Journal of Amran University 04 (2024) p. 299-306

مجلة جامعة عمران

journal homepage: www.auy.edu.ye

Surgical Outcomes of Decompressive Craniectomy among Patients with Severe Traumatic Brain Injury. A single-center Retrospective Study, Yemen

Mohamed Shamsaldin[1,2*], Mojahed Me'asar[1], Hael S. Siaour [2], Abdulghani Al-Aswadi [2,3], Noofel Alashhab[1,2] and Sakhr Alfakih[1,2]

[1] *Department of Neurosurgery, 21 September University of Medical and Applied Sciences, Yemen*

[2] *Department of Neurosurgery at 48 Modern Hospital, Yemen*

[3] *Faculty of Medicine and Health Sciences, Sana'a University, Yemen*

Received 4 September 2024; accepted in final form 2 November 2024.

Abstract

Decompressive craniectomy (DC) is a surgical procedure used to alleviate severe intracranial pressure and its complications in cases of traumatic brain injury (TBI). This retrospective study explores the surgical outcomes of DC performed on patients with severe TBI at 48 Modern Hospital in Sana'a, Yemen. The analysis focused on 31 male patients, aged 17 to 65, who underwent DC between January 2020 and December 2021. Collected data included patient demographics, mechanisms of injury, Glasgow Coma Scale (GCS) scores, CT scan findings, treatment methods, and the time between injury and hospital admission. The outcomes were assessed using an extended Glasgow Outcome Scale (GOS-E) one year after surgery via structured phone interviews. All participants in the study were male, predominantly within the adult age range. The most common cause of injury identified was gunshot wounds, accounting for 48.4% of cases. The outcomes revealed that 48.4% of patients made a full recovery, 25.8% experienced disabilities, and 25.8% died. Poor outcomes were significantly linked to lower GCS scores upon admission, hemiplegia, abnormal pupillary responses, and extended hospital stays. The findings indicate that, while DC can lead to positive outcomes for TBI patients, factors such as initial GCS, pupil dilation, and hemiplegia serve as indicators of a poor prognosis. Optimal timing for the surgery may further improve results.

Keywords: Decompressive craniectomy, Surgical outcome, Traumatic brain injury, Yemen.

الملخص: إصابات الرأس هي السبب الرئيسي للوفاة الناجمة عن الصدمات، وتعد عملية استئصال الجمجمة لإزالة الضغط طريقة شائعة لتقليل الضغط داخل الجمجمة في حالات إصابات الدماغ الرضية. تهدف هذه الدراسة إلى التحقيق في العوامل المؤثرة على نتائج المرضى الذين يعانون من إصابات دماغية رضية وخضعوا لعملية استئصال جزء من عظام الجمجمة في مستشفى 48 النموذجي بصنعاء، اليمن. شملت الدراسة 31 مريضًا خلال الفترة من يناير 2020 إلى ديسمبر 2021، وتم جمع بيانات حول التركيبة السكانية، وآلية الإصابة، ومقياس غلاسكو للغيبوبة، ونتائج التصوير، والعلاج الجراحي. تم تقييم النتائج باستخدام مقياس غلاسكو الموسع للنتائج (E-GOS) بعد عام من الجراحة عبر التواصل المنتظم هاتفيًا مع المرضى. أظهرت النتائج أن جميع المرضى من الذكور ومعظمهم من الفئة العمرية المتوسطة. كانت آلية إصابة معظم المرضى طلق ناري بنسبة 48.4%. توفي 25.8% من المرضى، و25.8% أصيبوا بإعاقة، بينما تعافى 48.4%. ارتبطت النتائج السلبية بانخفاض درجة الوعي، والشلل النصفي، وحالة حدقة العين، وطول مدة الرقود. خلصت الدراسة إلى أن استئصال الجمجمة قد يؤدي إلى نتائج إيجابية، لكن هناك حاجة لتحسين اختيار التوقيت المناسب للعملية لتحسين النتائج.

***Corresponding Author:** Emails: Dr_shamsaldin@21umas.edu.ye

Introduction

Head injuries are a significant cause of trauma-related deaths with TBI being the leading cause of mortality among young people in the western world. [1] Secondary brain injuries which are treatable complications of TBI can further aggravate the situation. [1] Decompressive craniectomy (DC) is highly regarded as one of the most effective treatments for lowering severe intracranial pressure ICP and preventing complications associated with traumatic brain injury (TBI). Common nonsurgical methods to manage elevated ICP include osmotic diuretics hyperventilation barbiturate therapy and therapeutic hypothermia. Still, these approaches may be ineffective in certain situations [2] requiring surgical intervention DC a procedure that involves removing a portion of the skull on the most affected side has been recommended to reduce ICP. [3] Beyond its use in TBI, DC is also applied in cases of middle cerebral artery infarction and aneurysmal subarachnoid hemorrhage to improve patient outcomes. [2] In this study, we tried to examine the exact outcomes of limited resources.

Material and Methods

Study design and setting: A retrospective review of data was conducted, using a medical database of patients who had undergone DC over 2 years (2020-2021) at the Department of Neurosurgery, 48 Modern Hospital, Sana'a, Yemen.

Study materials: Data about demographics, mechanism of injury, Glasgow Coma Scale (GCS) score, brain computed tomography (CT) findings, surgical treatment methods, the time interval between brain injury and admission as well as surgical outcomes for all cases who met the criteria of this study were obtained from database and medical records.

Inclusion and exclusion criteria: All patients aged between 17-65 years old and had a severe traumatic brain injury (GCS $\leq$ 8) and their brain CT findings demonstrated intracranial hemorrhage with midline shift greater than 5 mm and/or absence of basilar cisterns, and underwent decompressive craniectomy procedures. Other non-traumatic cases or children less than 17 years old or any file with missed or incomplete data were excluded. Furthermore, patients who had fixed-dilated pupils, mass lesions, nonreactive pupils, spinal cord injury, or cardiac arrest at the scene of the injury were excluded.

Statistical analysis: Statistical analyses were carried out utilizing SPSS program version 25. Categorical variables such as sex, preoperative GCS, preoperative pupil response to light, and functional outcome were analyzed using frequencies and percentages and/or mean ± SD as appropriate. Statistical analyses were performed using $\chi 2$ or Fisher's exact test for categorical variables. Differences were considered statistically significant if *p*-values were less than 0.05.

Ethical Approval: The ethical approval was obtained from the Medical Research and Ethics Committee at our hospital. Furthermore, all data, including patient identification, have been kept confidential. The patient's consent was not required.

Results

The study involved 31 patients, all of them were males. The age of participants ranges from 17 to 50 years with an overall mean age and standard deviation of 25.65±7.42 years old. In terms of age groups, most patients (41.9%) were under 23 years old, and 3 patients (9.7%) were aged over 31 years old. Further details are presented in Table 2.

According to the findings of the initial brain CT scans and based on Marshal's classification, the majority of our patients (n=22, 71.0%) belong to the Evacuated mass lesion V category in comparison to Diffuse Injury IV (n= 6, 19.4%), and Diffuse Injury III (n=3, 9.7%). See Table **1**.

Regarding the cause of injury, most cases were caused by gunshots (48.4%), while road traffic accidents (RTA) affected 29.0%, and the remaining patients (22.6%) were distributed for both bomb explosions and falls. According to the type of injury, the majority of patients (48.4%) were after penetrating trauma, 29.0% after blunt trauma, and a combination of penetrating and blunt at the same time involved 22.6%.

Table: 1: Distribution of patients according to the findings on initial brain CT scans based on Marshal's classification

Category	Frequency	%
Diffuse Injury I	0	0
Diffuse Injury II	0	0
Diffuse Injury III (Swelling)	3	9.7
Diffuse Injury IV (Shift)	6	19.4
Evacuated mass lesion V	22	71.0
Non Evacuated mass lesion V	0	0
Total	31	100

The most frequent primary brain injury was acute subdural hematoma (45.2%), with other injuries including combined acute subdural hematoma and skull fracture (12.9%), intracerebral hematoma and severe brain injury (12.9%), and multiple hemorrhagic brain contusions (12.9%). According to the location of the traumatic injury within the brain, the frontal-parietal-temporal region was the most common site of injury (71.0%), followed by the parietal-temporal region (16.1%). Most patients (48.4%) experience mono or hemiplegia and 45.2% mono or hemiparesis. Additionally, 54.8% of patients had anisocoria, 35.5% had unilateral fixed dilated pupils, and 3.2% had bilateral fixed dilated pupils. Further details are presented in Table **2**.

Decompressive Craniectomy Outcomes

Regarding the outcome of decompressive craniectomy, most patients (48.4%, n=15) were improved and significantly recovered, while 25.8% (n=8) were neurologically disabled. The mortality rate was 25.8% (n=8 cases). A Chi-Square Test of Independence was performed to assess the relationship between independent variables and traumatic brain injury outcomes, results are presented in Table 3. There was a significant relationship between the type of paralysis and the outcome (p-value <0.001). Death was more likely among patients with mono- or hemiplegia compared to patients with mono- or hemiparesis. Additionally, there is a statistically significant association between death and patients having a unilateral fixed dilated pupil (p-value <0.001). Moreover, death was associated with a lower GCS $\leq$ 5 (p-value <0.004). Finally, the mortality outcome was associated with the duration of hospitalization (in days) (p-value 0.011)., and the mortality was higher in the earlier days after admission.

The surgical outcome after DC was favorable. Only 29% of cases had some complications, either early or late complication. External cerebral herniation and surgical wound infection represented the early complications, in about 3.2% and 6.5% respectively. Late complications were in the form of brain abscess in 9.7% and sinking skin flap syndrome in 9.7%. The rate of complication is presented in Figure 1.

Table 2: Demographic and Clinical Distributions of the Study Sample. (N=31 patients).

Variables	Number (N)	Percent (%)
Age (years)		
< 23	13	41.9
23-27	9	29.0
28-32	6	19.4
> 32	3	9.7
Gender		
Male	31	100
Female	0	0
Hospital length of stay (in days)		
3—20	10	32.3
21-40	14	45.2
41-60	4	12.9
> 60	3	9.7
Cause of injury		
Bomb explosions & falls	7	22.6
Gunshot	15	48.4
Road Traffic Accidents (RTA)	9	29
Mechanism of injury		
Penetrating	15	48.4
Blunt	9	29
Combination of Penetrating and Blunt Trauma	7	22.6
Type of injury		
Acute Subdural hematoma (SDH)	14	45.2
Combined Acute SDH & skull Fracture	4	12.9
Intracerebral Hemorrhage (ICH) with severe brain edema	4	12.9
Multiple hemorrhagic brain contusions & severe brain edema	4	12.9
Subarachnoid Hemorrhage (SAH) & severe brain edema	3	9.7
Acute SDH & Epidural Hematoma (EDH)	1	3.2
ICH & Multiple hemorrhage brain contusions	1	3.2
Location of injury		
Frontal, Parietal and Temporal Lobes	22	71
Parietal and Temporal lobes	5	16.1
Frontal Lobe alone	1	3.2
Parietal and Occipital lobes	2	6.5
Frontal, Parietal and Occipital Lobes	1	3.2
Level of Consciousness (Glasgow Coma Scale)		
less than or equal to 5	4	12.9
6-8	23	74.2
9-12	4	12.9
Paralysis Status		
Mono or Hemiparesis	14	45.2
Mono or Hemiplegia	15	48.4
No paralysis	2	6.5
Pupillary status		
Unilateral Fixed Dilated Pupils	11	35.5
Anisocoria	17	54.8
Bilateral Fixed Dilated Pupils	1	3.2
Normal Pupils	2	6.5
Total	31	100

Table 3: Determinants of Outcome in 31 Patients with Severe Traumatic Head Injury Undergoing Decompressive Craniectomy

Variables	Outcome			P-value
	Death	Disable	Recovered	
Age (years)	28.63+8.37	24.38+3.42	24.73+8.38	**0.431**
Cause of injury				
Bomb explosion & fall	2 (25.0%)	3 (37.5%)	2 (13.3%)	**0.609**
Gunshot	3 (37.5%)	4 (50.0%)	8 (53.3)	
Road Traffic Accidents (RTA)	3 (37.5%)	1 (12.5%)	5 (33.3%)	
Paralysis Status				
Mono or Hemiplegia	7 (87.5%)	7 (87.5%)	1 (6.7%)	**<0.001**
Mono or Hemiparesis	1 (12.5%)	1 (12.5%)	12(80.0%)	
No paralysis	0 (0.0%)	0 (0.0%)	2 (13.3%)	
Pupillary status				
Unilateral Fixed Dilated Pupils	4 (50.0%)	7 (87.5%)	0 (0.0%)	
Anisocoria	3 (37.5%)	1 (12.5%)	13 (86.7%)	**0.001**
Bilateral Fixed Dilated Pupils	1 (12.5%)	0 (0.0%)	0 (0.0%)	
Normal Pupils	0 (0.0%)	0 (0.0%)	2 (13.3%)	
Glasgow Coma Scale)				
≤ 5	4 (50.0%)	0 (0.0%)	0 (0.0%)	**0.004**
6-8	3 (37.5%)	8(100.0%)	12(80.0%)	
9-12	1 (12.5%)	0 (0.0%)	3 (20.0%)	
Duration of hospitalization (in days)				
3—20	6 (75.0%)	1 (12.5%)	3 (20.05)	
21-40	1 (12.5%)	5 (62.5%)	8 (53.3%)	**0.011**
41-60	0 (0.0%)	0 (0.0%)	4 (26.7%)	
> 60	1 (12.5%)	2 (25.0%)	0 (0.0%)	
Total	**8 cases**	**8 cases**	**15 cases**	

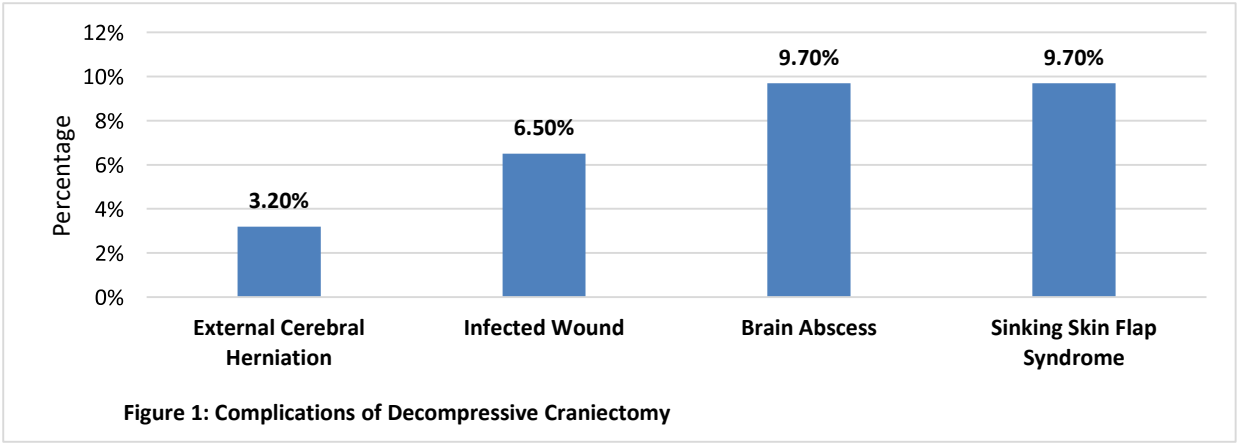

Figure 1: Complications of Decompressive Craniectomy

Discussion

This study involved 31 patients who underwent decompressive craniectomy (DC) over 2 years. The average age of these patients was 25.7±7.42 years, ranging from 15 to 50 years, and all were male. This is largely because the hospital caters to military personnel, with most patients coming from frontline and war zones where their health insurance is applicable. Other studies showed results for both genders with male predominance. [4]

According to the Marshall classification of intracranial pathologies on brain CT scans, the most common injury was an evacuated mass lesion (Type V), found in 22 patients (71.0%). The leading causes of injury were gunshot wounds (48.4%), followed by road traffic accidents (29.0%), and a combination of bomb explosions and falls (22.6%). Penetrating injuries were most prevalent (48.4%), followed by blunt injuries (29.0%), and combined penetrating and blunt injuries (22.6%). The most frequent primary brain injury was acute subdural hematoma (45.2%), with other injuries including

combined acute subdural hematoma and skull fracture (12.9%), intracerebral hematoma and severe brain injury (12.9%), and multiple hemorrhagic brain contusions (12.9%). The frontal-parietal-temporal region was the most common site of injury (71.0%), followed by the parietal-temporal region (16.1%). Most patients (48.4%) experience mono or hemiplegia and 45.2% mono or hemiparesis. Additionally, 54.8% of patients had anisocoric, 35.5% had unilateral fixed dilated pupils, and 3.2% had bilateral fixed dilated pupils.

The most common complication of the DC in our sample was found to be brain abscess being recorded in 3 (9.7%) and followed by sinking skin flap syndrome in 3 (9.7%) patients. The outcome was found to be death in 8 (25.8%), disabled in 8 (25.8%) and recovered in 15 (48.4%) patients. DC is still among the most important surgical procedures being performed in patients with TBI although the role and effects have remained controversial [5-78]. Although some new techniques have been introduced to replace DC, it remains the most frequent operation in TBI [9,10].

Despite several advancements in the management of patients with TBI, the mortality and morbidity of severe TBI remains high in injured patients; many prognostic models have been introduced to predict the outcome, yet no model has satisfied all the characteristics of an ideal model [11,12].

In the current study, we have reported the outcome of patients with TBI undergoing DC in our center and also determined the outcome determinants in 48 modern Hospital, in Sana'a, Yemen. Furthermore, it demonstrated that an older age is continuously associated with a worsening outcome after TBI. This study is consistence with previous studies that determined the effects of age on the outcome of TBI patients. They reported that older age is continuously associated with a worsening outcome after TBI [13]. Dhandapani *et al*., also demonstrated that age is an independent predictor of outcome in those with severe TBI [14]. This was probably due to the high rate of extracranial complications associated with the older age group after severe TBI [15-17].

GCS has been shown to strongly predict the outcome in patients with severe TBI. Our study showed GCS to be a significant prognostic factor determining the outcome after DC as well as previous reports [14, 18]. Our study revealed that GCS, pupillary dilation, and hemiplegia, in*fl*uence the decision to perform DC. Furthermore, GCS, pupil enlargement, and hemiplegia were clear indicators of the severity of TBI. The more severe the injury, the higher the likelihood that a patient would develop intracranial hypertension as well as intraoperative bulging of brain matter above the inner plate of the skull as a result of brain swelling as well as ICP. The rate of DC in patients with a GCS ≤ 5 was signi*fi*cantly higher than that of patients with a GCS of 9 to 12 (P=.004). Phan et al reported that a lower GCS correlated with a higher proportion of patients requiring DC [19].

Limitations

This study notes some limitations. This was a retrospective review of the data so some information could not be revealed appropriately. We included all those with complete medical chart information. The number of patients included in this study was small (take into consideration the point that these 31 patients were operated within 18 months). The study thus has an appropriate power, and the results are among the only reported ones from Yemen. Prospective studies with a larger sample size population and adequate trauma data registry are now underway in our center.

Conclusion

Decompressive craniectomy (DC) in patients with traumatic brain injury (TBI) is associated with positive outcomes. Indicators of poor prognosis include a lower Glasgow Coma Scale (GCS) score, bilateral pupil dilation, hemiplegia, and advanced age.

The most common cause of traumatic brain injuries is gunshot wounds, accounting for 48.4% of cases, with most affected patients being very young. Careful selection of patients and early mobilization may enhance the overall outcomes of TBI treatment. Our recent analyses indicate that the mortality rate is acceptable given the severity of the patients' injuries, and the majority of survivors achieve a reasonably high level of functioning, whether that be moderate disability or good recovery.

Recommendations

The craniectomy should be performed early, before the severe impairment of brain perfusion occurs, and should yield a wide decompression. Further government and public examinations for injury overall and infiltrating head injury specific are prescribed to assess the genuine size of the issue and its administration. Paying attention to the diagnostic criteria and signs of the patient's deteriorating health to make an early decision to perform the decompressive craniectomy to avoid complications. The government must impose laws that limit the illegal use of weapons and impose deterrent penalties.

References

[1] Ucar, T., Akyuz, M., Kazan, S., et al. Role of decompressive surgery in the management of severe head injuries: prognostic factors and patient selection. Journal of Neurotrauma, 2005; 22: 1311–1318

[2] Schirmer, C.M., Ackil, A.A. Jr, and Malek, A.M. Decompressive craniectomy. Neurocritical Care, 2008; 8: 456–470.

[3] Haque, M., Mandal, M., Zaman, M., Ahmed, K., Goni, M., Mahmud, M., and Rafiuzzaman, M. Surgical outcomes of decompressive craniectomy in traumatic brain injury: a study in a tertiary care hospital in Bangladesh. KYAMC Journal, 2022; 13: 153-157. DOI: 10.3329/kyamcj.v13i3.63200.

[4] Yang, X.F., Wen, L., Shen, F., et al. Surgical complications secondary to decompressive craniectomy in patients with head injuries: a series of 108 consecutive cases. Acta Neurochirurgica (Wien), 2008; 150: 1241–1247.

[5] Barthélemy, E., et al. Decompressive craniectomy for severe traumatic brain injury: a systematic review. World Neurosurgery, 2016; 88: 411–420.

[6] Bor-Seng-Shu, E., et al. Decompressive craniectomy: a meta-analysis of influences on intracranial pressure and cerebral perfusion pressure in the treatment of traumatic brain injury. Neurosurgery, 2012; 117(3): 589-596.

[7] Cooper, D.J., et al. Decompressive craniectomy in diffuse traumatic brain injury. New England Journal of Medicine, 2011; 364(16): 1493-1502.

[8] Sahuquillo, J., Martínez-Ricarte, F., and Poca, M.-A. Decompressive craniectomy in traumatic brain injury after the DECRA trial: where do we stand?, Current Opinion in Critical Care*, 2013; 19(2): 101-106.

[9] Cherian, I., Bernardo, A., and Grasso, G.J. Cisternostomy for traumatic brain injury: pathophysiological mechanisms and surgical technical notes. Neurosurgery, 2016; 89: 51-57.

[10] Masoudi, M.S., et al. *Cisternostomy for management of intracranial hypertension in severe traumatic brain injury: case report and literature review.* Journal of Neurotrauma, 2016; **4**(3): 161.

[11] Perel, P., Clayton, T., Edwards, K.E., Pocock, S.J., and colleagues. Predicting outcomes after traumatic brain injury: practical prognostic models based on a large cohort of international patients. BMJ, 2008; 336(7641): 425-429.

[12] Steyerberg, E.W., et al. Predicting outcomes after traumatic brain injury: development and international validation of prognostic scores based on admission characteristics. Journal of Neurotrauma, 2008; 5(8): e165.

[13] Hukkelhoven, C.W., et al. *Patient age and outcome following severe traumatic brain injury: an analysis of 5,600 patients.* Journal of Neurotrauma, 2003; **99**(4): 666-673.

[14] Eghwrudjakpor, P.O. and Allison, A.B. Decompressive craniectomy following brain injury: factors important to patient outcomes. Journal of Medicine, 2010; 5(1).

[15] Woertgen, C., et al. *Comparison of craniotomy and craniectomy in patients with acute subdural hematoma.* Journal of Neurosurgery, 2006; **13**(7): 718-721.

[16] Hu, Y., et al. Acute bilateral mass-occupying lesions in non-penetrating traumatic brain injury: a retrospective study. Journal of Neurotrauma, 2015; 15(1): 1-6.
[17] Lee, J.J., et al. Subdural hematoma as a major determinant of short-term outcomes in traumatic brain injury. Neurosurgery, 2017; 128(1): 236-249.
[18] Aarabi, B., et al. Outcomes following decompressive craniectomy for malignant swelling due to severe head injury. Journal of Neurosurgery, 2006; 104(4): 469-479.
[19] Phan, K., et al. *Craniotomy versus decompressive craniectomy for acute subdural hematoma: systematic review and meta-analysis.* Journal of Neurosurgery, 2017; **101**: 677-685.