Biomedical & Pharmacology Journal, September 2023. Vol. **16**(3), p. 1473-1481

Relationship between Decompressive Craniectomy and Traumatic Brain Injury Outcomes: A Single-Center Study

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https://dx.doi.org/10.13005/bpj/2725

(Received: 28 April 2023; accepted: 09 June 2023)

Traumatic Brain Injury (TBI) has significantly increased both mortality and morbidity in developed and developing countries. Decompressive Craniectomy (DC) is an option when conventional treatments fail to reduce intracranial pressure (ICP) when brain edema occurs in TBI. This study aims to determine the relationship between DC and patients with TBI in West Nusa Tenggara Provincial Hospital whose outcome was assessed with Glasgow Outcome Scale Extended (GOSE) and modified Rankin Scale (mRS). A total of 41 TBI patients who underwent DC were included in the study. Univariate analysis revealed that men made up the majority of the subjects, with 26 people (63.4%) compared to 15 women (36.3%). Traffic accidents (82.9%), falling (12.2%), and being crushed (4.9%) accounted for the majority of the causes of TBI. Bivariate analysis showed that pupillary reflex, length of stay, and Glasgow Coma Scale at discharge from the hospital were associated with outcome (p=0.002; p=0.000; p=0.000 respectively), GOSE (p=0.001; p=0.000; p=0.000 respectively), and mRS (p=0.001; p=0.000; p=0.000 respectively). Other factors such as gender, age, trauma mechanism, GCS admission, and operation time, however, did not significantly affect the outcome, GOSE, or mRS.

Keywords: Decompressive Craniectomy; Lombok Island; Outcomes; Traumatic Brain Injury.

Brain injury is considered as one of the main causes of death in traffic accidents.[1,2] Traumatic brain injury (TBI) caused approximately 56,000 deaths in the United States in 2013 and 82,000 deaths in Europe in 2012.[3,4] TBI is defined as disruption of the brain's normal functioning due to an impact, blow, or jolt to the head or a penetrating head injury. TBI can cause changes in brain function such as amnesia, neurological deficits, loss or impairment of consciousness, and changes in mental status at the time of injury.[5,6] The primary condition that frequently develops in TBI is cerebral edema, which increases intracranial pressure (ICP) and decreases cerebral perfusion pressure (CPP), disrupting brain oxygen metabolism.[6]

Decompressive craniectomy (DC) is an option when conventional treatments, such as head elevation, sedation, analgesia, and neuromuscular paralysis, fail to reduce ICP, according to the

European Brain Injury Consortium and the American Brain Injury Consortium guidelines for severe TBI.[6] DC refers to the process of removing a large bone flap and opening the underlying dura to control brain swelling and elevated ICP.[7] Previous studies imply that DC may still be helpful in reducing mortality and improving functional outcomes in TBI patients, particularly if administered early.[8]

Since there were so many brain injury cases in Indonesia, including in West Nusa Tenggara Province, the authors are encouraged to conduct research on DC in patients with TBI. This research is anticipated to give a general overview of the prognosis of the DC procedure done in patients with TBI, especially in Lombok, which is based at the Regional General Hospital of West Nusa Tenggara Province.

MATERIALS AND METHODS

Research Design, Location, and Period

This research is a quantitative retrospective study using data obtained from the medical records of neurosurgery patients who met the inclusion and exclusion criteria at the West Nusa Tenggara Province General Hospital. This study aims to determine the relationship between decompressive craniectomy (DC) and patients with traumatic brain injury (TBI) whose outcome was assessed with Glasgow Outcome Scale Extended (GOSE) and modified Rankin Scale (mRS). The research was conducted at the West Nusa Tenggara Province General Hospital located on Mataram City, Lombok Island, West Nusa Tenggara Province, Indonesia.

Research Population and Sample

The population in this study were patients with TBI who were treated at the West Nusa Tenggara Province General Hospital. This study aims to determine the relationship between DC and patients with TBI in West Nusa Tenggara Provincial Hospital whose outcome was assessed with Glasgow Outcome Scale Extended (GOSE) and modified Rankin Scale (mRS). This study did not employ a special sampling technique; instead, total sampling was used to select research subjects, meaning that all subjects who met the inclusion criteria in 2018 were included in the research sample.

Inclusion and Exclusion Criteria

Patients who underwent DC surgery and had a diagnosis of TBI after experiencing trauma events (such as car accidents, falls, or being crushed) met the inclusion criteria for this study. Patients with TBI that were not brought on by traumatic events were excluded from this study.

Research Variables

The independent variable in this study was DC procedure, while the dependent variable was outcome, in the form of GOSE and mRS. In addition, other prognostic variables such as age, sex, GCS in and GCS out, mechanism of trauma, pupillary reflex, onset to surgery, length of stay, and whether the patient was discharged alive or dead were also observed.

Research Procedure

Data collection is done by recording important information from the patient's medical record. The data collected included name, medical record number, age, sex, GCS in and GCS out, mechanism of trauma, pupil reflex upon arrival, onset of events to surgery, length of stay, and whether the patient was discharged from the hospital alive or dead.

Statistical Analysis

The statistical analysis used was the Somers'd test to determine whether there was a significant relationship between the variables and outcome (GOSE and mRS). Statistical tests were carried out using the SPSS version 23 software. The relationship between variables was considered significant if the p-value <0.05.

RESULTS

There were 41 samples of TBI patients who underwent Decompressive Craniectomy (DC) included in this research study. In this study, the univariate analysis revealed that men made up the majority of the subjects, with 26 people (63.4%) compared to 15 women (36.3%). The research participants ranged in age from 7 years old to 68 years old, with the highest age group being 16 to 24 years. The mean age of the research participants was 36 years. In this study, traffic accidents (82.9%), falling (12.2%), and being crushed (4.9%) accounted for the majority of the causes of TBI.

Of a total of 41 subjects, the majority of patients were admitted to the hospital with GCS of

Table 1. Characteristics of Research Subjects

Characteristics	Total (n)	Percentage (%)	Mean	Minimum	Maximum	Median
Gender						
Male	26	63.4				
Female	15	36.6				
Age Group						
7-15 year	6	14.6				
16-24 year	10	24.4				
25-33 year	3	7.3				
34-42 year	5	12.2	36.1	7	68	38
43-51 year	7	17.1				
52-60 year	6	14.6				
61-69 year	4	9.8				
Trauma Mechanism						
Traffic Accidents	34	82.9				
Fall	5	12.2				
Crushed	2	4.9				
GCS-in						
13-15	3	7.3				
9-12	20	48.8	9	4	15	9
3-8	18	43.9				
Pupillary Reflexes						
Normal	33	80.5				
Abnormal	8	19.5				
Time until Surgery						
d” 24 hours	22	53.7				
> 24 hours	19	46.3				
Length of Stay						
0-4 days	6	14.6				
5-9 days	10	24.4				
10-14 days	9	22	13.5	2	33	13
15-19 days	5	12.2				
20-24 days	8	19.5				
30-34 days	3	7.3				
GCS-Out						
13-15	18	43.9				
9-12	8	19.4	9.6	3	15	11
3-8	15	36.6				
Outcome						
Survived	26	63.4				
Died	15	36.6				
GOSE						
1	15	36.6				
2	2	4.9				
3	14	34.1				
4	8	19.5	2.5	1	6	3
5	1	2.4				
6	1	2.4				
7	0	0				
8	0	0				
mR Scale						
0	0	0				
1	0	0				
2	1	2.4				
3	6	14.6	4.6	2	6	4
4	15	36.6				
5	4	9.8				
6	15	36.6				

GCS (Glasgow Coma Scale); GOSE: Extended Glasgow Outcome Scale; mR: modified Rankin

9 to 12 (48.8%) and 3 to 8 (43.9%), with an average GCS of 9 and the lowest and highest GCSs being 4 and 15, respectively. About 33 subjects entered the study with normal pupil reflexes, and the other 8 subjects did not. All 41 subjects underwent DC surgery; 22 underwent surgery within 24 hours of the incident, and the remaining 19 underwent surgery more than 24 hours later, with an average length of stay in hospital for 13.5 days.

At discharge, the GCS of all patients was assessed; 43.9% had a GCS of 13 to 15, 19.5% had a GCS of 9 to 12, and the remaining 36.6% had a GCS of 3 to 8. Out of a total of 41 patients, 26 patients survived and the other 15 passed away. The GOSE scale for each subject at discharge ranged from 1 to 6, with an average of 2.5. Meanwhile, the average mRS scale was 4.6 with the highest score being 6 and the lowest being 2 (**Table 1**).

The results of bivariate analysis in this study showed that pupillary reflex, length of stay, and GCS at discharge from the hospital were associated with outcome (p=0.002; p=0.000; p=0.000 respectively), GOSE (p=0.001; p=0.000; p =0.000 respectively), and mRS (p=0.001; p=0.000; p=0.000 respectively). Other factors such as gender, age, trauma mechanism, GCS admission, and operation time, however, did not significantly affect the outcome, GOSE, or mRS (Tables 2, 3, and 4).

Table 2. Outcome Distribution

Characteristics	Outcome		*p*	*r*
	Survived (%)	Died (%)		
Gender				
Male	16 (39.0)	10 (24.4)		
			0.740	-0.051
Female	10 (24.4)	5 (12.2)		
Age (year)				
< 38	13 (31.7)	6 (14.6)		
e” 38	13 (31.7)	9 (22.0)	0.533	0.093
Trauma Mechanism				
Traffic Accidents	22 (53.7)	12 (29.3)		
Fall	3 (7.3)	2 (4.9)	0.699	0.077
Crushed	1 (2.4)	1 (2.4)		
GCS-in				
13-15	2 (4.9)	1 (2.4)		
9-12	15 (36.6)	5 (12.2)	0.149	0.198
3-8	9 (21.9)	9 (21.9)		
Pupillary Reflexes				
Normal	25 (61.0)	8 (19.5)		
			0.002*	0.633
Abnormal	1 (2.4)	7 (17.1)		
Time until Surgery				
d” 24 hours	15 (36.6)	7 (17.1)		
			0.495	0.103
> 24 hours	11 (26.8)	8 (19.5)		
Hospitalization (days)				
d” 13	8 (19.5)	15 (36.6)		
			0.000*	0.558
> 13	18 (43.9)	0 (0.0)		
GCS-out				
13-15	18 (43.9)	0 (0.0)		
9-12	8 (19.5)	0 (0.0)	0.000*	-0.652
3-8	0 (0.0)	15 (36,6)		

*$p < 0.05$: statistically significant

Table 3. GOSE Distribution

Characteristics	GOSE								*p*	*r*
	1	2	3	4	5	6	7	8		
Gender										
Male (%)	10 (24.4)	0 (0.0)	8 (19.5)	6 (14.6)	1 (2.4)	1 (2.4)	0 (0.0)	0 (0.0)	0.466	-0.123
Female (%)	5 (12.2)	2 (4.9)	6 (14.6)	2 (4.9)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)		
Age (year)										
< 38 (%)	6 (14.6)	0 (0.0)	9 (22.0)	3 (7.3)	0 (0.0)	1 (2.4)	0 (0.0)	0 (0.0)	0.637	-0.081
e” 38 (%)	9 (22.0)	2 (4.9)	5 (12.2)	5 (12.2)	1 (2.4)	0 (0.0)	0 (0.0)	0 (0.0)		
Trauma Mechanism										
Traffic Accidents (%)	12 (29.3)	2 (4.9)	11 (26.8)	7 (17.1)	1 (2.4)	1 (2.4)	0 (0.0)	0 (0.0)	0.550	-0.121
Fall (%)	2 (4.9)	0 (0.0)	2 (4.9)	1 (2.4)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)		
Crushed (%)	1 (2.4)	0 (0.0)	1 (2.4)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)		
GCS-in										
13-15 (%)	1 (2.4)	0 (0.0)	0 (0.0)	1 (2.4)	0 (0.0)	1 (2.4)	0 (0.0)	0 (0.0)	0.155	-0.245
9-12 (%)	5 (12.2)	2 (4.9)	8 (19.5)	5 (12.2)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)		
3-8 (%)	9 (22.0)	0 (0.0)	6 (14.6)	2 (4.9)	1 (2.4)	0 (0.0)	0 (0.0)	0 (0.0)		
Pupillary Reflexes										
Normal (%)	8 (19.5)	2 (4.9)	13 (31.7)	8 (19.5)	1 (2.4)	1 (2.4)	0 (0.0)	0 (0.0)	0.001*	-0.663
Abnormal (%)	7 (17.1)	0 (0.0)	1 (2.4)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)		
Time until Surgery										
d” 24 hours (%)	7 (17.1)	0 (0.0)	8 (19.5)	5 (12.2)	1 (2.4)	1 (2.4)	0 (0.0)	0 (0.0)	0.160	-0.232
> 24 hours (%)	8 (19.5)	2 (4.9)	6 (14.6)	3 (7.3)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)		
Hospitalization (days)										
d” 13 (%)	15 (36.6)	0 (0.0)	5 (12.2)	2 (4.9)	0 (0.0)	1 (2.4)	0 (0.0)	0 (0.0)	0.000*	0.621
> 13 (%)	0 (0.0)	2 (4.9)	9 (22.0)	6 (14.6)	1 (2.4)	0 (0.0)	0 (0.0)	0 (0.0)		
GCS-out										
13-15 (%)	0 (0.0)	0 (0.0)	10 (24.4)	7 (17.1)	0 (0.0)	1 (3.8)	0 (0.0)	0 (0.0)	0.000*	-0.811
9-12 (%)	0 (0.0)	2 (4.9)	4 (9.8)	1 (2.4)	1 (2.4)	0 (0.0)	0 (0.0)	0 (0.0)		
3-8 (%)	15 (36.5)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)		

*$p < 0.05$: statistically significant

Table 4. mRS Distribution

Characteristics	mRS							*p*	*r*
	0	1	2	3	4	5	6		
Gender									
Male (%)	0 (0.0)	0 (0.0)	1 (2.4)	5 (12.2)	8 (19.5)	2 (4.9)	10 (24.4)	0.683	0.069
Female (%)	0 (0.0)	0 (0.0)	0 (0.0)	1 (2.4)	7 (17.1)	2 (4.9)	5 (12.2)		
Age (year)									
< 38 (%)	0 (0.0)	0 (0.0)	1 (2.4)	2 (4.9)	9 (22.0)	1 (2.4)	6 (14.6)	0.475	0.122
e” 38 (%)	0 (0.0)	0 (0.0)	0 (0.0)	4 (9.8)	6 (14.6)	3 (7.3)	9 (22.0)		
Trauma Mechanism									
Traffic Accidents (%)	0 (0.0)	0 (0.0)	1 (2.4)	5 (12.2)	13 (31.7)	3 (7.3)	12 (29.3)	0.585	0.117
Fall (%)	0 (0.0)	0 (0.0)	0 (0.0)	1 (2.4)	1 (2.4)	1 (2.4)	2 (4.9)		
Crushed (%)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (2.4)	0 (0.0)	1 (2.4)		
GCS-in									
13-15 (%)	0 (0.0)	0 (0.0)	1 (2.4)	1 (2.4)	0 (0.0)	0 (0.0)	1 (2.4)	0.067	0.306
9-12 (%)	0 (0.0)	0 (0.0)	0 (0.0)	4 (9.8)	8 (19.5)	3 (7.3)	5 (12.2)		
3-8 (%)	0 (0.0)	0 (0.0)	0 (0.0)	1 (2.4)	7 (17.1)	1 (2.4)	9 (22.0)		
Pupillary Reflexes									
Normal (%)	0 (0.0)	0 (0.0)	1 (2.4)	6 (14.6)	14 (34.1)	4 (9.8)	8 (19.5)	0.001*	0.644
Abnormal (%)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (2.4)	0 (0.0)	7 (17.1)		
Time until Surgery									
d” 24 hours (%)	0 (0.0)	0 (0.0)	1 (2.4)	3 (7.3)	10 (24.4)	1 (2.4)	7 (17.1)	0.324	0.167
> 24 hours (%)	0 (0.0)	0 (0.0)	0 (0.0)	3 (7.3)	5 (12.2)	3 (7.3)	8 (19.5)		
Hospitalization (days)									
d” 13 (%)	0 (0.0)	0 (0.0)	1 (2.4)	2 (4.9)	4 (9.8)	1 (2.4)	15 (36.6)	0.000*	-0.587
> 13 (%)	0 (0.0)	0 (0.0)	0 (0.0)	4 (9.8)	11 (26.8)	3 (7.3)	0 (0.0)		
GCS-out									
13-15 (%)	0 (0.0)	0 (0.0)	1 (2.4)	5 (12.2)	10 (24.4)	2 (4.9)	0 (0.0)	0.000*	0.807
9-12 (%)	0 (0.0)	0 (0.0)	0 (0.0)	1 (2.4)	5 (12.2)	2 (4.9)	0 (0.0)		
3-8 (%)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	15 (36.6)		

*$p < 0.05$: statistically significant

DISCUSSION

Pupillary reflex upon first arrival in this study was associated with outcome, GOSE and mRS. Out of a total of 33 subjects with normal pupil reflexes, 8 people died and 25 others went home alive, while out of 8 subjects with abnormal pupil reflexes, 7 people died and only 1 person survived to go home. The results of this study are supported by research conducted by Sinha et al. and Ziaeirad et al. who found that abnormal pupil reflexes were a strong predictor of mortality in TBI.[9,10] This results from abnormal pupil reflexes associated with elevated ICP and severe brain damage.[11,12]

Additionally, Sinha et al. discovered that TBI patients' treatment outcomes were significantly correlated with the length of their hospital stays.[9] In a similar vein, our study discovered that the longer a patient was treated, the better the outcome (outcome, p=0.000, r=0.558; GOSE, p=0.000, r=0.621; mRS, p=0.000, r=- 0.587). Arango-Lasprilla, et al. found that prolonged hospitalization were associated with better outcomes, though in this study the longer stays were intended to enhance rehabilitation planning, education, and resource utilization.[13]

Gender did not significantly influence outcome (p=0.740), GOSE (p=0.466), or mRS (p=0.683), but it was discovered that men died more frequently than women (r=-0.051) and had worse GOSE and mRS than women (r=-0.123 and r=0.069, respectively). Sinha et al. discovered a relationship between gender and the severity of TBI, with men suffering from more TBI than women (severe TBI, 781:163; moderate TBI, 111:42; mild TBI, 112:27).[9] Ziaeirad et al. (2018) also found that men experienced more TBI than women, but there was no significant relationship between gender and outcome.[10] It is hypothesized that hormonal changes and the neuroprotective properties of estrogen, progesterone, and testosterone are responsible for the insignificance of this relationship. Though some studies claim the opposite, many studies demonstrate that women who suffer a TBI have worse outcomes than men.[14]

The factors gender, age, trauma mechanism, admission GCS, and operation time did not significantly affect the outcome. While Hukkelhoven et al. and Dhandapani et al. found that increasing age was associated to worse outcomes and mortality, Godbolt et al. found no relationship between age and outcome in TBI, supporting the findings of this study.[15–17] This is because the sample they used included all TBI patients, whereas the sample used in this study included TBI patients who were treated by DC. Sinha et al. and Ziaeirad et al. also found that there was no correlation between trauma mechanisms and outcomes in their research.

In this study, 19 patients underwent surgery more than 24 hours after the trauma incident, while 22 patients underwent DC within 24 hours of the trauma incident. The faster the DC is done, the lower the mortality (r=0.103), the better the outcome with GOSE (r=-0.232), and the better the outcome with mRS (r=0.167), but statistically it is not significantly related to the three predictors of outcome. This conclusion is supported by research by Choudhary and Bhargava, who discovered that DC performed within 24 hours of the incident had better results as measured by GOS.[18] The meta-analysis conducted by Fatima et al. also discovered that early DC reduced mortality even though there was no statistically significant difference in the outcomes of functional clinicians between the group that underwent early DC and the group that received standard medical therapy combined with late DC.[6]

Finally, this study provides a summary of the results of TBI patients undergoing DC procedures as well as a number of factors that are believed to affect these results. Given its numerous limitations, including its small sample size, the vast number of additional prognostic factors that were left out or even ended up becoming confounding variables, and the authors' minimal statistical processing skills, this study is thus anticipated to serve as a reference for future research.

CONCLUSION

Traffic accidents are the most frequent cause of traumatic brain injury (TBI) and are more common in men. The average age of the 41 TBI patients treated by decompressive craniectomy (DC) at the West Nusa Tenggara Province General Hospital was 36.1 years, and more of them were older than 38. The results of the correlation test indicated that pupillary reflexes, length of stay, and GCS at hospital discharge were related to outcome, GOSE, and mRS, but that gender, age,

mechanism of trauma, admission GCS, and time of operation were not significantly related to outcome, GOSE, or mRS. Nonetheless, the trend in this study showed that younger age, higher GCS, and earlier surgery time showed better outcomes as assessed by mortality, GOSE and mRS.

ACKNOWLEDGEMENT

A contributed in conception and design of the study, data acquisition, data analysis, and data interpretation. A draft the article and revised it critically for important intellectual content. Every contributor who participated in the research takes public responsibility for the appropriate content of the manuscript.

Conflict of Interest

The authors declare no conflicts of interest or financial interest in any product or service mentioned in this article.

Funding Sources

No financial support was provided for this study.

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