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Intracranial Hemorrhage Prediction for Traumatic Brain Injury Using Glasgow Comma Scale: Encountering the Absence of CT Scan

Rachmi Fauziah Rahayu[1]*, Luths Maharina[1], Adam Prabata[2], Muchtar Hanafi[1], Yuyun Yueniwati[3], Diah Pramudianti[4], Ida Prista Maryetty[1], Ropitasari Ropitasari[5]

[1]Department of Radiology, Faculty of Medicine, Universitas Sebelas Maret, Dr. Moewardi Hospital, Surakarta, Indonesia; [2]Cardiovascular Division, Graduate School of Medicine, Kobe University, Kobe, Japan; [3]Department of Radiology, Faculty of Medicine, Universitas Brawijaya, Dr. Saiful Anwar Hospital, Malang, Indonesia; [4]Department of Clinical Pathology, Faculty of Medicine, Universitas Sebelas Maret, Dr. Moewardi Hospital, Surakarta, Indonesia; [5]Diploma III of Midwifery, Faculty of Medicine, Universitas Sebelas Maret, Surakarta, Indonesia

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***Correspondence:** Rachmi Fauziah Rahayu, Department of Radiology, Faculty of Medicine, Dr. Moewardi Hospital, Universitas Sebelas Maret, Surakarta, Indonesia. E-mail: rachmifr_sprad@staff.uns.ac.id
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Abstract

BACKGROUND: Intracranial hemorrhage is a complication of head injury. The initial assessment of the consciousness using Glasgow Coma Scale (GCS) shows severity level of head injury since arriving to the hospital. The GCS score is also known to have association with the presence of intracranial bleeding caused by head injury.

AIM: This finding helps doctor lived in rural area with no facility of computed tomography (CT) scan to predict the intracranial hemorrhage by assessing the level of consciousness correctly using GCS score.

METHODS: This study is an observational analytic study using a cross-sectional design. The research was conducted in Dr. Moewardi Hospital for 6 months starting from July to October 2020. The population was all patients with head injury and was, then, examined by CT scan of head. The 61 subjects were established through the inclusion and the exclusion criteria.

RESULTS: There were 61 patients in this study. The reliability test of CT scan instrument used Kappa–Cohen test which showed K = 0.875 with $p < 0.001$. The finding of moderate-severe head injury (GCS score 3–12) was associated with the increased risk of intracranial bleeding in head CT scan by 20.70 (5.58–76.77) times significantly higher ($p < 0.001$).

CONCLUSION: There is significant relationship between the patient's level of consciousness represented by GCS and the intracranial bleeding based on the head CT scan in the patients with head injuries.

Introduction

Head injury or known as Traumatic Brain Injury is a case of head trauma with an increasing incidence every year [1]. Global Burden of Disease (2016), Traumatic Brain Injury, and Spinal Cord Injury Collaborators (2019) stated that there were 27 million new cases of head injury in 2016 [2]. Head injuries were known to cause disability in more than 8 million individuals. This data might be lower than the actual data, because many cases of head injuries often could not reach healthcare facilities. In the United States (US), head injury is one of the biggest causes of death and disability. From 2006 to 2014, the incidence of head injuries in US increased by 53% with more than 2 million hospital emergency room (ER) visits with an average of 155 people dying every day [3].

Level of consciousness assessed by Glasgow Coma Scale (GCS) is one example of examination used to determine the severity of head injury within hospital admission [4]. The GCS score at hospital admission can also be used as the scale to predict mortality within 30 days after intracranial hemorrhage in head injury [5]. GCS scores also have an association with the presence of intracranial hemorrhage in the head injuries to predict the level of dependency after going back to home [6].

Inequality of medical devices distribution including computed tomography (CT) scans is a problem faced in Indonesia, especially in remote areas. Head CT scan examination to determine the presence of intracranial bleeding in the patients with head injuries cannot be performed in every health facility due to this inequality. Intracranial hemorrhage predictors that are inexpensive and easy to use are urgently needed in Indonesia to increase the preparedness of medical staff to anticipate intracranial bleeding caused by head injury [7]. Therefore, the authors wanted to know the relationship between the patient's level of consciousness represented in the GCS scale with the findings of intracranial hemorrhage based on head CT scan examinations to determine the effectiveness of GCS as a predictor of intracranial bleeding caused by head injuries.

Methods

This study was an observational analytic study using a cross-sectional design approach. This research was conducted in RSUD Dr. Moewardi Surakarta with a period of 6 months starting from July–October 2020. The target population in this study consisted of all traumatic brain injury patients who had undergone GCS assessment and head CT scan examination. All subjects were finally treated in the surgical ward of Dr. Moewardi Hospital Surakarta during the study period of July–October 2020. The subject who had met the inclusions and exclusions criteria recruited until the minimum required subject was fulfilled. All patients recruited had agreed to be the study's subjects. This study had been approved by the Ethical Committee of Dr. Moewardi Hospital number 834/VII/HREC/2020.

The sampling technique used the consecutive sampling. Subjects who met the inclusion criteria which consisted of the minimum age 18 years old or more, diagnosed with head injury due to trauma, underwent a head CT scan and GCS assessment. The exclusion criteria are being diagnosed with brain tumor, uncomplete medical record, and the history of ischemic or hemorrhagic stroke. Medical record data were collected and grouped according to predefined categories using Microsoft Excel 2010. The assessment of intracranial hemorrhage was done by two radiologist who had experienced 1–5 years. The data were, then, analyzed statistically using SPSS version 25.0.

Data analysis began with a study of the subjects' characteristic to determine the subject's group. Based on the category, the data in this study could be divided into two, namely, numerical and nominal [8]. Numerical data were presented in accordance with the results of the normal distribution test which was carried out with the Saphiro–Wilk Test. Numerical data with normal distribution was, then, presented in the mean and deviation standard format, while those with non-normal distribution were presented in the median format (min-max). Nominal data are presented in the format of amount (n) and percentage (%).

The relationship between the dependent and independent variables was carried out using hypothesis testing of Chi-square when the 2 × 2 table of this study meets the requirements and using the Fiscer's Exact test if the 2 × 2 table did not meet the requirements. This study used the value of 0.05 and 95% of confidence interval, resulting in the definition of p-value as follows:

- $p < 0.05$ meant statistically significant relationship
- $p > 0.05$ meant statistically unsignificant relationship.

Results

Head CT scan instrument was used to assess intracranial hemorrhage. The head CT scan instrument reliability test was carried out before the instrument was used using Kappa–Cohen test. The reliability test is presented in Table 1.

Table 1: Computed tomography scan instrument reliability test

Appraiser 2	Appraiser 1		p-value	*K*
	Intracranial hemorrhage	No intracranial hemorrhage		
Intracranial hemorrhage	5	0	<0.001	0.875
No intracranial hemorrhage	1	14		

The reliability test of the head CT scan instrument for intracranial hemorrhage showed K value of 0.875 with $p < 0.001$. The results of the reliability test indicate that the head CT scan instrument used in this study had met the requirements. The characteristics of the subjects in this study are presented in Table 2.

Table 2: Subjects characteristic

Variable	Total, *n* (%)
Age (years)	37.7 ± 16.1 (100)
Sex	
Male	48 (78.7)
Female	13 (21.3)
Intracranial hemorrhage	
Present	33 (54.1)
Not present	28 (45.9)
GCS	
3–12 (moderate-to-severe brain injury)	32 (52.5)
13–15 (mild brain injury)	29 (47.5)
Maxilla-facial fracture	
Present	42 (68.9)
Not present	19 (31.1)
Subfalcine herniation	
Present	23 (37.7)
Not present	38 (62.3)
Calvaria fracture	
Present	24 (39.3)
Not present	37 (60.7)
Cerebral edema	
Present	36 (59.0)
Not present	25 (41.0)

GCS: Glasgow Coma Scale.

There are 61 subjects in this study. Table 2 presents the characteristics of the subjects consisting of age, gender, intracranial hemorrhage, GCS, maxillofacial trauma, subfalcine herniation, calvaria fracture, and cerebral edema. The mean age of the subjects was 37.7±16.1 years. There were 48 (78.7%) men and 13 (21.3%) women. There were 33 (54.1%) patients with intracranial bleeding and 28 (45.9%) patients without intracranial bleeding. Based on the GCS, there were 32 (52.5%) patients with a GCS score of 3–12 (moderate-severe head injury), as represented in Figures 1 and 2, while 29 (47.5%) patients with a GCS score of 12–15 (mild head injury) are represented in Figure 3.

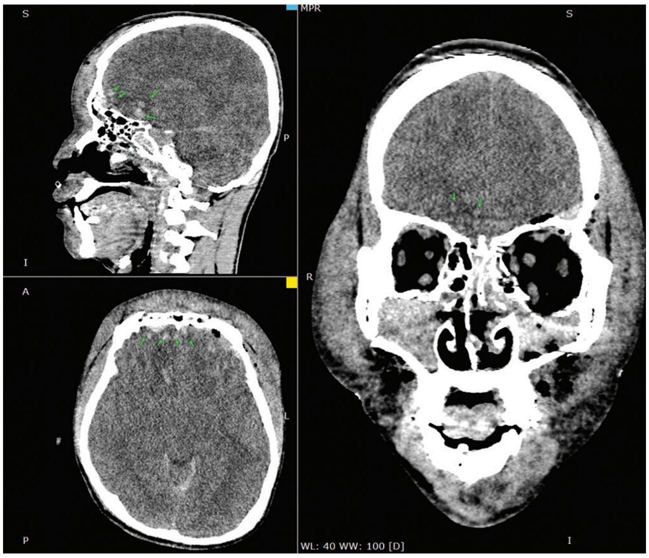

Figure 1: Multiple intracranial hemorrhages (intracerebral and subarachnoid hemorrhages) in moderate head injury with GCS score 12

There were 42 (68.9%) patients with maxillofacial fracture and 19 (31.1%) patients without maxillofacial fracture. There were 23 (37.7%) patients with subfalcine herniation and 38 (62.3%) patients without subfalcine herniation. There were 24 (39.3%) patients with calvaria fracture and 37 (60.7%) without calvaria fracture. There were 36 (59.0%) patients with cerebral edema and 25 (41.0%) without cerebral edema.

The relationship between the classification of GCS scores (moderate-severe head injury and mild head injury) and head CT scan findings, including intracranial hemorrhage in traumatic brain injury, is presented in Table 3.

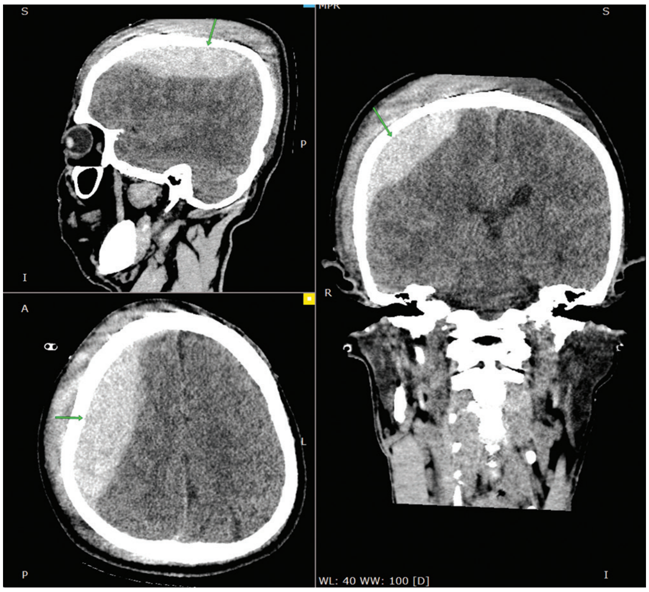

Figure 2: The epidural hemorrhage of severe head injury resulting in midline shifting to the left

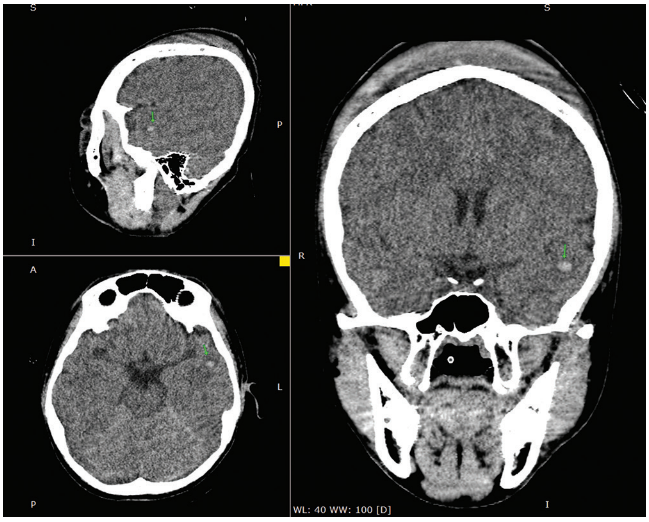

Figure 3: Intracerebral hemorrhage of the left temporal lobe in mild head injury with GCS score 14

Discussion

Based on statistical analysis, the GCS score with a moderate-severe classification (GCS 3–12) predicts the presence of head CT scan findings in the form of intracranial hemorrhage. The finding of moderate-severe head injury (GCS score 3–12) was associated with an increased risk of finding intracranial hemorrhage on CT scan examination of the head by 20.70 (5.58–76.77) times significantly higher (p < 0.001). This study found that GCS <12 or moderate-severe head injury was one of the predictors of intracranial bleeding with an increased risk of 20.70 (5.58–76.77) times higher than that of GCS >13 or mild head injury. GCS, which is classified into mild, moderate, and severe head injury, is one of the predictors that can be used to determine the occurrence of intracranial bleeding. Another study found that head trauma patients with GCS 3–8 had 82% risk of intracranial hemorrhage, GCS 9–12 had 65% risk, and GCS 13–14 had 50% risk. Besides, it was stated that head injury patients with GCS <13 had 6.2 times higher risk of intracranial bleeding so that a decrease in GCS more than two points could be used as a clinical predictor of intracranial bleeding in head injury patients.

The cerebral trunk is composed of many clusters of nerve cell bodies between myelinated axons [9], [10]. The area, where the nerve cell bodies and myelinated axons are arranged as a web-like structure, is known as the reticular formation. The reticular formation extends from the spinal cord to the

Table 3: Relationship between Glasgow Coma Scale and intracranial hemorrhage

GCS classification	Intracranial hemorrhage		p-value	OR (95% CI)
	Present	Not present		
Moderate-severe head injury (GCS 3–12)	27	5	<0.001	20.70 (5.58–76.77)
Mild head injury (GCS 13–15)	6	23		

OR: Odds ratio, CI: Confidence interval, GCS: Glasgow coma scale.

inferior border of the thalamus. From the thalamus, reticular formation continues as an ascending pathway to the cerebral cortex as the Ascending Reticular Activating System (ARAS) [11]. The ARAS pathway functions as a pathway that carries visual, auditory, pain, temperature, and pressure input to the cerebral cortex. ARAS also plays a role in individual mental activity [12]. He cerebral cortex will send back the sensory input which manifests as awareness continuous. So that the main function of ARAS is to maintain awareness, which is a state, in which an individual is fully awake, alert, aware, and oriented.

Impaired consciousness occurs as a result of structural or non-structural lesions resulting in impaired function of the ARAS and/or cerebral hemispheres [13]. In general, the mechanism of impaired consciousness includes structural lesions and non-structural lesions or diffuse encephalopathy; then, structural lesions are further subdivided into supratentorial structural lesions and subtentorial structural lesions summarizing the entire causes of loss of consciousness [14], [15]. Traumatic brain injury has effects ranging from cerebral edema to intracranial hematomas that have a pressing effect on the brain. Besides, traumatic brain injury blocks the signals transmission [16] including signals related to consciousness. The level of consciousness assessed through visual, verbal, and movement responses using Glasgow Comma Scales.

The limitation of this study was on the cross-sectional design which could not be determined causal relationship among variables. Data analysis of this study was only able to show the relationship between GCS scores and head CT scan findings in head trauma patients. Significant findings in this study could be influenced by various confounding factors whose data were not taken and not included in the analysis.

Conclusion

The results of this study indicate that there is significant relationship between GCS score and head CT scan findings in traumatic brain injury including intracranial hemorrhage. This significant relationship proposes the importance of GCS score less than 12 as a predictor of intracranial bleeding in head trauma patients detected by CT scan. We conclude that there is significant relationship between patient's level of consciousness represented by GCS with intracranial hemorrhage findings based on results of a head CT scan in traumatic brain injury patients.

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