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Treatment Outcomes of Decompressive Craniectomy in Patients with Traumatic Brain Injury

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ABSTRACT

Background

Decompressive craniectomy (DC) is a surgical procedure used to treat refractory intracranial hypertension, and traumatic brain injury (TBI) is a leading cause of morbidity and death.

Objective

This study aimed to evaluate the treatment outcomes of DC in patients with severe TBI by assessing survival rates, neurological recovery, and postoperative complications.

Methodology

This prospective observational study was conducted at different Tertiary Healthcare setups of Pakistan, from January 2022 to September 2023. There were 78 individuals with severe TBI who had DC in total. SPSS version 26 was used to gather and analyze data on demographics, Glasgow Coma Scale (GCS) scores, radiological findings, intraoperative specifics, complications, and Glasgow Outcome Scale functional results. Associations were found using chi-square testing, with a significance threshold of $p < 0.05$.

Results

Of the total number of survivors, 70.51% (n = 55) survived, but 29.49% (n = 23) did not. Of the survivors, 15.38% had severe impairment, 23.08% had moderate disability, and 25.64% had fair recovery. Increased mortality was linked to significant cerebral swelling ($p = 0.004$), bilateral DC ($p = 0.021$), and worse pretreatment GCS scores ($p = 0.015$). Functional results were strongly impacted by postoperative complications ($p = 0.002$).

Conclusion

Although DC increases survival in patients with severe TBI, functional recovery is still unpredictable, highlighting the need of cautious patient selection and postoperative care.

Keywords
Traumatic brain injury, decompressive craniectomy, Glasgow Coma Scale, intracranial hypertension.

INTRODUCTION

A major cause of morbidity and death worldwide, traumatic brain injury (TBI) is a serious health problem [1]. It continues to rank among the top causes of mortality and disability, especially for young people and those who have experienced severe trauma [2]. TBI has a complicated pathophysiology that includes both main and secondary damage [3]. brain edema, elevated intracranial pressure (ICP), and decreased brain perfusion are among the biochemical and physiological alterations that lead to secondary damage, while the initial injury happens at the time of impact. In order to stop more neuronal damage and enhance patient outcomes, these secondary processes are crucial targets for therapeutic intervention [4].

For patients with severe TBI and intractable intracranial hypertension, decompressive craniectomy (DC) has become a potentially life-saving surgical procedure [5]. In order to relieve pressure and avoid brain herniation, a part of the skull is removed during the treatment [6]. DC seeks to preserve cerebral circulation and lessen the harmful consequences of intracranial hypertension by making room for the enlarged brain [7]. The effectiveness of DC in enhancing long-term functional results is still up for discussion, despite its extensive usage [8]. Although some research indicates that DC dramatically lowers death rates, questions remain about how it may affect neurological recovery and quality of life [9].

A number of variables, including the patient's age, Glasgow Coma Scale (GCS) score, radiological findings, and related injuries, affect the clinical decision-making process when it comes to DC [10]. Even though DC may stop death right away, survivors often have to endure protracted recovery and differing levels of functional damage. Furthermore, a thorough risk-benefit analysis is required because to the possible side effects of DC, which include infections, hydrocephalus, and syndrome of the trephined [11]. Current studies have focused on improving perioperative care, honing surgical methods, and determining which patient subgroups stand to gain the most from DC [5].

It is crucial to comprehend the results of DC in TBI patients in order to direct therapeutic practice and enhance prognosis. Thus, the purpose of this research is to assess the effectiveness of DC in treating TBI patients, with an emphasis on functional recovery, mortality rates, and related comorbidities.

Research Objective

The objective of study was to assess the treatment outcomes of DC in patients with TBI by evaluating survival rates, neurological recovery, and postoperative complications.

METHODOLOGY

Study Design and Setting

This study was a prospective observational study conducted at different Tertiary Healthcare setups of Pakistan, from January 2022 to September 2023.

Inclusion and Exclusion Criteria

Participants in the study were individuals who were 18 years of age or older, had a diagnosis of severe TBI that required a DC, and had had a DC during the study period. Patients with severe systemic injuries that resulted in early death prior to surgical intervention, those with pre-existing neurological illnesses that affected outcome evaluation, and those with mild to moderate TBI who did not need surgical intervention were eliminated.

Sample Size

Convenience sampling was used to cover 78 patients in total since it was deemed practicable in a hospital environment. In order to provide a representative evaluation of the results of DC,

the sample size was determined by patient availability and resource feasibility.

Data Collection

Data was gathered via follow-up evaluations, surgical notes, and patient medical records. Among the variables were demographic information, Glasgow Coma Scale (GCS) scores, radiological results, intraoperative information, complications, and Glasgow Outcome Scale (GOS)-measured functional outcomes.

Statistical Analysis

Data analysis was done by using SPSS version 26. Clinical and demographic features were gathered using descriptive statistics. Whereas continuous data were represented as means and standard deviations, categorical variables were shown as frequencies and percentages. Chi-square tests were used to evaluate the relationship between covariates and treatment results, with a significance threshold of $p < 0.05$.

Ethical Approval

Ethical approval was obtained from the institutional review boards. Informed consent was obtained from patients or their legal guardians before inclusion in the study.

RESULTS

The demographic details of the 78 patients that were part of the trial are shown in Table 1. Of the patients, 38.46 percent were between the ages of 31 and 50, 32.05% were between the ages of 18 and 30, and 29.49% were beyond the age of 50. The study population was mostly composed of men (74.36%), with women making up 25.64%.

Table 1: Demographic Characteristics of Patients (n = 78)

Variable		Frequency (n)	Percentage (%)
Age Group (years)	18-30	25	32.05%
	31-50	30	38.46%
	>50	23	29.49%
Gender	Male	58	74.36%
	Female	20	25.64%

The patients' clinical and surgical features are listed in Table 2. The majority (57.69%) had a Glasgow Coma Scale (GCS) score of 6–8 prior to surgery, followed by 25.64% with a score of 3-5, which indicates significant impairment, and 16.67% with a score of 9–12. 65.10 percent of patients had a unilateral DC, whereas 35.90 percent needed a bilateral DC.

Table 2: Clinical and Surgical Characteristics

Variable		Frequency (n)	Percentage (%)
GCS Score (Pre-Op)	3-5	20	25.64%
	6-8	45	57.69%
	9-12	13	16.67%
Laterality of DC	Unilateral	50	64.10%
	Bilateral	28	35.90%

The patients' radiological results are presented in Table 3. With 44.87% of patients, midline displacement > 5mm was the most frequent anomaly, followed by widespread brain edema (38.46%). Additionally, common were extradural hematoma (23.08%) and subdural hematoma (28.21%). 19.23% of patients had contusions, although ischemic alterations (10.26%) and intraventricular hemorrhage (12.82%) were less frequent. Radiological results were normal in just 6.41% of individuals.

Table 3: Radiological Findings

Radiological Finding	Frequency (n)	Percentage (%)
Midline Shift > 5mm	35	44.87%
Extradural Hematoma (EDH)	18	23.08%
Subdural Hematoma (SDH)	22	28.21%
Contusions	15	19.23%
Diffuse Brain Swelling	30	38.46%
Intraventricular Hemorrhage	10	12.82%
Ischemic Changes	8	10.26%
Normal Findings	5	6.41%

Treatment results for individuals receiving DC are shown in Table 4. Overall, 70.51% of the population (n = 55) survived, whilst 29.49% of the population (n = 23) did not. Of the survivors, 15.38% had severe impairment, 23.08% had moderate disability, and 25.64% had fair recovery. Furthermore, the death rate (29.49%) matched the number of patients who died, while 6.41% remained in a vegetative state.

Table 4: Treatment Outcomes

Outcome Variable		Frequency (n)	Percentage (%)
Survival Status	Survived	55	70.51%
	Deceased	23	29.49%
Functional Outcome (GOS)	Good Recovery	20	25.64%
	Moderate Disability	18	23.08%
	Severe Disability	12	15.38%
	Vegetative State	5	6.41%
	Death	23	29.49%

The surgical problems among the 55 surviving patients are shown in Figure 1. Seizures were the most frequent consequence (15.38%), followed by hydrocephalus (10.26%) and infection (12.82%). 55.13% of patients had no postoperative problems, but 6.41% of cases had the syndrome of Trephined.

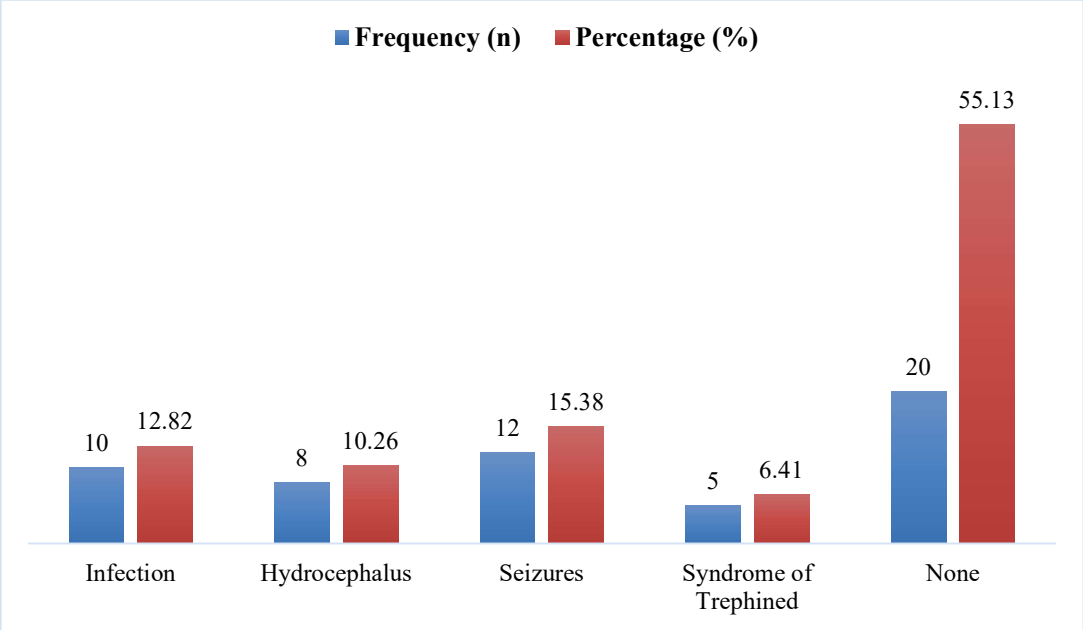

Figure 1: Postoperative Complications

The relationship between important factors and treatment results is shown in Table 5. Both the laterality of DC ($\chi^2 = 5.32$, $p = 0.021$) and preoperative GCS score were significantly correlated with survival ($\chi^2 = 10.52$, $p = 0.015$), with bilateral surgeries being associated with increased mortality. Additionally, there was a significant correlation between survival outcomes and widespread brain swelling ($\chi^2 = 9.12$, $p = 0.004$) and midline displacement > 5mm ($\chi^2 = 7.45$, $p = 0.008$). Age group ($p = 0.278$) and hematoma type ($p = 0.135$) did not, however, seem to have a statistically significant effect on survival. Furthermore, functional recovery was strongly impacted by surgical complications ($\chi^2 = 12.88$, $p = 0.002$), suggesting that patients with problems had poorer results.

Table 5: Association between Variables and Treatment Outcomes

Variable	Treatment Outcome Categories	Chi-Square (χ^2)	p-value
GCS Score (Pre-Op)	Survival vs. Mortality	10.52	0.015
Age Group	Survival vs. Mortality	3.85	0.278
Laterality of DC	Survival vs. Mortality	5.32	0.021
Midline Shift > 5mm	Survival vs. Mortality	7.45	0.008
Type of Hematoma (EDH, SDH)	Survival vs. Mortality	2.98	0.135
Diffuse Brain Swelling	Survival vs. Mortality	9.12	0.004
Postoperative Complications	Good vs. Poor GOS	12.88	0.002

DISCUSSION

The results of this research provide important new information on how DC affects TBI patients. With 25.64% obtaining excellent recovery and 23.08% enduring moderate impairment, our research showed a 70.51% survival rate. These findings are consistent with earlier research showing that DC dramatically lowers mortality in individuals suffering from intractable intracranial hypertension [12]. Our results were supported by a meta-analysis conducted by Grindlinger et al. (2016), which found that survival rates for patients receiving DC ranged from 60% to 80% [13]. The variation in functional results, however, draws attention to the continuous discussion over how well the method works to promote long-term healing.

A significant predictor of survival in our research was the preoperative Glasgow Coma Scale (GCS) score ($p = 0.015$). Better results were obtained by patients with a GCS of 6–8 than by those with lower scores. This result is in line with the earlier study's findings that patients' survival and functional recovery were better when their preoperative GCS scores were higher [14]. Furthermore, DC was less likely to be beneficial for individuals with significant brain injury and lower GCS scores, which supports our finding that preoperative neurological state is a critical prognostic factor [15].

According to our findings, the survival outcomes were substantially poorer for patients with widespread brain edema (38.46%) and midline shift >5 mm (44.87%) ($p = 0.008$ and $p = 0.004$, respectively). These results are consistent with the earlier research, which discovered that extensive cerebral edema and substantial midline displacement were significant predictors of poor neurological recovery and death after DC [12,16]. These radiological indicators point to substantial secondary brain damage, which might account for our cohort's poor functional results and higher death rate.

Survival was significantly impacted by DC laterality, with bilateral DC linked to increased mortality ($p = 0.021$). Our findings corroborate earlier research showing that patients with more severe brain damage often need bilateral DC, which leads to worse outcomes [17]. Bilateral DC raises the risk of sequelae such infections and hydrocephalus, which were seen in our research with rates of 10.26% and 12.82%, respectively, while providing higher decompression.

Functional recovery was strongly influenced by postoperative complications ($p = 0.002$). Both seizures (15.38%) and syndrome of the trephined (6.41%) were significant side effects that impacted long-term results. A prior research that found seizures and delayed cranial reconstruction to be important variables influencing post-DC rehabilitation revealed similar results [18]. To enhance functional recovery, these issues call for prompt cranioplasty and careful postoperative care.

All things considered, our research supports the advantages of DC in lowering mortality while emphasizing the difficulties in maximizing functional results. To improve recovery for TBI patients receiving DC, further research is required to improve patient selection standards and postoperative care techniques.

Study Strengths and Limitations

One of the study's advantages is its prospective observational design, which made it possible to gather data in real time and conduct a thorough assessment of the results of DC in patients with TBI. Patients from two significant tertiary care institutions were included to improve the results' generalizability, and objective evaluation was guaranteed by the use of established outcome measures such the Glasgow Outcome Scale (GOS). Nevertheless, the research had drawbacks, such as a small sample size and convenience sampling, which might lead to selection bias. Furthermore, the short follow-up time made it difficult to evaluate long-term functional results. To confirm these results and draw more firm conclusions, bigger cohorts and longer follow-up periods are required in future research.

CONCLUSION

The study's 70.51% survival rate for individuals with severe TBI demonstrates the benefit of DC. Even though DC successfully lowers mortality, functional recovery is still quite varied and depends on a number of variables, including radiological findings, surgical complications, and preoperative Glasgow Coma Scale (GCS) scores. While bilateral DC and significant cerebral edema were linked to greater mortality, patients with higher preoperative GCS scores and less comorbidities had better results. These results highlight how crucial it is to choose patients carefully and manage them after surgery in order to maximize functional recovery. For TBI patients receiving DC, further studies with bigger sample sizes and longer follow-up times

are necessary to enhance long-term prognostic results and fine-tune treatment approaches.

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