ORIGINAL ARTICLE
Bali Medical Journal (*Bali MedJ)* 2023, Volume 12, Number 2: 1502-1506
P-ISSN.2089-1180, E-ISSN: 2302-2914

Causality relationship between Hounsfield Unit in epidural hematoma and subdural hematoma and hematoma expansion

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Received: 2023-02-18
Accepted: 2023-04-18
Published: 2023-05-09

ABSTRACT

Background: Traumatic brain injury (TBI) is damage to the head caused by an external physical attack/impact. Deaths that occur from brain injury are 14-30 out of 100,000 population each year. TBI is diagnosed using Computed Tomography (CT) as the gold standard. Different densities of the pathological feature on CT can be measured by Hounsfield Unit (HU) to define its pathology. We try to asses if the HU can predict the hematoma expansion in TBI.

Methods: This research is an observational study. The data is taken from the radiology installation data of the emergency care installation at the Dr. Soetomo Regional General Hospital regarding factors that play a role in hematoma expansion with related factors in patients with subdural and epidural bleeding. Data were taken from January 2021 to December 2021. The factors analyzed were Hounsfield Unit, age, and hemostasis factors.

Results: In this study, there were 30 patients. This study was dominated by men (73.00%) and the age group of 16-20 years (26.6%). The mean PTT value in this study's subjects was 13.3±3.27. The mean value of APTT is 29.8±2.82. The average Hounsfield Unit is 43.60±5.82. No significant relationship was found between Houndsfield Unit, Age, APTT level, and age with hematoma expansion. A significant relationship was found between PTT and hematoma expansion. Simultaneously Hounsfield Unit, PTT, APTT, and age had a significant relationship with hematoma expansion.

Conclusion: There was no statistically significant relationship between Hounsfield Unit and hematoma expansion. There is a statistically significant relationship between PTT and hematoma expansion. Simultaneously found a significant relationship between Hounsfield Unit, PTT, APTT, age, and bleeding activity.

Keywords: computed tomography, Hounsfield unit, traumatic brain injury.
Cite This Article: Putra, G.H., Turchan, A., Utomo, S.A., Parenrengi, M.A., Fauzi, A.A., Wibowo, A. 2023. Causality relationship between Hounsfield Unit in epidural hematoma and subdural hematoma and hematoma expansion. *Bali Medical Journal* 12(2): 1502-1506. DOI: 10.15562/bmj.v12i2.4114

INTRODUCTION

According to the National Center for Health Statistics, in many cases of trauma, 28% of cases of brain injury or brain injury die. Deaths that occur from brain injury are 14-30 out of 100,000 population each year. In the last 30 years. The death rate in brain injury patients, especially in patients with severe brain injury, has been reduced from 50-25% of deaths.[1]

CT scan is the main diagnostic tool in trauma cases, especially in head trauma (neurotrauma), because of its good sensitivity to detect bleeding. One of the characteristics of intracranial hemorrhage is mixed-density clots, also known as Swirl Sign, which is considered active bleeding with the potential for re-bleeding or an increase in bleeding volume, which will give a poor prognosis for the patient.[2]

The current problem is that there are no tools and indicators to determine bleeding activity in patients with intracranial bleeding using a non-contrast head CT scan.[1,2] Therefore, this study assessed the bleeding activity using the Hounsfield Unit from a non-contrast CT scan because the cost is relatively more affordable, more health facilities use it, and it can be used in any clinical condition.

METHODS

This research is an observational study. The data were taken from radiological data in the radiology installation of the emergency care (IRD) Regional General Hospital Dr. Soetomo, regarding the relationship of factors that play a role in the bleeding activity and HU with bleeding activity in patients with traumatic SDH or EDH during treatment and treatment at the IRD at the Regional General Hospital Dr. Soetomo. The activity variable, as measured by the Houndsfield Unit (HU), was measured directly before surgery and during the operation.

The study population was all patients with brain injury accompanied by EDH and/or traumatic SDH with a minimum thickness of 5mm during the treatment and management period at the IRD Regional Hospital Dr. Soetomo from January 2021 – December 2021. From the population, a sample size of 30 patients was obtained using Consecutive Sampling that matched the inclusion criteria. The inclusion criteria in this study were all patients diagnosed with brain injury accompanied by traumatic EDH and/or SDH with a minimum thickness of 5mm during the treatment and treatment period at the IRD Regional Hospital Dr. Soetomo or referral patients from other hospitals who are willing to be respondents, during the period January 2021-December 2021.

Several exclusion criteria included: brain injury patients with EDH and/or SDH lesions less than 5mm, intracranial lesions that had undergone surgery, no neurological deficit/no indication for CT-scan, and patients with factor abnormalities hemostasis. The

Patients with brain injury accompanied by intracranial hemorrhage are divided into 2 types of bleeding: unclotted and clotted. Clotted and unclotted blood are influenced by several factors, namely characteristic factors (age and sex) and hemostasis factors. On CT scan, it was found that there was a density of hypodense/ unclotted/ blood which had a value range of 30-60 HU, while hyperdense/ clotted blood had a value range of 60-80 HU. We will see whether there is a hematoma expansion or whether the hematoma persists with the HU indicator. Statistical analysis in this study was carried out using SPSS.

RESULTS

From the registration data for the period January 2021 to December 2021 at RSUD Dr. Soetomo obtained a total of 30 patients with a diagnosis of brain injury accompanied by EDH and/or traumatic SDH with a minimum thickness of 5 mm. The basic information collected was the demographic characteristics of the patient, the type of intracranial lesion, the Houndsfield Unit, the volume of bleeding, and the thickness of the bleeding.

Subjects in this study were dominated by male patients (22; 73.00%). The data are grouped into seven age groups, based on the division of the Indonesian Ministry of Health, 2009 using an ordinal scale into 11-15 years, 16-20 years, 21-25 years, 26-30 years, 31-35 years, 36-40 years, 41- 45 years, 46-50 years and over 50 years. From the data, most of them are young adults (16-20 years), obtained 8 people (26.60%), followed by groups of 11-15 years, 26-30 years, and 46-50 years, each with 5 people. Meanwhile, for the age group 36-40, as many as 4 people (13.30%) and for the age group above 50 years, as many as 3 people (10.00%). The most lesions of the 30 subjects in this study were EDH, with 16 cases (53.30%). A total of 5 people (16.70%) had combined lesions of EDH and SDH, as stated in Table 1.

Table 1. Subject characteristics.

Characteristics	n (%)
Gender	
• Male	22 (73.00)
• Female	8 (27.00)
Age Group	
• 11-15	5 (16.60)
• 16-20	8 (26.60)
• 21-25	0 (0.00)
• 26-30	5 (16.60)
• 31-35	0 (0.00)
• 36-40	4 (13.30)
• 41-45	0 (0.00)
• 46-50	5 (16.60)
• >50	3 (10.00)
Age Mean±SD (years)	32.77±15.87
Bleeding Type	
• EDH	16 (53.30)
• SDH	9 (30.00)
• EDH + SDH	5 (16.70)

Table 2. The PTT and APTT value of the study subject.

Variables	Mean sample value	Smallest value	Greatest value	Reference value
PTT (seconds)	13.30	10.10	20.50	10-13
APTT (seconds)	29.80	21.60	30.10	25-35

Table 3. *Simultaneous Significance Test Results* (*Test F*).

F-count	p	Conclusion
3.931	0.017	There is a significant correlation on one variable.

Table 4. Determination Coefficient Test Results.

Model	R	R square	Adjusted R square
1	0.673	0.453	0.338

Based on Table 2, the mean value of PTT in the subjects of this study was 13.3±3.27, with a range of 10.1 to 20.5. The normal value of PTT adopted at RSUD Dr. Soetomo is 10-13 seconds. A total of 21 patients had PTT values above the normal range adopted at RSUD Dr. Soetomo. The mean value of APTT is 29.8± 2.82, with a range of 21.6 to 30.1. The normal value of APTT adopted at RSUD Dr. Soetomo is 25-35 seconds. All patients had APTT values within the normal range. A total of 30 patients measured the volume of bleeding at the time before surgery using CT Scan modalities. Bleeding volume was calculated by Broderick's formula based on CT-scan (length x width x height x 0.52). Based on Broderick's formula, the mean preoperative bleeding volume was 41±21.85 cc, while the mean bleeding volume during surgery in EDH patients was 42±20.7 cc.

A total of 9 patients with SDH were measured bleeding thickness with the help of the RadiANT application. The mean thickness of preoperative bleeding was 18.8±7.22 mm, while the thickness of bleeding during surgery was 17.4±7.0 mm. Measurements of the Houndsfield Unit on 30 subjects were carried out directly at the radiology unit workstation in the emergency department of Dr. Soetomo Hospital. The average Hounsfield Unit was 43.6±5.82, with the lowest value of 35 and the highest of 55. The average value was obtained from a random three-point measurement. If the appearance of the bleeding lesion shows a mixed density or hypodense impression, this point is included in one of the three measured points.

Based on the table of significant test results (F test), it can be seen that the F-count has a value of 3.931 which is greater than the F-table of 2.895 and a significance value of 0.017 ($p<0.05$) (Table 3). Thus, it can be said that the HU, PTT, APTT, and age factors simultaneously affect changes in the volume or activity of bleeding.

From the results of the R2 test, the adjusted R2 value is 0.338 or 33.8% (Table 4). This shows that changes in the volume or activity of bleeding can be influenced by 33.8% by simultaneous independent variables, namely the value of Hounsfield Unit, PTT, APTT, and Age. Meanwhile, a 66.2% change in bleeding volume can be obtained from variables not examined in this study.

The coefficient value provides information about the regression equation and the presence or absence of the influence of the PTT variable on changes in bleeding volume. The PTT coefficient value ($\beta 2$) is -1.797 with a negative value. This means that for every increase in PTT value by 1 unit (PTT unit), the bleeding volume will decrease by 1.797, assuming that the other variables are constant. The significance level is $p=0.002$ ($<\alpha= 0.05$). Thus, this study supports the second hypothesis, which means that there is an influence between PTT values on hematoma expansion.

The HU coefficient value ($\beta 1$) is 0.329 with a positive value. This means that for every 1 unit increase in HU, the bleeding volume will increase by 0.329, assuming the other variables are constant. The significance level is 0.287, which is greater than = 0.05. Thus, this study does not support the first hypothesis, which means that bleeding density is not affected based on HU on hematoma expansion.

The APTT coefficient value ($\beta 3$) is 0.96 with a positive value. This means that for every 1 unit increase in the APTT value, the bleeding volume will increase by 0.96, assuming the other variables are constant. The significance level is 0.193, which means it is greater than = 0.05. Thus, this study does not support the third hypothesis, which means there is no effect between APTT values on changes in bleeding volume.

The age coefficient value ($\beta 4$) is 0.096 with a positive value. This means that for every 1 unit increase in age, the bleeding volume will increase by 0.096, assuming the other variables are constant. The significance level is 0.118, which means it is greater than = 0.05. Thus, this study does not support the fourth hypothesis, which means that there is no effect between age on changes in bleeding volume

DISCUSSION

This study found that the research subjects were dominated by men (73%). This is to findings in the United States which found that patients with brain injury tend to suffer from men. It was found that men suffered brain injury twice as much as women. This is generally related to the line of work performed by men. In general, men do a lot of high-risk jobs that can increase the incidence of brain injury. In addition, men are also more likely to take high-risk actions, hobbies, or activities that can lead to a high incidence of brain injury.[3] It was found that the brain injury rate in men was 55% in Sweden, while in Ireland, it was found to be as much as 80%. The South Korean study also confirmed our findings in this study. It was found that the majority of brain injury patients were male (59.5%), while only females (40.5%) were found.[4] According to the literature, traumatic SDH affects men more than women, especially those aged <50. Similarly, EDH is more common in men due to road traffic accidents. In contrast, unlike the case study by Aromatario M et al. EDH with a clear prevalence of motor vehicle accidents (MVA), showing the percentage of falls and VMAs that overlap.[5]

In looking at the causes of brain injury in the ED, using the latest summary of data from the CDC, the main causes of brain injury are falls (178.4 per 100,000 people) and motor vehicle accidents (74.7 per 100,000 people). The demographic aspect, namely the age factor, in this study, it was found that brain injuries were most commonly found in the young adult age group, namely 16-20 years, as much as 26.6%, followed by the 11-15 years group and the 46-50 years group 16.6%, and the age group 36-40 years as much as 13.3%. Then from the age group over 50 years as much as 10%. In general, the incidence of brain injury in this study was fairly evenly distributed. This finding is similar to the study from Niryana IW et al. in Bali, which found that the age group most frequently experienced brain injury was 19-40 years (47.6%), followed by the age group 41-59 years (23, 4%). The study also found that traffic accidents were the most common cause of brain injury. This finding of brain injury in young adults may be due to the high traffic users among young adults.[6]

However, these findings are not similar to findings in the United States. It was found that the incidence of brain injury was highest in the age group under 10 years and was most often found in the age group above 74 years.[3] While a study in Europe found that the incidence of brain injury is most commonly found in young adults and middle age. The incidence of brain injury in Europe was found to have a mean age of 26.7 years in the Republic of San Marino and a mean age of 44.5 years in Austria.[7] While data from South Korea also confirm our findings in this study. It was found that from 2011 to 2014, brain injury was dominated by adults in the 15-64 age group (61.1%). While children aged 0-14 were 23.1%, and adults over 65 were 15.8%. This study also found that most brain injuries were caused by traffic accidents, which could explain the predominance of young age in the incidence of brain injury.[4] A cohort study was conducted by McKinlay on the incidence and prevalence of brain injury in Christchurch. The incidence ranges from 1100 per 100,000 to 2360 per 100,000, with the lowest rates occurring at ages 5 to 10 years and highest at ages 15 to 20.[8]

Based on the literature, traumatic SDH and EDH incidence mostly occurs in the age group under 50 years.[9] A population-based study found that individuals in the 10-24 age group more often experience EDH due to motor vehicle accidents.[10] In addition, a total of 81% of all EDHs are caused by incidental events, especially traffic accidents.[11] In this study, we report PT and APTT rates in patients with EDH or SDH. This is important to report because coagulopathy is a common finding in patients with a brain injury that affects the clinical course. Nearly two-thirds of patients with severe brain injury have abnormalities on conventional coagulation tests on admission to the emergency department.[12]

This study found that the average value of PTT was 13.3 + - 3.27, with a range of 10.1 to 20.5. The normal value of PPT in RSUD Dr. Seotomo is 10-13 seconds. It was found that 21 patients had higher than normal PTT values. Meanwhile, the average APTT value is 29.8, +- 2.82, with a range of 21.6 to 30.1. Hospital Dr. Seotomo set the normal APTT value as 25-35 seconds. In our study, it was found that all patients had normal APTT values.

Coagulopathy may refer to hypo-coagulopathy associated with prolonged bleeding and hemorrhagic progression and hyper-coagulopathy with an increased prothrombotic tendency, which can occur after brain injury. The coexistence of varying degrees of brain injury and coagulopathy has repeatedly been associated with adverse outcomes, with reported mortality rates of between 17% and 86%, reflecting the heterogeneity of brain injury.[13] The prevalence of coagulopathy in brain injury at hospital admission ranges from 7% to 63%. The incidence of coagulopathy after brain injury also increases with the severity of the injury and occurs more frequently in penetrating trauma than blunt trauma.[13] Recent studies have shown that elevated levels of inflammatory markers are predictors of poorer prognosis in emergencies, such as brain injury, intracerebral hemorrhage (ICH), and subarachnoid hemorrhage (SAH). In addition, INR, APTT, and fibrinogen are also prognostic parameters in severe brain injury. However, it is not clear which biomarkers are the best prognostic parameters for different severity and types of brain injury. A study by Kim NY et al. found that the APTT in those with non-surviving brain injury was higher ($p<0.005$).[14]

Coagulopathy is common in patients with severe brain injury, and the incidence of coagulopathy increases with the severity of the brain injury. Studies have found that abnormal values for coagulation parameters such as INR, aPTT, and fibrinogen are associated with a poorer prognosis after brain injury. Prediction of mortality at admission is important for effective Intra and postoperative patient management. Data on the significant prognostic factors identified in this study can be easily obtained at admission to stratify patients according to risk profile and to assist in patient management.[14,15] All of the above findings explain why this study found a normal level of APTT. For further research, a more current method of measuring coagulopathy is needed to be applied to the Indonesian population.

In our study, the mean HU of hematoma at first CT, the higher the association with increased bleeding because it may reflect insufficient clot contraction for hemostasis. The mean HU shows a linear relationship with blood hematocrit and platelet count, which may influence hematoma attenuation. The platelet cytoskeletal system provides clot contractile strength to the platelet-fibrin web, which is stronger in the presence of red blood cells. This could be a lesson for future research: anemia is an independent predictor of a larger EDH/SDH volume at presentation.[14,16] The main limitation of this study is that because exposure and outcome were assessed simultaneously, there is generally no evidence of a temporal relationship between exposure and outcome. In addition, a larger sample is needed to obtain results representing the population.

CONCLUSION

There was no statistically significant relationship between the Hounsfield Unit and bleeding activity in subdural and epidural hematoma cases. There is a statistically significant relationship between PTT and bleeding activity in subdural and epidural hematoma cases. Simultaneously, HU, PTT, APTT, and age significantly affected bleeding activity in subdural or epidural hemorrhage. There was no statistically significant relationship between age and bleeding activity in subdural and epidural hematomas. There is no statistically significant relationship between APTT and bleeding activity in subdural and epidural hematoma cases**.** Further research that considers the time from injury factor can be done to get more accurate results.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

ETHICS CONSIDERATION

This study has received ethical clearance from the Ethics Commission of Dr. Soetomo Hospital with permission Number 0367/KEPK/II/2022.

FUNDING

This study did not receive any grant or funding from any organization.

AUTHORS' CONTRIBUTIONS

GHP, AT, SAU, MAP, and AAF contributed to the study concept and design. GHP, AT, SAU, and MAP, contributed to abstract and/ or full-text screening, quality assessment, and data acquisition. SAU, MAP, AAF, and AW, analyzed and interpreted data. GHP, AG, and AAF drafted the manuscript. GHP, AGT, SAU, MAP, AAF, and AW, contributed to the critical revision of the manuscript for intellectual content.

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