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RESEARCH

Outcome of Traumatic Brain Injury Patients with EDH, SDH, and ICH Bleeding Undergoing Craniotomy Surgery at Dr. General Sardjito Hospital, Yogyakarta

Muhammad Fiqih Hidayat, Akhmad Yun Jufan, Sudadi
Department of Anesthesiology and Intensive Therapy Faculty of Medicine, Public Health, and Nursing, Universitas Gadjah Mada Dr. Sardjito Hospital Yogyakarta, Indonesia
*Corresponding author: Muhammad Fiqih Hidayat, Department of Anesthesiology and Intensive Therapy Faculty of Medicine, Public Health, and Nursing, Universitas Gadjah Mada Dr. Sardjito Hospital Yogyakarta, Indonesia (piqimonkey@gmail.com)

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ABSTRACT

Background: Traumatic brain injuries (TBI) are clinically divided into primary and secondary. Primary TBI is a direct impact of trauma such as epidural hematoma (EDH), subdural hematoma (SDH), and intracranial hematoma (ICH). The clinical outcomes of TBI patients can be assessed using the Glasgow Outcome Scale- Extended (GOSE) scale and are influenced by various factors, one of which is the type of patient's brain hemorrhage. GOSE is a post-treatment outcome scale for traumatic brain injury patients.
Objective: To determine the differences in clinical outcomes in traumatic brain injury patients with different types of brain hemorrhage after undergoing craniotomy surgery.
Methods: This study employed a prospective observational cohort design. The sampling technique used whole sampling of traumatic brain injury patients undergoing craniotomy surgery at Dr. Sardjito General Hospital Yogyakarta between May and October 2024 with CT Scan images of brain hemorrhage in the form of SDH, EDH, or ICH. Then the patient's clinical outcomes were observed using the Glasgow Outcome Scale – Extended (GOSE). The samples taken met the inclusion criteria of age > 18 years, experiencing traumatic brain injury requiring craniotomy, and the presence of one type of brain hemorrhage, namely EDH, SDH, or ICH with exclusion criteria in the form of incomplete medical record data and CT Scan results in other pathological images.
Results: A total of 36 subjects met the inclusion and exclusion criteria. EDH was the dominant type of TBI (72.2%), followed by SDH (19.4%) and ICH (8.3%). The mean age of the subjects was 22.25±16.91 years. The majority of subjects had good TBI outcomes (86.1%), which were reported for SDH (100%), EDH (84.61%), and ICH (66.6%). There was no significant association between age (p=0.53), gender (p=0.63), TBI CT Scan appearance (p=0.34), and GCS (p=0.54) with TBI patient outcomes.
Conclusion: The majority of TBI patients who undergo craniotomy have good outcomes. This study found no statistically significant differences in TBI patients outcomes between patients with CT Scan showing EDH, SDH, and ICH who underwent craniotomy as assessed by the Glasgow Outcome Scale–Extended (GOSE).

Keywords: Craniotomy, GOSE, traumatic brain injury, types of brain hemorrhage.

INTRODUCTION

Traumatic brain injury (TBI) is defined as a change in brain function or brain pathology caused by external force. TBI is a global health problem with high morbidity and mortality rates.[1] Intracranial hemorrhages, such as epidural hemorrhage (EDH), subdural hemorrhage (SDH), subarachnoid hemorrhage (SAH), and intracerebral hemorrhage (ICH), are common complications and require immediate treatment. Intracranial hemorrhage occurs in 25–45% of patients with severe TBI, 3–12% of those with moderate TBI, and approximately 1 in 500 patients with mild TBI. EDH, SDH, and ICH are the most common types of intracranial hemorrhage.[1,2] EDH, SDH, and ICH have distinct pathophysiological characteristics and prognoses.

EDH is typically acute and has a better prognosis if treated promptly. Patients with EDH have a lower mortality rate (12%) compared to those with SDH (50–70%) and ICH (80%). This is because EDH often occurs in isolation, whereas SDH and ICH involve the brain parenchyma, which is more complex and may lead to significant complications. However, studies comparing patient outcomes based on the type of intracranial hemorrhage remain limited, particularly in Indonesia.[3]

Decompressive craniotomy is one of the treatment options for TBI with intracranial hemorrhage. This procedure aims to reduce intracranial pressure, control bleeding, and prevent further brain damage. However, clinical outcomes after craniotomy may be influenced by the type of intracranial hemorrhage, surgical technique, injury severity, and the patient's preoperative and postoperative condition.[4] The outcomes of patients with traumatic brain injury can be assessed using the Glasgow Outcome Scale-Extended (GOSE), an updated version of the Glasgow Outcome Scale (GOS). While the GOS consists of only five outcome categories, the GOSE provides eight levels of outcomes for TBI patients.[5] The GOSE ranges from 1 to 8 and includes death, vegetative state, lower severe disability, upper severe disability, lower moderate disability, upper moderate disability, lower good recovery, and upper good.[4]

METHODS

This study used a prospective observational design with a cohort approach. It is part of a multicenter study entitled "Post-Surgical Outcome Profile of Traumatic Brain Injury Patients in Indonesia", conducted by the College of Anesthesiology and Intensive Care across 17 hospitals in Indonesia. Data collection in this multicenter study aimed to identify clinical profiles associated with outcomes in TBI patients in Indonesia. Researchers observed and collected CT Scan variables at baseline, followed by prospective follow-up to assess clinical outcomes in each patient. This study was conducted at Dr. Sardjito General Hospital after obtaining ethical approval from the Research Ethics Committee of the Faculty of Medicine, Public Health, and Nursing, Universitas Gadjah Mada, and a research permit from the Research and Clinical Department of Dr. Sardjito General Hospital. The study period was from May to November 2024.

The target population of this study included all patients with traumatic brain injury who underwent craniotomy at Dr. Sardjito General Hospital, Yogyakarta. The accessible population consisted of TBI patients with intracranial hemorrhage treated between May 6, 2024, and November 30, 2024, at the same hospital. The study sample comprised patients from the accessible population who met the inclusion and exclusion criteria. The inclusion criteria were: age >18 years, TBI patients undergoing craniotomy, and patients who underwent non-contrast head CT Scans showing a single type of intracranial hemorrhage (EDH, SDH, or ICH).

Demographic data (numeric variables) are presented as means and standard deviations, while categorical data are presented as frequencies and percentages. Normality testing was performed using the Shapiro–Wilk or Kolmogorov–Smirnov test to determine whether the data were normally distributed. Bivariate analysis for numeric data (age) was performed using the Student's t-test for normally distributed data or the non-parametric Mann–Whitney test for non-normally distributed data. The chi-square test was used to assess the association between nominal variables (gender,

CT Scan findings of intracranial hemorrhage, and GCS) and TBI outcomes. Multivariate analysis was performed when variables with a p-value <0.25 were identified, using binomial logistic regression to evaluate the relationship between independent and dependent variables simultaneously. A one-tailed hypothesis was applied with an α value of 5% and β of 10%, and statistical significance was set at p <0.05.

RESULT

A total of 139 patients with traumatic brain injury (TBI) met the inclusion criteria for analysis. Most patients (48.9%) did not undergo craniotomy. Eighty-three patients (59.7%) had mixed types of intracranial hemorrhage (i.e., more than one type). Thirty-six patients had a single type of hemorrhage.

Characteristics and Outcomes of the Study Subjects

The majority of subjects were male (63.9%), with a mean age of 22.25 ± 16.91 years. Analysis by hemorrhage type showed that EDH, the most common type of TBI, predominantly occurred in males (44.4%) and had the youngest mean age (19.38 ± 14.05 years). In comparison, SDH cases had a mean age of 25.00 ± 21.64 years, while ICH cases had the oldest mean age (40.67 ± 22.23 years), Table 1.

Patient outcomes were assessed using the Glasgow Outcome Scale-Extended (GOSE), which ranges from 1 (death) to 8 (good recovery). The best outcomes (GOSE score of 8) were observed in patients with SDH (30.7%) and EDH (69.23%), whereas patients with ICH achieved a maximum GOSE score of 5 (33.3%). A GOSE score of 1 was observed in one patient each in the EDH and ICH groups. In contrast, the lowest GOSE score observed in SDH cases was 5 (16.6%), Table 2.

Association Between Variables and Study Outcomes

Bivariate analysis showed no statistically significant association between CT Scan findings and TBI patient outcomes (p = 0.34). All patients with SDH (100%) had favorable outcomes. Favorable outcomes were also observed in the majority of patients with EDH (84.61%) and ICH (66.6%), table 3.

Table 1. Characteristics and Outcomes of the Subjects

No	Variable	N(%)	Mean±SD
1	Age (Years)		22.25±16.91
2	Gender		
	Male	23(63.9)	
	Female	13(36.1)	
3	CT Scan Findings		
	SDH		
	EDH	7(19.4)	
	ICH	26(72.2)	
		3(8.3)	
4	Mean Age by Hemorrhage Type		
	SDH	250±21.64	
	EDH	19.38±14.05	
	ICH	40.67±22.23	
5	GCS Classification		
	Mild	23(63.9)	
	Moderete	6(16.7)	
	Severe	7(19.4)	

Table 2. Distribution of Outcomes in Subjects Based on CT Scan Images

CT scan Images	TBI Patient Outcomes		P
	Good N(%)	Poor N (%)	
SDH	7(100)	0,(0)	0,34
EDH	22 (84,61)	4 (15,38)	
ICH	2(66,6)	1(33,3)	
Total	31 (86,1)	5(13,8)	

Table 3. Relationship Between CT Scan Images and TBI Patient Outcomes

CT Scan Images	TBI Patient Outcomes		P
	Good N(%)	Poor N(%)	
SDH	7(100)	0(0)	0.34
EDH	22(84.61)	4(15.38)	
ICH	2(66.6)	1(33.3)	
Total	31(86.1)	5(13.8)	

Table 4. Bivariate Analysis of the Relationship between Variables and TBI Patient Outcomes

No	Variable	[N(%) Mean ±SD]		P
		Poor GOSE	Good GOSE	
1	Age (Yars)	24.00±	21.97±17.26	0.53
2	Sex			
	Male	4(21.05)	19(78.94)	0.63
	Female	1 (8.3)	12(91.6)	
3	Initial GCS			
	Mild	4(17.39)	19(82.6)	
	Moderate	0(0)	6(100.0)	
	Severe	1(14.28)	6(85.71)	

There was no statistically significant difference in mean age between subjects with poor and favorable outcomes (p = 0.53). Subjects with poor outcomes had a slightly higher mean age (24.00 ± 16.23 years) compared to those with favorable outcomes (21.97 ± 17.26 years). Additionally, no significant associations were found between age, gender, CT Scan findings, or GCS and TBI outcomes (p > 0.05), table 4.

Association Between Variables

GCS analysis based on CT Scan findings showed variation across different types of TBI hemorrhage. Most patients had a mild initial GCS. However, no significant association was found between CT Scan findings and GCS. Additionally, no statistically significant association was observed between gender and CT Scan findings. EDH was the most common type of intracranial hemorrhage observed in both males (44.4%) and females (27.7%). The mean ages of subjects with SDH, EDH, and ICH differed significantly (p = 0.009), with SDH having the youngest mean age (25.0 ± 13.34 years) and ICH the oldest (63.0 ± 17.34 years), table 5.

Table 5. Subject Characteristics Based on CT Scan Image Type

No	Variable	CT Scan Images			P
		SDH	EDH	ICH	
1	GCS				
	Mild	5(60)	16(61.53)	2(66.6)	0.55
	Moderete	2(40)	4(15.38)	0(0)	
	SEvere	0(0)	6(23.07)	1(33.3)	
2	Sex				
	Male	5(40)	16(61.53)	2(66.6)	0.88
	Female				
3	Mean Age	25±3.34	31.22 ±13.8	63.0± 17.34	0.009

DISCUSSION

This study found that TBI patients with CT Scan findings of intracranial hemorrhage had a mean age of 22.25 ± 16.91 years. The most common type of hemorrhage was EDH (72.2%), followed by SDH (19.4%) and ICH (8.3%).[6] The majority of patients (86.1%) achieved a Glasgow Outcome Scale-Extended (GOSE) score of 5–8, indicating moderate disability to good recovery. Based on initial GCS characteristics, 63.9% of subjects had mild GCS scores (13–15). Most patients (86.1%) had a favorable GOSE outcome (score 5–8), while only 5 subjects (13.9%) had poor outcomes (score 1–4). No significant association was found between GOSE and TBI type based on CT Scan findings of intracranial hemorrhage (p = 0.17). The highest proportion of favorable outcomes was observed in patients with SDH (100%) and EDH (84.6%).

This study found the mean ages for SDH, EDH, and ICH to be 25.0 ± 3.34 years, 31.22 ± 13.8 years, and 63.0 ± 17.34 years, respectively. These results differ from those of several previous studies. Earlier research reported a younger mean age for EDH subjects—specifically 27.1 years compared to the present study.[7] Another study found an older mean age for SDH cases, reaching 56 years for males and 68 years for females.[8] Meanwhile, a different study reported a younger mean age for ICH cases—26.8 ± 7.4 years—than that found in this study.[9] Other studies have also reported varying mean ages; a case series of 12 head injury cases in Indonesia reported mean ages of 40.6 years for EDH patients and 13.42 years for SDH patients.[10]

Age may influence TBI outcomes through reduced neuroplasticity and the presence of comorbidities in older patients. Younger patients (<40 years) tend to have greater regenerative capacity and lower mortality, whereas older patients (>65 years) have a higher risk of poor outcomes due to brain atrophy, impaired blood–brain barrier integrity, and increased

frailty, which may exacerbate hemorrhage and ischemia. Previous studies have shown poorer outcomes in older adults with similar injury severity.[3] However, in this study, no significant association was found between age and GOSE outcomes after craniotomy in TBI patients (p = 0.53).

The majority of TBI patients were male (63.9%). The highest proportion of males was observed in ICH (66.6%), followed by EDH (61.53%) and SDH (40%). Gender may influence TBI outcomes through hormonal modulation and vascular responses. In men, higher testosterone levels may exacerbate neuroinflammation and the secondary injury cascade following TBI, potentially leading to poorer outcomes. In contrast, estrogen in women has neuroprotective effects by reducing oxidative stress and apoptosis. Previous studies have reported better recovery of consciousness in women, despite no differences in initial GCS or CT Scan findings.[11] However, no significant association was found between gender and GOSE outcomes (p = 0.63).

No significant differences in TBI outcomes were observed across different CT Scan findings. Poor GOSE outcomes were found in patients with EDH and ICH, with proportions of 15.38% and 33.3%, respectively. Most patients achieved a GOSE score of 8, particularly those with SDH (30.7%) and EDH (69.23%). Additionally, no statistically significant association was found between GCS and TBI outcomes (p = 0.54).

A mild initial Glasgow Coma Scale (GCS) score was most commonly observed in patients with EDH (61.53%). EDH was associated with the highest proportion of mild GCS scores (13–15), indicating relatively preserved neurological function at presentation. However, statistical analysis showed no significant association between GCS and lesion type (p = 0.55). Similar findings have been reported in previous studies, where patients with good GCS were predominantly those with EDH (43%).[12] EDH is often associated with better initial GCS scores, with prior studies reporting that 70–90% of EDH cases had an initial GCS >8.[13]

The distribution of GCS among TBI patients based on hemorrhage type showed a predominance of mild to moderate GCS scores. In SDH, 40% of patients had moderate GCS and 60% had mild GCS. In EDH, 23.07% had severe GCS, 15.38% had moderate GCS, and 61.53% had mild GCS. In contrast, 33.3% of patients with ICH had severe GCS and 66.6% had mild GCS, with no cases of moderate GCS observed.[13]

This study found no statistically significant association between GCS and TBI patient outcomes (p=0.54). These results differ from a previous study that identified a significant correlation between admission GCS and GOSE (p=0.024). That study found a positive correlation between GCS and GOSE (r=0.29), indicating that higher GCS scores were associated with better TBI patient outcomes.[14] The findings also differ from another study examining outcomes in patients with traumatic SDH, which found a statistically significant association between admission GCS and TBI patient outcomes (p=0.006), with mild GCS scores associated with better outcomes compared to moderate and severe GCS scores.[15]

Several limitations should be noted: 1) the number of subjects who met the inclusion and exclusion criteria was limited; 2) This study was conducted at a single center; therefore, the small sample size may not be representative of the broader TBI population, particularly for comparative analysis of patient outcomes; 3) There are several variables that have not been included in the study, such as the volume of intracranial bleeding, the degree of midline shift, the time interval between trauma and craniotomy, patient comorbidities, anticoagulant use, as well as perioperative management.

CONCLUSION

There was no statistically significant difference in outcomes among TBI patients with CT Scan findings of EDH, SDH, and ICH. Furthermore, no significant associations were found between age, gender, CT Scan findings of intracranial hemorrhage, and GCS and TBI outcomes. In addition, CT Scan findings of intracranial hemorrhage were not significantly associated with age, gender, or GCS.

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