MAK HILL Publications Research Journal of Medical Sciences

Research Article
doi: 10.36478/makrjms.2024.5.40.46

Decompressive Craniotomy in Traumatic Brain Injury: A Prospective Study of 25 Patients

[1]Vineet Tanwar, [2]Gian Chand, [3]Digvijay Singh Thakur and [4]Biplav Singh

[1,3,4]Department of Neuro Surgery, I.G.M.C., Shimla (HP) India
[2]Department of Neurosurgery, Indira Gandhi Medical College, Shimla, Himachal Pradesh India

OPEN ACCESS

Key Words
Decompressive craniotomy, severe traumatic brain injury, raised intracranial pressure, glasgow outcome scale, pupillary response, timing of surgery

Corresponding Author
Biplav Singh,
Department of Neuro Surgery, I.G.M.C., Shimla (HP) India
biplavsingh.1@gmail.com

Author Designation
[1,3,4]Assistant Professor
[2]Professor and Head

Received: 20 November 2023
Accepted: 31 December 2023
Published: 8 January 2024

Citation: Vineet Tanwar, Gian Chand, Digvijay Singh Thakur and Biplav Singh, 2024. Decompressive Craniotomy in Traumatic Brain Injury: A Prospective Study of 25 Patients. Res. J. Med. Sci., 18: 40-46, doi: 10.36478/makrjms.2024.5.40.46

ABSTRACT

The management of raised intracranial pressure (ICP) is crucial in patients with severe traumatic brain injury (TBI). Decompressive craniotomy (DC) is a surgical procedure used to relieve brain pressure and improve outcomes in these cases. This study aimed to analyze the outcomes and complications of DC in severe TBI patients and investigate their correlation with various factors. This prospective, observational study was conducted at a tertiary care center and included 25 patients with severe TBI who underwent DC. Various demographic, clinical and radiological variables were recorded and their correlation with patient outcomes was analyzed using the Glasgow Outcome Scale (GOS). Statistical analysis was performed to determine the significance of different factors in predicting the outcome of DC. The majority of patients were males (92%) and a higher proportion of patients (56%) belonged to the age group of 15-45 years. Road traffic accidents (RTA) were the most common cause of head injury (88%). Pupillary responses were non-reactive in 56% of patients and 80% of patients required ventilatory support. The initial Glasgow Coma Scale (GCS) was less than 5 in 76% of cases. CT findings revealed subdural hematoma with contusion as the most common lesion (68%). Patients with non-reactive pupils had a higher percentage of unfavorable outcomes ($p = 0.047$) and those with a GCS score greater than 5 had more favorable outcomes ($p = 0.032$). Early surgery within 8 hrs of trauma showed better outcomes compared to surgery after 8 hours ($p = 0.017$). Age, gender, comorbidities, midline shift, size of craniotomy and duroplasty did not show statistically significant correlations with outcomes ($p>0.05$). The study highlights the Patients with salvageable GCS, normal or unilateral dilated pupils and those operated on within 8 hrs of trauma had better outcomes. However the impact of comorbidities and duroplasty on outcomes was not statistically significant. Further research is required to better understand the complexities of factors influencing the outcome of decompressive craniotomy in severe traumatic brain injury. Decompressive craniotomy, severe traumatic brain injury, raised intracranial pressure, glasgow outcome scale, pupillary response, timing of surgery.

INTRODUCTION

The human brain resides within the nonexpandable compartment of the skull, consisting of fixed volumes of brain tissue, cerebrospinal fluid (CSF) and blood. According to the Monroe Kellie doctrine the sum of these volumes remains constant. When there is an increase in intracranial pressure (ICP) due to factors like mass lesions the body attempts to maintain normal ICP initially by reducing CSF volume. If this compensatory mechanism is insufficient the brain decreases blood volume. However, if these measures fail, brain function begins to deteriorate[1-3].

Raised ICP can result from various causes such as cerebral trauma, infarction, subarachnoid hemorrhage (SAH) spontaneous hemorrhage and tumors. The speed and nature of the cause influence the patient's outcome. Chronic causes may be better tolerated, while acute trauma leads to poorer tolerance. Preventing further brain function deterioration requires various interventions[3,4].

Medical management using agents like steroids, hyperosmotic agents and mechanical ventilation is the first line of treatment for raised ICP. However, pharmacological therapies are slow-acting and not always permanent. When medical approaches prove inadequate, surgical treatment becomes necessary. Decompressive Craniotomy (DC) has emerged as a popular surgical method involving craniotomy and removal of the bone flap to relieve brain pressure. To achieve further decompression the dura is also opened and the bone flap is repositioned at a later date[4-6].

Kocher first mentioned decompression of brain parenchyma for raised ICP. Surgical decompression is the second-line treatment after failed medical management and is the first-line treatment for rapidly progressive conditions like severe traumatic brain injury (TBI) or MCA infarct. Malignant MCA infarct patients managed conservatively have high mortality rates, making surgical treatment crucial in severe intracranial hypertension with mass effect and clinical deterioration[5,6].

This study aims to analyze patients undergoing DC for severe TBI, which aims to maintain cerebral blood flow, prevent brain herniation and avoid clinical deterioration. Outcomes depend on factors such as post-traumatic brain edema, hypoxic brain injury, contusions and extensive brain infarcts. Craniotomy diameter also affects prognosis, with a size of at least 12 cm providing extra space for brain expansion[6,7].

While beneficial effects of decompressive craniotomy are observed in many conditions, some debate its advantages and suggest potential harm. In pediatric populations, positive outcomes have been observed. However the procedure is not without complications, including early and late complications such as hemorrhages, infections, hydrocephalus and structural failures. This study aims to investigate outcomes and complications after DC and their correlation with age, sex, clinical profile and timing of the craniotomy[6-8]. By examining these factors, we hope to gain a deeper understanding of the role of DC in managing raised ICP and its impact on patient outcomes.

Aims and objectives: The primary aim of this prospective, observational study was to analyze the overall outcome of patients with severe traumatic brain injury (TBI) who underwent decompressive craniotomy (DC).

The specific objectives were:

- To evaluate the correlation between the overall outcome and various factors such as age, sex and neurological status at the time of decompressive craniotomy
- To assess the impact of the time interval between trauma and surgery on patient outcomes
- To investigate the association between comorbidities, including hypertension, diabetes and cardiac disease and the overall outcome in patients undergoing decompressive craniotomy

MATERIAL AND METHODS

The study was conducted at Fortis Hospital Mohali and included 25 patients with severe TBI who underwent decompressive craniotomy. The sample size was determined based on a previous study's findings to achieve a power of 90% and a confidence interval of 95%. Due to possible dropouts, 25 subjects were included. Patients meeting the inclusion criteria, which consisted of those with trauma, aged between 18-70 years and exhibiting signs of raised intracranial pressure such as vomiting, altered consciousness and headache, were enrolled in the study. Patients with congenital malformations and/or pre-existing neurological deficits were excluded.

After obtaining consent, patients were examined and investigated following a specific study proforma. Demographic profiles, personal habits, neurological status and CT findings were documented. Cerebral decongestants were administered as required. Surgical details, bone flap and dura status and timing of surgery were recorded. Pre and post-operative CT scans were conducted for all patients.

The outcome was assessed at the time of discharge and at a 3-month follow-up using the Glasgow Outcome Scale (GOS). Favorable outcomes were assigned to patients with GOS grades 4 and 5, while GOS grades 1, 2 and 3 were considered unfavorable outcomes. Statistical analysis was performed using IBM SPSS Statistics (version 22.0).

Mean, medians, standard deviation and standard error were calculated for quantitative variables. Normality of data was checked using the Kolmogorov-Smirnov test. Proportions were compared using Chi-square or Fisher's exact test. A p-value of <0.05 was considered statistically significant.

Multivariate analysis was conducted to explore the correlation between the outcome of decompressive craniotomy and factors such as age, sex, comorbidities, underlying brain pathology and timing of surgery.

OBSERVATION AND RESULTS

The study was conducted in a tertiary care hospital. Twenty five patients admitted to the hospital with severe head injury underwent clinical and radiological evaluation followed by DC. Table 1 presents the socio-demographic characteristics of the patients included in the study, who were admitted to the hospital with severe head injuries and subsequently underwent a surgical procedure called decompressive craniectomy (DC).

Age groups: There were 14 patients in the age group of 15-45 years and 11 patients were over 45 years old. It indicates that a majority of patients with severe head injuries who underwent DC were in the younger age group of 15-45 years.

Gender: Out of the 25 patients, 23 were males and only 2 were females, suggesting that males were more affected by severe head injuries in this study.

Mode of injury: Among the causes of head injuries, 22 patients suffered from road traffic accidents (RTA) 2 patients fell from heights and 1 patient had an assault injury due to a sword attack.

Co-morbidities: The study observed that 16 patients had hypertension (HTN) 1 patient had coronary artery disease (CAD) and 6 patients had diabetes mellitus (DM). Table 2 provides information on various clinical variables related to the patients who underwent DC for severe head injuries.

Respiration: 20 patients were on ventilatory support, while only 5 patients were able to breathe spontaneously.

Pupils: Pupillary responses were assessed and it was found that 14 patients had non-reactive pupils (either single or bilateral) 9 had bilateral non-reactive pupils, 5 had unilateral non-reactive pupils, and 11 had bilateral reactive pupils.

Glasgow coma scale (GCS): The initial GCS was used to assess the severity of the head injury. 19 patients had a GCS less than 5, 4 patients had a GCS between 6-8, and 2 patients had a GCS of 8 and above.

Table 1: Distribution of socio-demographic variables

Socio-demographic variables	Frequency
Age groups	
15-45 yrs	14
>45yrs	11
Gender	
Females	2
Males	23
Mode of injury	
Assault	1
Fall	2
RTA	22
Comorbidities	
HTN	8
HTN/CAD	1
DM	6
Total	25

Table 2: Distribution of clinical variables

Clinical variables	Frequency
Respiration	
Spontaneous	5
Ventilator	20
Total	25
Pupils	
N/N	9
N/R	5
R/R	11
Glasgow coma scale	
≤5	19
6-8	4
≥8	2
Ct. Findings	
Contusion	9
EDH	1
ICH/SDH	1
Infarct	2
SDH/contusion	8
SDH/SAH	3
SDH/SAH/contusion	1
Midline shift (mm)	
≤6	7
6-10	7
≥10	11
Time from injury to surgery	
≤8 hrs	12
8-12 hrs	11
≥12hrs	2
Status of dura after surgery (dduroplasty)	
No	17
Yes	8
Glasgow outcome scale	
≤3	19
4, 5	6

Ct findings: CT scans were performed to identify the specific brain lesions. The most common lesion observed was subdural hematoma (SDH) with contusion, seen in 17 patients. Other findings included epidural hematoma (EDH) intracerebral hematoma (ICH), infarct and combinations of SDH and other lesions.

Midline shift: Midline shifts on CT scans were measured and it was observed that 14 patients had a midline shift of less than 10 mm, while 11 patients had a shift of more than 10 mm.

Time from injury to surgery: The time interval between the injury and surgery was recorded. 12 patients underwent surgery within 8 hrs of the injury,

Table 3: Comparison of different variables with outcome of the patient Using glasgow outcome scale

Variables	GOS groups			
	≤3	4,5	Total	p-value
Age category				
18-25 years	1	3	4	.057
26-35 years	4	1	5	
36-45 years	5	0	5	
≥45 years	9	2	11	
Gender				
Female	1	1	2	0.43
Male	18	5	23	
DM				
No	14	5	19	>0.05
Yes	5	1	6	
HTN/CAD				
HTN	7	1	8	>0.05
HTN/CAD	1	0	1	
None	11	5	16	
Duroplasty				
No	14	3	17	.344
Yes	5	3	8	
Midline shift				
≤6mm	5	2	7	.248
6-10mm	4	3	7	
≥10mm	10	1	11	
Size of craniotomy				
8-12 cm	6	4	10	.175
≥12 cm	13	2	15	
Pupil status				
N/N	8	1	9	0.047*
N/R	5	0	5	
R/R	6	5	11	
Duration to surgery				
≤8hrs	8	4	12	.017*
8-12 hrs	11	0	11	
≥12 hrs	0	2	2	
GCS				
≤5	16	2	18	.032*
≥5	3	4	7	

11 patients between 8-12 hrs and 2 patients more than 12 hrs after the injury.

Status of dura after surgery (duroplasty): After surgery, 17 patients had their dura left open, while 8 patients underwent duroplasty using artificial dural substitutes or pericranium.

Glasgow outcome scale (GOS): The patient's outcomes were assessed using the GOS after discharge. 19 patients had an unfavorable outcome (GOS ≤3) while 6 patients had a favorable outcome (GOS 4 or 5). Comparison of different variables were made with outcome of the patient using Glasgow Outcome Scale and statistical tests were applied to see for statistical significance. This table summarizes the comparison of different variables with the Glasgow Outcome Scale (GOS) to determine their impact on the final outcome of the patients.

Age groups: The study found that younger patients (between 18-25 years) had a better outcome, with only 25% experiencing an unfavorable outcome. However, the p-value (0.057) indicated that this relationship was not statistically significant.

Gender: The limited number of female patients (only 2) made it difficult to draw meaningful conclusions about gender differences in outcomes. The p-value (0.43) indicated that there was no significant difference between males and females.

Comorbidities: Patients with comorbidities like hypertension (HTN)/coronary artery disease (CAD)/diabetes mellitus (DM) tended to have a higher percentage of unfavorable outcomes but the results were not statistically significant.

Duroplasty: Patients who underwent duroplasty had a relatively better outcome compared to those who did not but the p-value (0.344) indicated that this difference was not statistically significant.

Midline shift: Patients with midline shifts greater than 10 mm had poorer outcomes than those with smaller shifts but the p-value (0.248) suggested that this finding was not statistically significant.

Size of craniotomy: The size of the craniotomy did not show a significant correlation with the GOS.

Pupils: Patients with non-reactive pupils had a higher percentage of unfavorable outcomes compared to those with reactive pupils. The p-value (0.047) indicated that this relationship was statistically significant.

Time from injury to surgery: Patients who underwent emergency surgery (within 8 hrs) had poorer outcomes than those who had surgery after 8 hrs. The p-value (0.017) showed that this difference was statistically significant.

Glasgow coma scale (GCS): GCS was the most important determinant of GOS, with lower GCS scores associated with higher percentages of unfavorable outcomes. The p-value (0.032) indicated that this relationship was statistically significant.

DISCUSSIONS

The study was conducted at a tertiary care center and included 25 patients with severe traumatic brain injury (TBI) and evidence of raised intracranial pressure (ICP) who underwent decompressive craniotomy (DC). The majority of patients were males and the age distribution showed that 14 patients were younger than 45 years, while 11 were older than 45 years. Similar trends of male preponderance and a higher incidence of head injury in the age group of 15-45 years were reported in previous studies[9,10].

The study investigated various factors that could influence the outcome of DC in TBI patients. Age was found to have an impact on the prognosis, with an increasing percentage of unfavorable outcomes in older patients. However the relationship between age and outcome was not linear and statistically not significant. Previous studies have shown varying results regarding the relationship between age and outcome in TBI patients[11-14]. Some studies have reported better outcomes with younger age groups, while others have suggested better outcomes with older age groups[5].

Comorbidities like hypertension, diabetes mellitus and cardiovascular disease did not independently affect the outcome, as their presence did not show a significant difference in the overall results. This finding is consistent with previous studies that have shown mixed results regarding the impact of comorbidities on the outcome of TBI patients[15,16]. The severity of midline shift on CT scan was analyzed as a predictor of outcome. Patients with greater midline shift tended to have a worse prognosis but the relationship was not statistically significant. Previous studies have shown conflicting results regarding the correlation between midline shift and outcome in TBI patients[17,18].

Duroplasty the closure of the dura after the craniotomy, did not show a significant difference in outcomes compared to leaving the dura open. Some studies have suggested that duroplasty may be beneficial in controlling intracranial hypertension and improving outcomes in TBI patients[19,20]. However, other studies have not found a clear advantage of duroplasty[21,22]. The timing of surgery was crucial, with better outcomes observed in patients operated on within 8 hrs of trauma compared to those operated on after 8 hrs. Early surgery within 6 hrs of trauma is considered crucial in TBI cases to prevent life-threatening brain swelling[23]. Previous studies have also emphasized the importance of early surgical intervention in improving the outcome of TBI patients[24,25].

The initial Glasgow Coma Scale (GCS) at admission was found to be a significant predictor of outcome. Patients with a GCS score greater than 5 had a more favorable outcome compared to those with a lower score. This finding is supported by other studies that have highlighted the importance of GCS in predicting the outcome of TBI patients[13,25,26]. Pupillary changes were also identified as important independent predictors of mortality, with bilateral non-reactive pupils associated with a poorer prognosis. Pupillary changes have been recognized as significant indicators of prognosis in TBI patients in previous studies as well[13-27].

While some previous studies support the benefits of decompressive craniotomy in improving outcomes for severe TBI patients[28-31], others have found conflicting results[32-35]. The varying findings in different studies highlight the complexity of factors influencing the outcome of decompressive craniotomy in severe traumatic brain injury.

CONCLUSION

The study suggests that decompressive craniotomy may be beneficial in carefully selected TBI patients with salvageable GCS, normal or unilateral dilated pupils and those who have failed medical management. Early surgery within 8 hrs of trauma appears to yield better outcomes. The study also highlights the importance of initial GCS and pupillary status as significant predictors of prognosis in TBI patients. However, further research is needed to better understand the complex factors influencing the outcome of decompressive craniotomy in severe traumatic brain injury.

REFERENCES

1. Dczi, T., 1993. Volume regulation of the brain tissue a survey. Acta. Neurochirurgica., 121: 1-8.
2. Cushing, H., 1905. The establishment of cerebral hernia as a decompressive measure for inaccesible brain tumor. Surg. Gyn. Obst., 1: 297-314.
3. Kocher, T., 1901. Die therapiedes hirndruck und chirurgische eangriffebei hirnkrankhete. Vienna. A. Holder., 1: 262-266.
4. Hacke, W., 1996. 'malignant' middle cerebral artery territory infarction. Arch. Neurol., 53: 309-315.
5. Polin, R.S., M.E. Shaffrey, C.A. Bogaev, N. Tisdale, T. Germanson, B. Bocchicchio and J.A. Jane, 1997. Decompressive bifrontal craniectomy in the treatment of severe refractory posttraumatic cerebral edema. Neurosurgery, 41: 84-94.

6. Ma, J., C. You, L. Ma and S. Huang, 2011. Is decompressive craniectomy useless in severe traumatic brain injury? Crit. Care, Vol. 15 .10.1186/cc10358
7. Mukherjee, K.K., S. Mohindra, S.K. Gupta, R. Gupta and V.K. Khosla, 2006. True hemicranial decompression for severe pediatric cranial trauma: A short series of 4 cases and literature review. Surg. Neurol., 66: 305-310.
8. Csókay, A., L. Nagy and B. Novoth, 2001. Avoidance of vascular compression in decompressive surgery for brain edema caused by trauma and tumor ablation. Neurosurgical. Rev., 24: 209-213.
9. WHO., 2008. Violence, injuries, and disability: Biennial. report. World Health Organization, G e n e v a , https://scirp.org/reference/referencespapers?referenceid=1025460
10. CDC., 2021. Centers for disease control and prevention: Traumatic brain injury in the united states: Assessing outcomes in children. Available at, https://www.cdc.gov/TraumaticBrainInjury/index.html
11. Ucar, T., M. Akyuz, S. Kazan and R. Tuncer, 2005. Role of decompressive surgery in the management of severe head injuries: Prognostic factors and patient selection. J. Neurotrauma, 22: 1311-1318.
12. Taylor, A., W. Butt, J. Rosenfeld, F. Shann and M. Ditchfield et al., 2001. A randomized trial of very early decompressive craniectomy in children with traumatic brain injury and sustained intracranial hypertension. Child's. Nervous Syst., 17: 154-162.
13. Gouello, G., O. Hamel, K. Asehnoune, E. Bord, R. Robert and K. Buffenoir, 2014. Study of the long-term results of decompressive craniectomy after severe traumatic brain injury based on a series of 60 consecutive cases. Sci. World J., 1: 1-10.
14. Chibbaro, S. and L. Tacconi, 2007. Role of decompressive craniectomy in the management of severe head injury with refractory cerebral edema and intractable intracranial pressure. our experience with 48 cases. Surg. Neurol., 68: 632-638.
15. Noufal, B, G. Deepak and A.K. Mahapatra, 2010. Cranioplasty following decompressivecraniectomy in traumatic brain injury: Experience at Level -1 apex trauma cetre. Indian. J. Neuro., 7: 139-144.
16. Miller, J.D., D.P. Becker, J.D. Ward, H.G. Sullivan, W.E. Adams and M.J. Rosner, 1977. Significance of intracranial hypertension in severe head injury. J. Neurosurg., 47: 503-516.
17. Tabaddor, K., A. Danziger and H.S. Wisoff, 1982. Estimation of intracranial pressure by ct scan in closed head trauma. Surg. Neurol., 18: 212-215
18. Yang, X.J., G.L. Hong, S.B. Su., et al ., 2003. Complications in duced by decompressivecraniectomies after traumatic brain injury. Chin. J. Traumatol., 6: 99-103.
19. Ruf, B., M. Heckmann. and I. Schroth, *et al* ., 2003. Early decompressivecraniectomy and duraplasty for refractory intracranial hypertension in children: Results of a pilot study. Crit. Care., 7: 133-138.
20. Fagiji, A.A., A.G. Fieggen and Argent, 2006. Surgical treatment for 'brain compartment syndrome' in children with severe head injury. Afr. Med. J., 96: 969-975.
21. Mathai, K.I., S.M. Sudumbrekar, Shashivadhanan, 2010. Decompressive craniectomy in traumatic brain injury Rationale and practice. Indian. J. Neurotr., 7: 9-12.
22. Wani, A.A., T.I. Dar, A.U. Ramzan, N.K. Malik and A.R. Kirmani et al., 2009. Decompressive craniectomy in head injury. Indian J. Neurotrauma, 6: 103-110.
23. Grille, P. and N. Tommasino, 2015. Decompressive craniectomy in severe traumatic brain injury: Prognostic factors and complications. Rev. Bras. Terapia Intensiva, 27: 113-118.
24. Schneider, G.H., T. Bardt, W.R. Lanksch and A. Unterberg, 2002. Decompressive craniectomy following traumatic brain injury: Icp, cpp and neurological outcome. Intracranial Pressure Brain Biochem. Monit., 1: 77-79.
25. Sinha, S., A. Raheja, G. Satyarthee, P. Singh and V. Tandon et al., 2015. Decompressive craniectomy in traumatic brain injury: A single-center, multivariate analysis of 1, 236 patients at a tertiary care hospital in India. Neurol. India, 63: 175-183.
26. Choksey, M., H.A. Crockard and M. Sandilands, 1993. Acute traumatic intracerebral haematomas: Determinants of outcome in a retrospective series of 202 cases. Br. J. Neurosurg., 7: 611-622.
27. Hase, U., H. ,J Reulen, G. Meinig and K. Schürmann, 1978. The influence of the decompressive operation on the intracranial pressure and the pressure-volume relation in patients with severe head injuries. Acta Neurochirurgica, 45: 1-13.
28. Aarabi, B., D.C. Hesdorffer, E.S. Ahn, C. Aresco, T.M. Scalea and H.M. Eisenberg, 2006. Outcome following decompressive craniectomy for malignant swelling due to severe head injury. J. Neurosurg., 104: 469-479.
29. Guerra, W.K.W., M.R. Gaab, H. Dietz, J.U. Mueller, J. Piek and M.J. Fritsch, 1999. Surgical decompression for traumatic brain swelling: Indications and results. J. Neurosurg., 90: 187-196.
30. Olivecrona, M., M. Rodling-Wahlström, S. Naredi and L.O.D. Koskinen, 2007. Effective icp reduction by decompressive craniectomy in patients with severe traumatic brain injury treated by an icp-targeted therapy. J. Neurotrauma, 24: 927-935
31. Morgalla, M.H., B.E. Will, F. Roser and M. Tatagiba, 2008. Do long-term results justify decompressive craniectomy after severe traumatic brain injury? J. Neurosurg., 109: 685-690.

32. Bonis, P.D., A. Pompucci, A. Mangiola, Q.G. D'Alessandris, L. Rigante and C. Anile, 2010. Decompressive craniectomy for the treatment of traumatic brain injury: Does an age limit exist? J. Neurosurg., 112: 1150-1153.
33. Sahuquillo, J., 2006. Decompressive craniectomy for the treatment of refractory high intracranial pressure in traumatic brain injury. Cochrane Database Syst. Rev., Vol. 1 .10.1002/14651858.cd003983.pub2