Nusantara Medical Science Journal
Volume 6 Issue 1, January - June 2021
P-ISSN: 2460-9757, E-ISSN: 2597-7288
Nationally Accredited Journal, Decree No. 36/E/KPT/2019.

Original Article Template

COMPARISON OF HELSINKI CT AND ROTTERDAM CT SCORING SYSTEMS AS PROGNOSTIC FACTORS OF BRAIN INJURY

Kenny Edward Yap[1], Andi Asadul Islam[2], Andi Ihwan[2], Junus Asiu Bulu Baan[3], Firdaus Hamid[4]

[1] *Department of Surgery, Faculty of Medicine, Hasanuddin University*
[2] *Neurosurgery Division, Department of Surgery,Faculty of Medicine, Hasanuddin University*
[3] *Department of Radiology, Faculty of Medicine, Hasanuddin University*
[4] *Microbiology Department, Faculty of Medicine, Hasanuddin University*

Corresponding Author:
Name : Kenny Edward Yap
Email : kennyedwardyap@yahoo.com

ARTICLE INFO

Keywords:
Brain Injury;Helsinki CT; Rotterdam CT; Computerized tomography ; prognostic;

How to cite:
Yap K., Islam A ., Ihwan A., Baan J., Hamid F. (2021). Comparison of Helsinki CT and Rotterdam CT Scoring Systems as Prognostic Factors of Brain Injury. Nusantara Medical Science Journal. 2021; 6(1): 33-43.

DOI:
10.20956/nmsj.v6i1.13967

ABSTRACT

Introduction: *Brain injury is a major cause of death and disability. Computerized Tomography (CT) scanning of the brain is essential for diagnostic screening in need of neurosurgical intervention and also provide information about patient prognosis.* ***Methods:*** *This study is a retrospective study design to assess the comparison of the CT scan scoring system of the head with the prognostic factors of brain injury. Head CT Scans were assessed according to the following Rotterdam and Helsinki CT Scores. All patients were managed according to standard guidelines. Surgery was performed as indicated. The primary objective was mortality assessed using the Glasgow Outcome Scale (GOS) at discharge and 3 months after.* ***Results****: Altogether, 60 patients were included. The results of the ROC analysis of the two CT scoring systems, the Helsinki score provided a better sensitivity score> 80% compared to the Rotterdam score, with a positive predictive value of around 74% each for assessing the outcome (GOS) of brain injury patients* ***Conclusions:*** *The Helsinki score scoring system provides a better sensitivity compared to the Rotterdam score*

1. INTRODUCTION

Brain injury is a major cause of death and disability, as well as a health and social problem in many countries around the world. Brain injury is defined as a non-degenerative and non-congenital disease caused by a mechanical mass from outside the body. This injury will result in impaired cognitive and psychosocial functioning, which can occur temporarily or permanently and can lead to decreased consciousness.[1,2]

Brain injury causes death in half of patients due to trauma. Approximately 75% of accident-victim patients show evidence of brain injury at postmortem.[3] The World Health Organization (WHO) predicts that by 2030, brain injury will become a cause of disability and death globally.[4]

Brain injury is often called the silent epidemic. Brain injuries occur every 15 seconds in the United States, resulting in 1.7 million new patients each year. This results in 50,000 deaths, 80,000 individuals with permanent disabilities and costs over USD 77 billion annually.[5] Based on *National Basic Health Research* 2013 data, the highest prevalence of brain injury in Indonesia nationally was found in South Sulawesi with falls and motorcycle accidents being the most common causes of injury.[6] Epidemiological data on brain injury in Makassar, particularly at Wahidin Sudirohusodo Hospital showed 861, 817, and 1078 cases in 2005 until 2007, respectively.[7]

Brain injury has different causes, pathologies, severity and prognosis, resulting in unclear patient outcomes. Therefore, a reliable predictor of outcome is needed that can provide realistic information for the patient's family, for efficient design and analysis of clinical trials, and can provide a reference for assessing the quality of health care providers.[8] Computerized Tomography (CT) scanning of the brain is essential for diagnostic screening in need of neurosurgical intervention and also provide information about patient prognosis.

The Rotterdam score has been developed to predict the 6-month mortality of traumatic brain injured patients, but cannot assess the long-term neurological or mortality outcome of these patients. To use a prognostic CT model in predicting long-term outcomes including mortality and adverse neurological outcomes, Rahul et al redesigned and proposed an assessment of the Helsinki CT score based on data from 869 patients in 2014.[4] To the best of the authors knowledge, there have not been many studies comparing these two CT scoring systems as prognostic factors for mild, moderate and severe traumatic brain injury. Therefore, researchers are interested in conducting this research. We specifically aimed to evaluate the performance of two head CT classification systems Rotterdam CT score and Helsinki CT score in predicting 3-months functional outcome with brain injury outcome predictors.

2. METHODS

This study is a retrospective study design to assess the comparison of the CT scan scoring system of the head with the prognostic factors of traumatic brain injury. We analyzed 60 patients admitted to the emergency room with severe, moderate, and mild traumatic brain injury during the period of 1st January 2020 to 30th June 2020. The study was conducted after the ethical clearance approvement by the Health Research Ethics Commission of the Medical Faculty of Universitas Hasanuddin. Inclusion criteria included all brain injury patients who are treated at the Emergency Room of Wahidin

Sudirohusodo Hospital who underwent head CT Scan within less than 24 hours after onset of trauma.

Patients under 10 years or over 60 years old, multiple trauma, brain injury with other comorbid disease were excluded from this study. All patients were managed according to standard guidelines. Surgery was performed as indicated. Primary objective was the mortality assessed using the Glasgow Outcome Scale (GOS) at discharge and 3 months after. GOS consists of 5 categories: death, vegetative state, severe disability, moderate disability, and good recovery (Supplementary Table 1). We dichotomized outcome into unfavorable (GOS 1) and favorable (GOS 2–5) for the analysis.

Variables collected included demographic data, namely age and sex, Glasgow Coma Scale (GCS) scores, and present surgery or not. A plain CT scan of the brain was done for all the patients, which was used to assign individual CT scores. The CT scans were reviewed by the first author, consultant neurosurgeon and neuroradiologist. The CT parameters collected included midline shift (MLS), status of suprasellar cisterns, subarachnoid haemorrhage (SAH), intraventricular haemorrhage (IVH) and mass lesions. The term mass lesion included all SDHs, EDHs, and ICHs, of any size. A large mass lesion was defined as any SDH, EDH, or ICH >25 cm^3 and a small mass lesion was defined as any aforementioned lesion <25 cm^3 in volume. The volume of a mass lesion was estimated with the ABC/2 method. Each CT-scan was scored, based on visual inspection, according to the Rotterdam CT and the Helsinki score (Supplementary Table 2 and 3).

The statistical analysis for scores was done with unadjusted models. The Discrimination power of the proposed models was assessed by calculating the area under receiver operating characteristic (ROC) curve. Data analysis was performed using SPSS version 24. The hypothesis test used was the chi square test / Fisher-Exact test, Spearman correlation test

3. RESULT

Research has been carried out on 60 subjects that met inclusion criteria, including every 20 subjects with mild, moderate, and severe traumatic brain injury. Data analysis was performed using SPSS version 24. The hypothesis test used was the chi-square test/Fisher-exact test, Spearman correlation test, and multiple logistic regression test.

1) General Characteristics of Research Subjects

   Subjects in this study were traumatic brain injury patients who underwent a CT scan of the head without contrast within <24 hours after the onset of trauma who were included in the inclusion criteria. Based on the research results, from the 60 subjects studied, the characteristics of the research subjects were indicated in Table 1. Based on data on Table 1, of the 60 subjects in this study, there were 47 (78.3%) male subjects where the unfavorable outcomes were more (59.6%) than favorable outcomes (40.4%) and 13 (21.7%) female subjects were obtained where around 38.5% with unfavorable outcomes and 61.5% with favorable outcomes. Based on age, the youngest patient was 11 years old and the oldest was 57 years old with a mean age of 34.28±21.13 years old (data not presented). The subjects were divided into 5 age groups, with the majority

(38.3%) being in the 11-20 years age group. There were 47 patients (78.3%) who underwent surgery.

Table 1. Characteristics of Research Subjects

Variable	GOS		Total (n = 60)	p-value
	Unfavorable (n = 33)	Favorable (n = 27)		
Gender				
Man	28 (84.8%)	19 (70.4%)	47 (78.3%)	0.176*
Women	5 (15.2%)	8 (29.6%)	13 (21.7%)	
Age				
11-20 years	10 (30.3%)	13 (48.1%)	23 (38.3%)	
21-30 years	5 (15.2%)	3 (11.1%)	8 (13.3%)	0.128**
31-40 years	6 (18.2%)	0	6 (10.0%)	
41-50 years	5 (15.2%)	3 (11.1%)	8 (13.3%)	
51-60 years	7 (21.2%)	8 (29.6%)	15 (25%)	
Operation				
Yes	28 (84.8%)	19 (70.4%)	47 (78.3%)	0.176*
Not	5 (15.2%)	8 (29.6%)	13 (21.7%)	

* Chi-square test; ** Fisher-exact test

The percentage of brain injury outcomes based on the Rotterdam CT score system is indicated in Figure 1. It shows that based on the Rotterdam CT score, the percentage of unfavorable outcomes of patients with scores of 1 until 3 were 28.0%, 52.9%, 85.7%, respectively. In addition, the percentage of an unfavorable outcome of patients was 100.0% for the patients with a score of 4 or above. These results indicate that the higher the Rotterdam CT score, the more unfavorable outcome will appear.

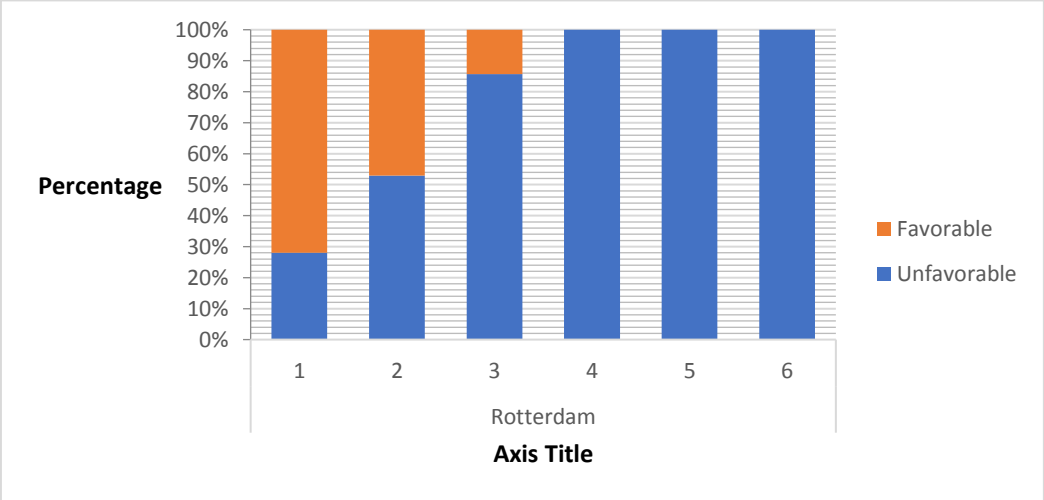

Figure 1. Percentage of brain injury outcomes based on the Rotterdam CT score system.

The percentage of brain injury outcomes based on the Helsinki CT score system is indicated in Figure 2. It shows that based on the Helsinki CT score, the percentage of an unfavorable outcome of patients was 0 % for the patients with a score of -3 until -1. The percentage of unfavorable outcomes of patients with scores of 0 until 5 was 27.3%, 20.0%, 62.5%, 66.7%, 50.0%, and 80.0%, respectively. In addition, the percentage of an unfavorable outcome of patients was 100.0% for the patients with a score of 6 or above, except for scores of 8,10, and 13. These results indicate that the higher the Helsinki CT score, the more unfavorable outcome will appear.

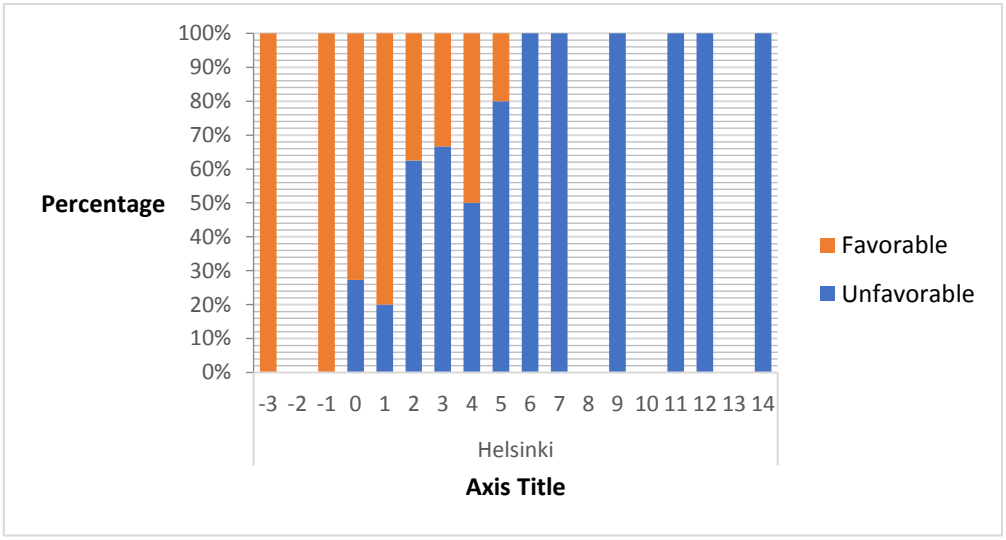

Figure 2. Percentage of brain injury outcomes based on the Helsinki CT score system

2) Comparison of the Helsinki and Rotterdam Scoring Systems against the Glasgow Outcome Score (GOS)

The correlation of the Helsinki and Rotterdam CT scoring system to GOS is indicated in Table 2. There is a significant correlation between the Rotterdam CT score and the GOS score with a strong negative correlation ($r = -0.720$, p value < 0.001), which means the higher the Rotterdam CT score correlates with the lower of the GOS score. In addition, there is also a significant correlation between the Helsinki CT score and the GOS score with a strong negative correlation ($r = -0.682$, p value < 0.001), which means the higher the Helsinki CT score correlates with the lower of the GOS score. These results indicate that the Rotterdam and Helsinki CT scores have a strong correlation with GOS score.

Table 2. Correlation of Rotterdam and Helsinki Scores to Glasgow Outcome Score (GOS)

Variable	GOS	
	r	*p
Rotterdam score	-0.720	**<0.001**
Helsinki score	-0.682	**<0.001**

*Spearman Correlation test

Receiver Operating Characteristic (ROC) curve estimation was performed to compare the predicted outcome (outcome) with the Rotterdam and Helsinki scores as indicated in Figure 3 and Table 3. The area under the curve (AUC) on the Rotterdam score was 0.805, with the sensitivity and specificity values maximized by a score of 1 (cut-off) (sensitivity = 0.78; specificity = 0.66). On the Helsinki score, the area under the curve (AUC) was 0.833, with the sensitivity and specificity values maximized at a score of 1 (cut-off) (sensitivity = 0.87; specificity = 0.62). Summarizing the results of the ROC analysis of the two CT scoring systems, the Helsinki score also provides a better sensitivity score > 80% ($p < 0.001$) compared to the Rotterdam score, with a positive predictive value of around 74% each for assessing the outcome (GOS) of brain injury patients .

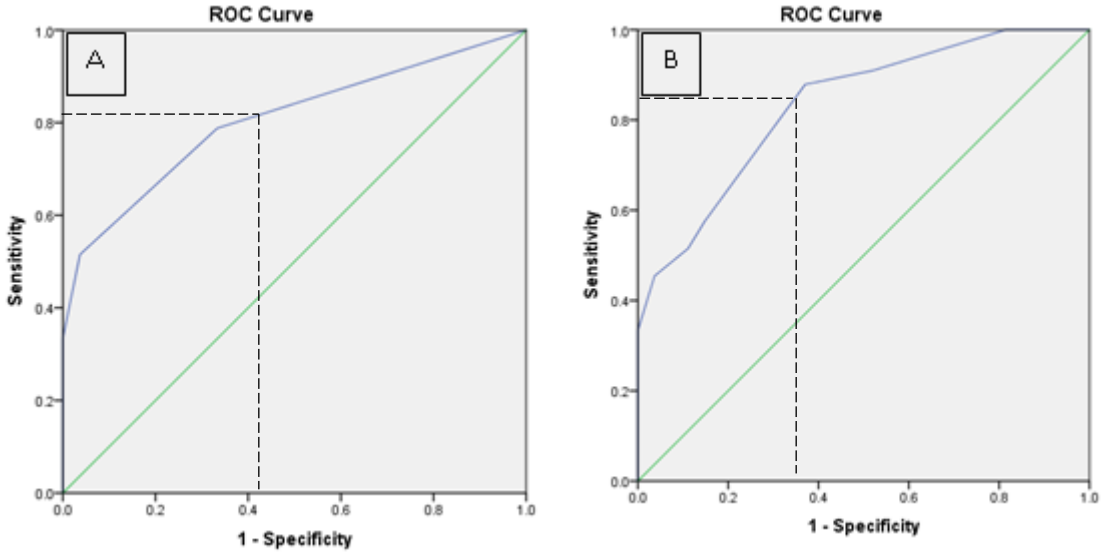

Figure 3. Area Under Curve (AUC) of Receiver Operating Characteristic (ROC) on Rotterdam (A) and Helsinki (B) scores in predicting brain injury outcome

Table 3. ROC Analysis of Rotterdam and Helsinki CT scores in predicting brain injury outcomes

	Skor Rotterdam		Skor Helsinki	
Statistic	Value	95% CI	Value	95% CI
Cut-off	1	-	1	-
AUC	0.805	-	0.833	-
P value	<0.001	-	<0.001	-
Disease Prevalence	55.0%	-	55.0%	-
Sensitivity	78.79%	61.1% – 91.0%	87.88%	71.8% – 96.6%
Specificity	66.67%	46.0% – 83.5%	62.96%	42.4% – 80.6%
+ Likelihood Ratio	2.36	1.3 – 4.1	2.37	1.4 – 3.9
- Likelihood Ratio	0.32	0.2 – 0.6	0.19	0.07 – 0.5
+ Predictive Value	74.3%	62.2% – 83.5%	74.4%	63.6% – 82.8%
- Predictive Value	72.0%	55.8% – 83.9%	81.0%	61.9% – 91.8%

4. DISCUSSIONS

Characteristics of Research Subjects

Based on the results of this study, brain injury was more prevalent in men with a percentage of 78.3% which was divided into unfavorable as much as 59.6% and favorable outcomes as much as 40.4% while in female subjects it was obtained 21.7%. This study is comparable to a study conducted by Putra (2019) where the highest prevalence of brain injury was in men (67.7%) compared to women. This is related to the activity and the risk that heavy work done by men is more likely to cause brain injury.[10]

The results showed that the age range of the most frequent occurrence of capitis trauma was at the age of 11-20 years, where this study is comparable to a study conducted by Faul et al. The highest incidence rate was found at the level of adolescence or young adults. This can be caused by adolescents who are still in the active stage of doing new things and negligence in driving.[11]

Traumatic brain injury cases are found in various levels of emergencies. There are 3 main causes of brain injury, namely traffic accidents, collisions due to falls, and acts of violence. Traffic accidents are the most external cause of brain injury among the other two, and are twice as common in men as in women.[2]

Comparison of the Helsinki and Rotterdam Scoring Systems against the Glasgow Outcome Score (GOS)

Based on the results of this study, it was found that there was a significant and strong negative correlation between the Rotterdam score and GOS, which mean the higher the Rotterdam score correlated with the lower the Glasgow Outcome Score. In another words, the higher the Rotterdam score, the worse the prognosis of the patient with traumatic brain injury. Katar et al (2020) found that the Rotterdam CT score as a prognostic stratification tool in emergencies where information obtained from neurological examinations is limited. The cure rate for patients with medical and surgical treatment generally decreases as the Rotterdam score increases. Patients with need for surgery had a higher Rotterdam score and a higher traumatic brain injury severity.[12]

In addition, there is also a significant correlation between the Helsinki score and the GOS with a strong relationship with a value of r = - 0.68 where the

higher the Helsinki score correlates with the lower the GOS. One study showed that all CT classification systems performed well in predicting outcome at 6 months and there was no significant difference between individual CT scan scores. However, in predicting mortality for 6 months, the Helsinki CT score showed slightly better performance than the other CT scores.[13]

This study provides the same results for the correlation test for both the Rotterdam and Helsinki scoring systems in determining outcome and prognosis based on GOS. So a further analysis was carried out to see the sensitivity and specificity of each scoring using the ROC analysis to compare the better scoring in predicting the outcome and prognosis. The results of the ROC analysis of the two CT scoring systems, the Helsinki score provided a better sensitivity score> 80% compared to the Rotterdam score, with a positive predictive value of around 74% each for assessing the outcome (GOS) of brain injury patients. This result is comparable to the research conducted by Pargaonkar et al. (2019), while they compared three scores, namely the Marshall score, the Rotterdam score, and the Helsinki Score to predict mortality assessed from obliteration of the suprasellar cisterns, presence of subarachnoid haemorrhage, intraventricular haemorrhage and epidural mass lesion. They found that the Helsinki score was superior in predicting mortality compared to the other two scores. The Helsinki scoring system is a better prognostic model with significantly improved outcome prediction accuracy, although according to Marshall and the Rotterdam scoring system it has good predictability for assessing mortality. The Helsinki scoring system is a better prognostic model with significantly improved outcome prediction accuracy, although according to Marshall and the Rotterdam scoring system it has good predictability for assessing mortality.[14]

The scoring analysis that makes the Helsinki scoring superior in predicting brain injury outcomes is the presence of several variables assessed on CT-Scan predicting long-term outcomes including the type and size of mass lesions, presence of IVH, and suprasellar cisterns status. According to a study conducted by Maas et al, the CT Rotterdam score did not differentiate between the type and size of mass lesions (with the exception of EDH) whereas the most recent IMPACT study found that SDH and ICH were strong predictors of unfavorable outcome and the presence of EDH was significantly associated with outcome. which is more profitable.[15]

From the results of this study, the Helsinki score was better in assessing the outcome based on the GOS assessment than the Rotterdam score. This study is in line with research conducted by Yao et al in 2017 which showed the multivariate regression analysis of the Helsinki CT score to be an independent predictor of mortality and unfavorable outcome with an odds ratio of more than 1 compared to the Rotterdam score. In that study, the CT Helsinki scoring was also found to be the most accurate for predicting mortality with an accuracy of 74.5% and unfovarable with an accuracy of 71.5%.[16]

5. CONCLUSION

The Helsinki score scoring system provides a better sensitivity score> 80% compared to the Rotterdam score, with a positive predictive value of about 74% each for assessing the outcome (GOS) of brain injury patients. Existing head CT classification systems demostrate good to excellent statistical performance in outcome prediction, yet do not significantly improve the performance of a simple model based on age, motor response, and pupil responsiveness. Further prospective multicenter studies into outcomes and prognostic models for brain injury are warranted.

REFERENCES

1. Chen H, Gou Y, Chen SW, Wang G, Cao HL, Chen J, et al. Progressive Epidural Hematoma in Patients with Head Trauma: Incidence, Outcome, and Risk Factors. Emergency Medicine International. 2012; 2012: (8 p).

2. Lalenoh DC, Tatang B, Yusuf I. Brain Protection Effect of Lidocaine Measured by Interleukin-6 and Phospholipase A2 Concentration in Epidural Haematoma with Moderate Head Injury Patient. Journal of Anesthesia & Clinical Research. 2014; 5(3): (8 p).

3. Marshall LF. Outcome prediction in severe head injury. 2nd ed. *In:* S, W. R. A. R. (ed.). Neurosurgery. New York: Mc Graw Hill; 1996.

4. Raj R, Siironen J, Skrifvars MB, Hernesniemi J, Kivisaari R. Predicting outcome in traumatic brain injury: development of a novel computerized tomography classification system (Helsinki computerized tomography score). Neurosurgery. 2014; 75(6)**:** 632-647.

5. Prins M, Greco T, Alexander D, Giza CC. The Pathophysiology of Traumatic Brain Injury at a Glance. Dis Model Mech. 2013; 6(6): 1307-1315.

6. RISKESDAS. Riset Kesehatan Dasar. Jakarta: Badan Penelitian dan Pengembangan Kesehatan. Kementerian Kesehatan Republik Indonesia; 2013.

7. Zainuddin SZ, Kwandow L, Akbar M, Muis A, Kaelan C, Patellongi I. Hubungan Amnesia Post Trauma Kepala dengan Gangguan Neurobehavior pada Penderita Cedera otak Ringan dan Sedang. Repository Universitas Hasanuddin. 2014.

8. Roozenbeek B, Lingsma HF, Lecky FE, Lu J, Weir J, Butcher I, et al. Prediction of Outcome After Moderate and Severe Traumatic Brain Injury: External Validation of the International Mission on Prognosis and Analysis of Clinical Trials (IMPACT) and Corticoid Randomisation After Significant Head injury (CRASH) Prognostic Models. Crit Care Med. 2012; 40(5): 1609-1617.

9. Mailles A, Broucker T, Costanzo P, Almoyna LM, Vaillant V, Stahl JP, et al. Long-term Outcome of Patients Presenting With Acute Infectious Encephalitis of Various Causes in France. Clinical Infectious Diseases. 2012; 54(10): 1455-1464.

10. Putra, M.B. 2019. Karakteristik pasien cedera kepala di Rumah Sakit Umum Daerah (RSUD) Umbu Rara Meha Waingapu periode 1 Januari 2017 – 31 Desember 2018. Intisari Sains Medis 10 (2): 511-515.

11. Faul M, Coronado V. Epidemiology of traumatic brain injury. Handb Clin Neurol. 2015;127:3-13.

12. Katar S, Ozturk PA, Ozel M, Arac S, Evran S, Cevik S, et al. The Use of Rotterdam CT Score for Prediction of Outcomes in Pediatric Traumatic Brain Injury Patients Admitted to Emergency Service. Pediatric Neurosurgery. 2020: 55(5): 237-243.

13. Lindfors M, Lindblad C, Nelson DW, et al. Prognostic performance of computerized tomography scoring systems in civilian penetrating traumatic brain injury: an observational study. Acta Neurochir. 2019; 161: 2467-2478.

14. Pargaonkar R, Kumar V, Menon G, Hegde A. Comparative study of computed tomographic scoring systems and predictors of early mortality in severe traumatic brain injury. Journal of Clinical Neuroscience. 2019; 66: 100-106.

15. Maas AI, Steyerberg EW, Butcher I, Dammers R, Lu J, Marmarou A, et al. Prognostic value of computerized tomography scan characteristics in traumatic brain injury: results from the IMPACT study. J Neurotrauma. 2007; 24(2): 303-314.

16. Yao S, Song J, Li S, Cao C, Fang Li, Wang C, et al. Helsinki Computed Tomography Scoring System Can Independently Predict Long-Term Outcome in Traumatic Brain Injury. World Neurosurgery. 2017; 101: 528-533.

Conflict of Interest Statement:

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Supplementary Table 1. Glasgow Outcome Scale (GOS) Score consist of 5 categories.[9]

GOS Score	Clinical Meaning
1	Death
2	Neurovegetative state; patient unresponsive and speechless for weeks or months
3	Severe disability; patient dependent for daily support
4	Moderate disability; Patient independent in daily life
5	Good recorvery; Resumption of normal life with minor neurological and psychological deficits

Supplementary Table 2.The Rotterdam Computerized Tomography Score.[4]

Rotterdam CT Score	**Score**
Basal cisterns	
Normal	0
Compressed	1
Absent	2
Midline shift	
No shift or ≤ 5 mm	0
Shift > 5 mm	1
Epidural mass lesion	
Present	0
Absent	1
IVH or tSAH	
Absent	0
Present	1
Sum Score	**+1**

CT, Computerized tomography; IVH, Intraventricukar hemorrhage; tSAH, traumatic subarachnoid hemorrhage

Supplementary Table 3. The Helsinki Computerized Tomography Score Chart.[4]

Variable	**Score**
Mass lesion type (s)	
Subdural hematome	2
Intracerebral hematome	2
Epidural hematome	-3
Mass lesion size > 25 cm^3	2
Intraventricular hemorrhage	3
Suprasellar cysterns	
Normal	0
Compressed	1
Obliterated	5
Sum Score	-3 to14