, Adeleye A, Aklilu AT, Apriawan T, et al. Consensus statement from the International Consensus Meeting on the Role of Decompressive Craniectomy in the Management of Traumatic Brain Injury: Consensus statement. Vol. 161, Acta Neurochirurgica. Springer-Verlag Wien; 2019. p. 1261–74.
17. Timofeev I, Santarius T, Kolias AG, Hutchinson PJA. Decompressive craniectomy — operative technique and perioperative care. In: Pickard JD, Akalan N, Benes V, Di Rocco C, Dolenc V V, Antunes JL, et al., editors. Advances and Technical Standards in Neurosurgery [Internet]. Vienna: Springer Vienna; 2012. p. 115–36. Available from: https://doi.org/10.1007/978-3-7091-0676-1_6
18. Cooper DJ, Rosenfeld J V., Murray L, Arabi YM, Davies AR, Ponsford J, et al. Patient Outcomes at Twelve Months after Early Decompressive Craniectomy for Diffuse Traumatic Brain Injury in the Randomized DECRA Clinical Trial. J Neurotrauma. 2020 Mar 1;37(5):810–6.
19. Hutchinson PJ, Kolias AG, Timofeev IS, Corteen EA, Czosnyka M, Timothy J, et al. Trial of Decompressive Craniectomy for Traumatic Intracranial Hypertension. New England Journal of Medicine. 2016 Sep 22;375(12):1119–30.
20. Perel PA, Olldashi F, Muzha I, Filipi N, Lede R, Copertari P, et al. Predicting outcome after traumatic brain injury: Practical prognostic models based on large cohort of international patients. BMJ. 2008 Feb 23;336(7641):425–9.
21. Haque M, Alam M, Das S, Hossain Z, Mahmood E, Hossain S. Outcome of Decompressive Craniectomy in Adult Patients with Severe Traumatic Brain Injury. 2017 Jul 1;7:9–12.
22. Williams RF, Magnotti LJ, Croce MA, Hargraves BB, Fischer PE, Schroeppel TJ, et al. Impact of Decompressive Craniectomy on Functional Outcome After Severe Traumatic Brain Injury. Journal of Trauma and Acute Care Surgery [Internet]. 2009;66(6). Available from: https://journals.lww.com/jtrauma/fulltext/2009/06000/impact_of_decompressive_craniectomy_on_functional.9.aspx
23. Aarabi B, Hesdorffer DC, Ahn ES, Aresco C, Scalea TM, Eisenberg HM. Outcome following decompressive craniectomy for malignant swelling due to severe head injury. Vol. 104, J. Neurosurg. 2006.
24. Landes M, Venugopal R, Berman S, Heffernan S, Maskalyk J, Azazh A. Epidemiology, clinical characteristics and outcomes of head injured patients in an Ethiopian emergency centre. African Journal of Emergency Medicine. 2017 Sep 1;7(3):130–4.
25. Gouello G, Hamel O, Asehnoune K, Bord E, Robert R, Buffenoir K. Study of the long-term results of decompressive craniectomy after severe traumatic brain injury based on a series of 60 consecutive cases. The Scientific World Journal. 2014;2014.
26. Saade N, Veiga JCE, Cannoni LF, Haddad L, Araújo JLV. Avaliação dos fatores prognósticos da craniectomia descompressiva no tratamento do traumatismo cranioencefálico grave. Rev Col Bras Cir. 2014 Jul 1;41(4):256–62.
27. Grille P, Tommasino N. Decompressive craniectomy in severe traumatic brain injury: Prognostic factors and complications. Rev Bras Ter Intensiva. 2015 Apr 1;27(2):113–8.
28. Sinha S, Raheja A, Garg M, Moorthy S, Agrawal D, Gupta DK, et al. Decompressive craniectomy in traumatic brain injury: A single-center, multivariate analysis of 1,236 patients at a tertiary care hospital in India. Neurol India. 2015 Mar 1;63(2):175–83.
29. Gopalan RC, Abu SU, Kollannur LJ, Louis R. Analysis of prognostic factors and complications following decompressive craniectomy for traumatic brain injury. Int J Res Med Sci. 2021 Sep 28;9(10):2940.
30. Ogunlade J, Elia C, Duong J, Yanez PJ, Dong F, Wacker MR, et al. Severe Traumatic Brain Injury Requiring Surgical Decompression in the Young Adult: Factors Influencing Morbidity and Mortality – A Retrospective Analysis. Cureus. 2018 Jul 24;

31. Celi F, Saal-Zapata G. Decompressive Craniectomy for Traumatic Brain Injury: In-hospital Mortality-Associated Factors. J Neurosci Rural Pract. 2020 Oct 1;11(4):601–8.
32. Albanèse J, Leone M, Alliez JR, Kaya JM, Antonini F, Alliez B, et al. Decompressive craniectomy for severe traumatic brain injury: Evaluation of the effects at one year*. Crit Care Med [Internet]. 2003;31(10). Available from: https://journals.lww.com/ccmjournal/fulltext/2003/10000/decompressive_craniectomy_for_severe_traumatic.19.aspx
33. Rubiano AM, Villarreal W, Jimenez Hakim E, Aristizabal J, Hakim F, Dìez JC, et al. Early decompressive craniectomy for neurotrauma, an institutional experience. Turkish Journal of Trauma and Emergency Surgery [Internet]. 2009;15(1):28–38. Available from: https://dx.doi.org/
34. Akyuz M, Ucar T, Acikbas C, Kazan S, Yılmaz M, Tuncer R. Effect of Early Bilateral Decompressive Craniectomy on Outcome for Severe Traumatic Brain Injury. Turk Neurosurg. 2010 Jul 1;20:382–9.
35. Al-Jishi A, Saluja R, Al-Jehani H, Lamoureux J, Maleki M, Marcoux J. Primary or secondary decompressive craniectomy: Different indication and outcome. Canadian Journal of Neurological Sciences. 2011 Jul 1;38(4):612–20.
36. Cooper PR, Rl R, Ransohoff J. Hemicraniectomy in the treatment of acute subdural hematoma: a re-appraisal. Surg Neurol [Internet]. 1976;5 1:25–8. Available from: https://api.semanticscholar.org/CorpusID:30610227
37. Wen L, Wang H, Wang F, Gong JB, Li G, Huang X, et al. A prospective study of early versus late craniectomy after traumatic brain injury. Brain Inj. 2011;25(13–14):1318–24.

Figures

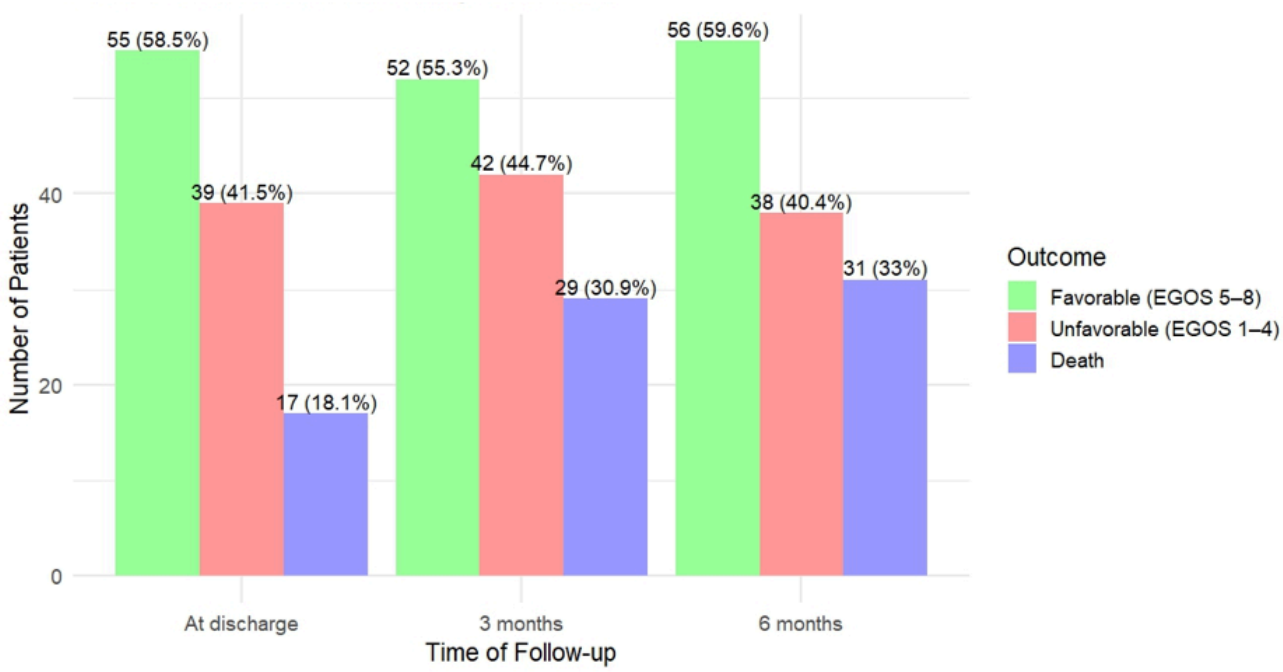


Figure 1

Postoperative course and extended Glasgow Outcome Scale (EGOS) outcomes during follow-up