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The Effect of Platelets Lymphocyte Ratio and Intracerebral Hemorrhage Score on the Outcome of Intracerebral Hemorrhage Patients in the ICU

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ABSTRACT

Intracerebral hemorrhage (ICH) can be caused by hypertension, head trauma, aneurysm, or blood clotting disorders, all of which are related to the inflammatory and coagulation processes. The ICH score is a scoring system used to predict prognosis in ICH patients. The ICH score results correlate with the mortality rate, where a higher score indicates a greater risk of death. The ratio of platelets to lymphocytes is known as the platelet-to-lymphocyte ratio (PLR), and it serves as a diagnostic for systemic inflammation. Data from routine complete blood counts can be used to rapidly and efficiently do the calculation. From January 1 to December 31, 2024, 155 patients with an ICH diagnosis received treatment in the intensive care unit of Dr. Ramelan Hospital in Surabaya, had data taken from medical records, including name, age, diagnosis, vital signs, ICH volume, ICH site, and routine laboratory results. Then, PLR numbers and the ICH score were computed. The ICH score had a significant effect on the mortality of ICH patients ($p <0.05$). Clarity, the PLR score from the analysis results showed no significant effect on ICH patient mortality ($p>0.05$). When using an ICH score cutoff of 2 and statistical testing of the PLR score on ICH patient mortality, a significant effect was found ($p<0.05$). The patient's ICH score significantly influenced the outcome of ICH patients. The chance of mortality increases with the patient's ICH score.

Keywords: *Intracerebral hemorrhage, ICH score, PLR, ICH patient outcome*

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1. INTRODUCTION

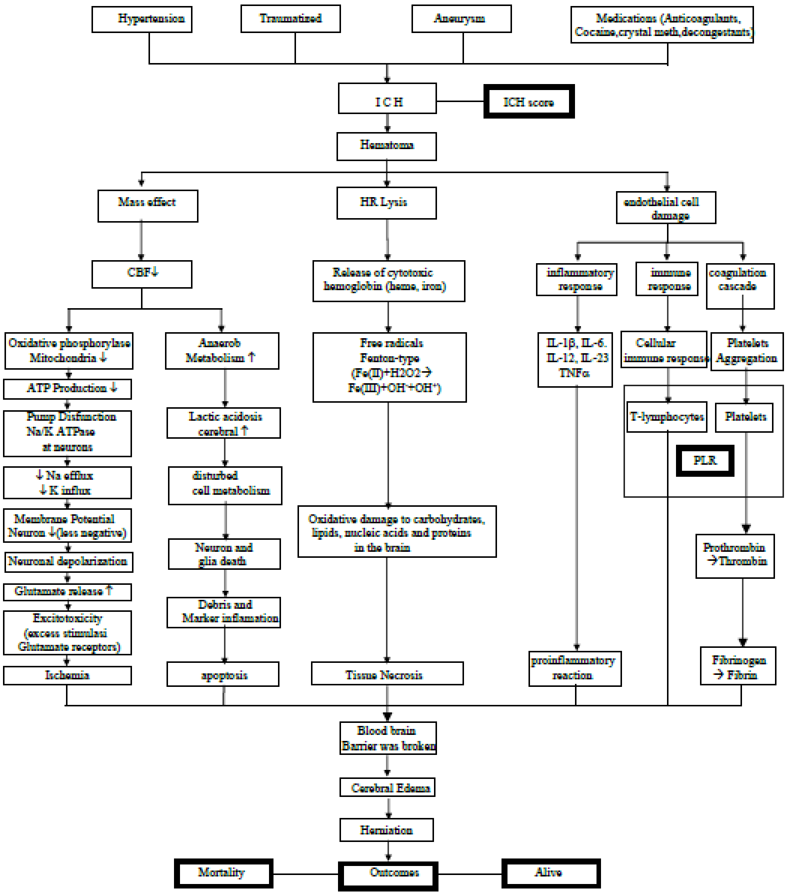
A dangerous medical disease known as intracerebral hemorrhage (ICH) is brought on by bleeding inside or around brain tissue. ICH can be caused by hypertension, head trauma, aneurysms, or blood clotting disorders, all of which are related to inflammation and coagulation processes. ICH is often an unexpected and life-threatening event, with 10-15% of strokes being caused by intracerebral hemorrhage.[1] The incidence of ICH varies by country. In the 1980s, the incidence of hospitalizations related to ICH in the United States was reported to be around 20 cases per 100,000 people per year. However, there was a 47% increase in ICH cases between 1990 and 2010, especially in low-income countries. Due to the rising use of antithrombotic and anticoagulant medications, which raise the risk of intracranial bleeding in patients, the number of ICH cases continues to rise despite advancements in the treatment of hypertension in high-income nations.[2,3] Between 2000 and 2008, the incidence was twice as high in developing or low- to middle-income nations as it was in high-income nations (22 vs. 10 per 100,000 population annually).[4] According to the Basic Health Research (Riskesdas) findings, Indonesia's stroke prevalence rose from 7 per 1000 people in 2013 to 10.9 per 1000 people in 2018, a 56% rise.[5]

A number of pathophysiological mechanisms are involved in cerebral hemorrhage. The reduction of hematoma expansion and hemostasis are greatly aided by inflammation or the hyperacute inflammatory response to cerebral bleeding. Neutrophils, macrophages, monocytes, and activated microglia are all signs of the neuroinjury caused by inflammation surrounding the hematoma.[6] Due to the high number of cases of ICH, whether due to trauma or cardiovascular disease, the role of the ICU is crucial. Most ICH cases with decreased consciousness or complications require intensive care (ICU). Furthermore, ICH patients often have comorbidities, most of whom are geriatric, and many also have organ dysfunction and other metabolic disorders. Furthermore, many ICH patients develop other complications, such as infection and even sepsis. This poses a problem for the treatment and supervision of ICH patients in the intensive care unit. The prognosis of ICH patients has been the subject of numerous research. The prognosis of ICH patients can be evaluated using the ICH score and the Platelet Lymphocyte Ratio (PLR).[4,7]

One biomarker for the systemic inflammatory response is the platelet-to-lymphocyte ratio (PLR), which is the ratio of platelet count to lymphocyte count. The PLR, which can be quickly and readily calculated using information from a standard complete blood count, can be used to predict prognosis in certain patients with sepsis, pulmonary disease, cardiovascular disease, and cancer. In order to predict the outcome of a stroke, the platelet-to-lymphocyte ratio (PLR), which is a measure of the inflammatory response and coagulation state, is essential. Neutrophil-Lymphocyte Ratio (NLR) and PLR levels prior to thrombolysis were found to be strongly linked with early neurologic impairment following thrombolysis in individuals with acute ischemic stroke, according to a larger cohort research.[8] The PLR is computed by dividing the blood's platelet (thrombocyte) count by its lymphocyte count. An overview of the equilibrium between the immunological response (represented by lymphocytes) and the inflammatory response (represented by platelets) can be obtained from the PLR.[9]

A greater PLR has been linked in a number of studies to a higher Glasgow Coma Scale (GCS) upon hospital release; however, this has not been linked to long-term neurological consequences. In the assessment and treatment of patients with acute neurological conditions, including traumatic brain injury and different forms of stroke, clinical rating scales are essential. In essence, any clinical rating scale needs to balance prediction accuracy with ease of use. The baseline neurological examination (GCS), baseline patient parameters (age), and initial neuroimaging (ICH volume, IVH, and infratentorial or supratentorial origin) are all included in the ICH score, a clinical rating system. After ICH or other acute neurological illnesses, the prognosis is still complicated and challenging to evaluate, and it frequently influences patient treatment. To provide a framework for clinical decision-making and trustworthy criteria for assessing therapy, the ICH score and other suitable clinical rating scales are therefore required.[7] One grading method for predicting prognosis in people with ICH is the ICH score. Higher ICH scores indicate a higher risk of death, and they are correlated with mortality rates. According to a number of studies, this score can help direct treatment choices and support patient management in the intensive care unit (ICU).[7]

Prognoses and outcomes can vary among ICH patients with varying causes and risk factors, and because to the huge number of potential consequences, intensive therapy and close monitoring are necessary.[10] Assessment of ICH patient mortality using laboratory markers or scoring is still limited; therefore, markers with high reliability, speed, and widespread availability are needed. Platelet and lymphocyte counts can be obtained from the differential count in a complete blood count, allowing for the calculation of the PLR. Complete blood counts are easier to perform and widely available in healthcare facilities. Similarly, the ICH score can be calculated simply from the clinical symptoms of ICH patients.



Notation :

: not checked

: checked

→ : effected

Figure 1. Symptoms of ICH patients

Intracerebral hemorrhage (ICH) can be caused by several things, the most common of which are cerebrovascular accident (CVA) or hemorrhagic stroke, head trauma, aneurysm, and drug use (e.g., anticoagulants like cocaine, crystal meth, and decongestants). Bleeding in the head cavity causes a hematoma to form, which causes a mass effect, red blood cell lysis, and damage to blood vessel endothelial cells. Endothelial cell damage results in an inflammatory response, an immune response, and a coagulation cascade. The inflammatory response triggers the release of inflammatory markers, including IL-1b, IL-6, IL-12, IL-23, and TNFa, resulting in an inflammatory reaction. The immune response consists of a humoral immune response and a cellular immune response that triggers lymphocytes to fight pathogens through antibody formation, thus helping to maintain a balance between pro-inflammatory and anti-inflammatory responses. Damage to endothelial cells triggers the coagulation cascade, where platelets play a role in thrombin and fibrin formation, ultimately leading to platelet aggregation. If a proper balance between the inflammatory reaction, lymphocytes in the immune response, and platelets in fibrin formation is not achieved, this may cause the blood-brain barrier to deteriorate, resulting in cerebral edema, which can lead to herniation and mortality.

Based on this background, the central theme of this study is: Patients with intracerebral hemorrhage require appropriate monitoring and management. This monitoring includes the PLR value and the intracerebral hemorrhage score. It is hoped that monitoring and assessing the PLR and the intracerebral hemorrhage score can provide a better prognosis for the outcome. Consequently, studies are required to investigate the impact of the PLR value and the intracerebral hemorrhage score on the outcome of patients receiving treatment in the intensive care unit (ICU) for intracerebral hemorrhage. The purpose of this study is to examine how the PLR and ICH score affect the course of treatment for ICH patients.

2. METHODS

This research is a retrospective observational study. The medical records of ICH patients receiving treatment in the intensive care unit at Dr. Ramelan Hospital in Surabaya served as the source of materials and data. The study location was the ICU of Dr. Ramelan Hospital, Surabaya, from January 1 to December 31, 2024. After the idea was accepted and given ethical clearance by the Dr. Ramelan Hospital's Health Research Ethics Committee in Surabaya, the study was carried out within a month. From January 1 to December 31, 2024, ICH patients will be treated in the intensive care unit of Dr. Ramelan Hospital in Surabaya. Based on the population of ICH patients in the intensive care unit of Dr. Ramelan Hospital in Surabaya in 2024, the authors of this study employed a straightforward random selection technique. Patients having an ICH diagnosis, those over the age of 18, and full medical record information were all requirements for inclusion. The exclusion criteria were multiple trauma or trauma in more than 1 place. The research variables consist of independent variables (PLR and ICH score), dependent variables (survival or death outcome), and confounding variables (comorbidities, hypertension, MAP, and management/treatment) is displayed in the table that follows.

Table 1. Operational Definition of Independent Variables and Dependent Variables

<table>
<tr><td>Independents Variabel</td><td colspan="3">Operational Definitions</td><td>Data Scale</td></tr>
<tr><td>PLR</td><td colspan="3">Using information from a standard complete blood count, the Platelet Thrombocytocyte Ratio (PLR), which is the ratio of platelet count to lymphocyte count, is utilized as a biomarker for systemic inflammatory response. The platelet and lymphocyte count is $10^3/\mu L$. A higher PLR indicates a poorer prognosis for ICH patients, requiring a longer ICU stay.[7]</td><td>interval</td></tr>
<tr><td rowspan="3">ICH score</td><td colspan="3">The severity of the prognosis for people with ICH is assessed using a rating system called the ICH score. It is computed starting on the day of admission to the intensive care unit (ICU) and the time of arrival in the emergency department (ED). The ICH score consists of [8] :</td><td rowspan="3">interval</td></tr>
<tr><td></td><td>Score</td><td>Poin</td></tr>
<tr><td>GCS :

Bleeding volume</td><td>3-4
5-12
13-15</td><td>2
1
0</td></tr>
</table>

	Intraventricular hemorrhage	>30 ml < 30 ml Exist None	1 0 1	
	Infratentorial hemorrhage Patient's age	Exist None >80 th <80 th	1 0 1 0	
Dependent Variabel	Operational Definitions			Data Scale
Outcomes	ICH patient outcomes are the final conditions of ICH patients treated in the ICU on day 7. These can be: Alive (discharged home or treated in a non-ICU room) Death			Nominal

The tools and materials used in this study include medical records of ICH patients treated in the ICU of Dr. Ramelan Hospital during the study period and patient data tables covering patient characteristics, independent and dependent variables. The study's methods begin with the evaluation of patients receiving treatment in the intensive care unit (ICU) of Dr. Ramelan Hospital Surabaya who have been diagnosed with ICH due to stroke or trauma, including all head bleeding, which may be intracranial, epidural, subarachnoid, intraventricular, intracerebellar, subdural, or a combination of these, and who satisfy the inclusion and exclusion criteria. Second, assessment of the ICH score upon arrival at the ER (D-0) and admission to the ICU (D-1). Third, complete blood laboratory examination to see the Platelet and Lymphocyte values upon arrival at the ER (D-0), admission to the ICU (D-1), and treatment in the ICU (D-7). Fourth, assessment of patient outcomes in the form of mortality or survival during treatment until the 7th day. The research flow is shown in the following **Figure 2**.

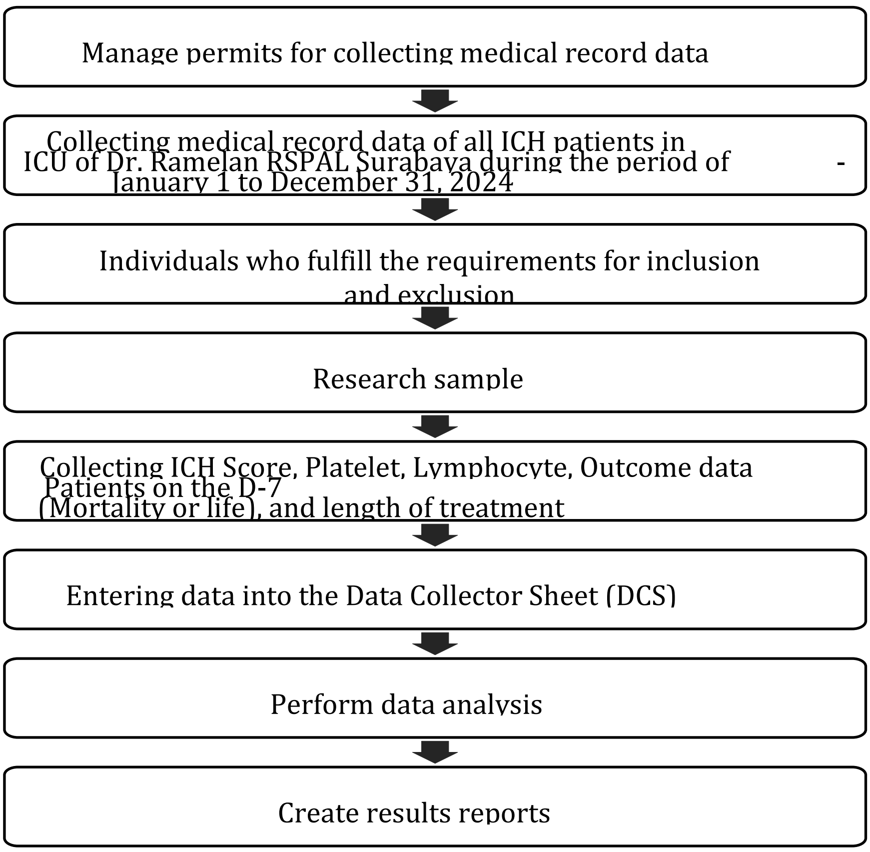


Figure 2. Research flow

Data were collected through medical records and patient statuses, then presented in tabular form and text or written text to clarify graphs/diagrams. Multiple Logistic Regression analysis was then used to examine the data.

3. RESULTS

Results of Analysis of Research Sample Data Description

As explained above, the sample of this study was ICH patients undergoing treatment in the ICU of Dr. Ramelan Hospital, Surabaya, from January 1 to December 31, 2024. The sample can be categorized as either survivors or non-survivors based on the outcome of ICH patients and mortality. Of the 155 ICH patients in this trial, 73, or 47.1%, survived treatment, whereas 82, or 52.9%, died during treatment (non-survivors). The following are the characteristics of the ICH patients who were the subjects of this study based on their outcome or mortality.

Table 2. Age Characteristics of Research Samples Based on Outcomes

	Died (n=82)	Alive (n=73)
Age (years)		
Mean	58,85	51,00
Standard Deviaton	13,14	15,94
Range (min-max)	61 (24-85)	65 (18-83)

It is evident from **Table 2** above that the mean values for the age variable differ between the two patient groups. Compared to the surviving patient group, the average age of ICH patients in the deceased patient group is higher.

Table 3. Gender Characteristics of Research Samples Based on Outcomes

	Died (n=82)	Alive (n=73)
Gender		
Male	51 (62,2%)	49 (67,1%)
Female	31 (37,8%)	24 (32,9%)

There were 100 more male patients overall than there were female patients (55 total). Of the patients who passed away, 31 patients (37.2%) were female and 51 patients (62.2%) were male. Of the patients who survived, 24 patients (32.9%) were female and 49 patients (67.1%) were male.

Table 4. Body Weight Characteristics of Research Samples Based on Outcomes

	Died (n=82)	Alive (n=73)
Body weights (kg)		
Mean	68,23	67,33
Standard Deviation	12,92	10,64
Range (min-max)	80 (40-120)	60 (40-100)

From **Table 4** above, in the form of numerical variables of patient weight, the test results show that between the groups of patients who died and those who survived, there is no discernible difference in the mean (average) value of patient weight.

Table 5. Characteristics of Vital Signs of Research Samples Based on Outcomes

	Died (n=82)	Alive (n=73)
Temperatures (ºC)		
Mean	36,71	36,42
Standard Deviation	0,58	0,23
Range (min-max)	3,0 (36,0-39,0)	1,2 (36,0-37,2)
Pulse Rate (beats per minute)		
Mean	89,99	84,42
Standard Deviation	20,54	19,49
Range (min-max)	100 (52-152)	99 (49-148)
Systolic Blood Pressure (mmHg)		
Mean	170,85	157,75
Standard Deviation	47,14	35,74
Range (min-max)	192(90-282)	164 (106-270)
Diastolic Blood Pressure (mmHg)		
Mean	95,04	91,18
Standard Deviation	24,88	18,17
Range (min-max)	118 (51-169)	85 (55-140)
MAP (mmHg)		
Mean	119,96	113,07
Standard Deviation	31,04	22,67
Range (min-max)	132 (68-200)	102 (72-174)

It is evident from **Table 5** above that the mean values for the temperature variable differ between the two patient groups. Compared to ICH patients in the surviving patient group, the average body temperature of ICH patients in the deceased patient group is noticeably higher. The numerical variables of blood pressure, pulse, and MAP of patients are shown in the above table. The test results indicate that there is no discernible difference between the surviving and deceased patient groups' mean (average) values for these variables.

Table 6. GCS Characteristics of the Research Sample Based on Outcomes

	Died (n=82)	Alive (n=73)
GCS		
Mean	7,17	10,42
Standard Deviation	4,43	4,07
Range (min-max)	12 (3-15)	12 (3-15)

It is known that the mean values of the GCS variable differ between the two patient groups based on **Table 6** above. The average GCS value of ICH patients in the deceased patient group is significantly lower than the average GCS value of ICH patients in the surviving patient group.

Table 7. Characteristics of Length of Treatment of Research Samples Based on Outcomes

	Died (n=82)	Alive (n=73)
Length of Treatments in ICU		
1-3 days	18 (21,95%)	50 (68,49%)
4-7 days	28 (34,15%)	18 (24,66%)
8-14 days	22 (26,83%)	4 (5,48%)
15-30 days	10 (12,95%)	1 (1,37%)
>30 days	4 (4,88%)	0 (0%)
Length of Treatments in hospital		
1-3 days	13 (15,85%)	0 (0%)
4-7 days	27 (32,93%)	23 (31,51%)
8-14 days	22 (26,83%)	32 (43,84%)
15-30 days	15 (18,29%)	16 (21,92%)
>30 days	5 (6,10%)	2 (2,74%)

Table 7 above for testing a number of categorical variables, information can be obtained that there is a close relationship between the length of treatment (both treatment in the ICU and treatment in the hospital) and the mortality rate of ICH patients.

Table 8. Comorbid Characteristics of the Research Sample Based on Outcomes

		Died (n=82)	Alive (n=73)
Comorbid			
Have		58 (70,73%)	39 (53,42%)
	Hypertension	45 (77,59%)	30 (76,92%)
	DM	13 (22,41%)	8 (20,51%)
	CVA	26 (44,83%)	4 (10,26%)
	PJK	5 (8,62%)	0
	CKD	1 (1,72%)	0
	Asthma	1 (1,72%)	0
	Obesity	1 (1,72%)	1 (2,56%)
	Tyroid	1 (1,72%)	0
	GERD	1 (1,72%)	1 (2,56%)
	TB	0	1 (2,56%)
	Violence	0	1 (2,56%)
Not have		24 (29,27%)	34 (46,58%)

As can be observed in **Table 8**, the most prevalent patient comorbidities in this study were a history of hypertension, followed by a history of diabetes mellitus, a prior stroke, obesity, GERD, TB, and cancer. There is a strong correlation between comorbid history and patient mortality rates, according to data from the patient comorbid history table used to assess several categorical factors.

Table 9. Characteristics of ICH Causes in Research Samples Based on Outcomes

	Died (n=82)	Alive (n=73)
Causes		
Non-traumatic	67 (81,71%)	52 (71,23%)
Traumatic	15 (18,29%)	21 (28,77%)

To test the relationship between the causes of intracerebral hemorrhage, namely trauma or non-trauma, with the mortality of ICH patients, the test results show that the causes, namely trauma or non-trauma, are not closely related to the mortality of ICH patients.

Table 10. ICH patient outcomes based on ICH cause and GCS

GCS	Died (n=82)		Alive (n=73)	
	Non-Traumatic (n=67)	Traumatic (n=15)	Non-Traumatic (n=52)	Traumatic (n=21)
1-8	46 (68,66%)	10 (66,66%)	16 (30,77%)	8 (38,10%)
9-12	8 (11,94%)	2 (13,33%)	11 (21,15%)	7 (33,33%)
13-15	13 (19,40%)	3 (20,00%)	25 (48,77%)	6 (28,57%)

Data in **Table 9** and **Table 10** show that patients with the most common causes of ICH were non-traumatic. **Table 10** shows that the majority of patients who died had a severe level of consciousness loss or GCS of 1-8, both non-traumatic and traumatic. The most frequent cause of mild level of consciousness loss (GCS = 13–15) in the group of patients with the best survival results was non-traumatic. The correlations among mild, moderate, and severe states of consciousness were nearly same for trauma. **Table 10**'s chi-square analysis results indicate a p-value of 0.0009, a chi-square value of 22.70, and six degrees of freedom (df). GCS, the source of ICH, and patient outcomes are statistically significantly correlated, as indicated by the p-value of less than 0.05.

Table 11. Characteristics of Management or Administration of Research Samples Based on Output

	Died (n=82)	Alive (n=73)
Management or Implementation		
Operative	49 (59,76%)	65 (89,04%)
Non-operative	33 (40,24%)	8 (10,96%)

Surgical operations and the death rate of ICH patients are closely related, according to data gathered from the management or implementation of ICH patients in the form of categorical variables.

Table 12. ICH Patient Outcomes based on Management or Treatment and GCS

GCS	Died (n=82)		Alive (n=73)	
	Operative (n=49)	Non-Operative (n=33)	Operative (n=65)	Non-Operative (n=8)
1-8	39 (79,59%)	17 (51,52%)	22 (33,85%)	2 (25%)
9-12	3 (6,12%)	7 (21,21%)	16 (24,62%)	2 (25%)

13-15	7 (14,29%)	9 (27,27%)	27 (41,54%)	4 (50%)

Compared to patients who died, more patients who had a favorable result had surgery, according to data in Table 11. Whether or not surgery was performed, Table 12 demonstrates that a greater number of patients with a low degree of awareness (GCS 1-8) had surgery. This might be because the patient was so unconscious when they arrived that surgery was not possible. Table 5.11 displays the findings of the chi-square analysis, which include a p-value of 0.0002, a chi-square value of 26.29, and six degrees of freedom (df). In ICH patients, there is a statistically significant correlation between level of consciousness (GCS), operative and non-operative therapy, and patient outcomes, as indicated by the p-value of less than 0.05.

Analysis of the Effect of ICH Score and PLR on ICH Patient Outcomes Using Logistic Regression Analysis

Numerous clinical factors that can raise a patient's risk of death have an impact on patient outcomes or mortality in ICH patients. The impact of the ICH Score and PLR on ICH patient mortality was assessed in this study using a logistic regression analysis. Since the dependent variable is binary (dead or alive), logistic regression analysis was employed in order to find the elements that are most important in predicting the outcomes of ICH patients. The results of this analysis will provide information on which variables have a strong relationship with mortality and how much influence they have on the risk of death or the chance of recovery of patients.

Table 13. Results of PLR values on ICH scores

ICH scores	Died (n=82)		Alive (n=73)	
	Number	PLR	Number	PLR
0	8 (9,76%)	88-256	18 (24,66%)	34-606
1	13 (15,85%)	33-243	22 (30,14%)	7-380
2	27 (32,93%)	26-970	20 (27,40%)	71-1091
3	19 (23,17%)	20-545	13 (17,81%)	34-461
4	12 (14,63%)	43-489	0 (0%)	0
5	3 (3,66%)	61-142	0 (0%)	0
6	0 (0 %)	-	0 (0%)	0

The ICH score of the died patient group was higher than that of the surviving group, as the above table demonstrates. Meanwhile, the PLR values for the two groups showed roughly the same range of results.

Table 14. Mean and Median PLR in ICH patient outcomes

PLR	Died	Alive
N	82	73
Mean	204,45	195,64
Median	158,09	170,83

Table 14 shows that the PLR value for ICH patients with a survival outcome was a mean of 195.64 and a median of 170.83. Meanwhile, for ICH patients with a mortality outcome, the mean was 204.45 and a median of 158.09. In addition to the ICH score and PLR, this study also measured several confounding variables, such as MAP, hypertension (yes/no), comorbidities (yes/no), and treatment (operative/non-operative). These four confounding variables can potentially introduce bias into statistical analysis, particularly in regression analysis (including logistic regression analysis), if not controlled for or included in the model. These variables are simultaneously related to both the independent variable (X) and the dependent variable (Y), thus obscuring or influencing the true relationship between the two. To ensure that the

presence of these confounding variables does not affect the relationship between ICH score and patient mortality, they must be tested by being incorporated into the logistic regression model.

Table 15 displays the findings of the analysis of the impact of ICH score and PLR on ICH patient mortality by incorporating confounding variables into the logistic regression model. After

Table 15. Results of Logistic Regression Analysis of the Effect of ICH Score, PLR and Confounding Variables on Patient Mortality

Variables							
		B	**S.E.**	**Wald**	**df**	**Sig.**	**Exp(B)**
Step 1[a]	ICH	0,859	0,190	20,518	1	<0,001	2,360
	PLR	0,001	0,001	0,348	1	0,555	1,001
	Hypertension	-1,046	0,608	2,958	1	0,085	0,351
	MAP	0,021	0,011	3,666	1	0,056	1,021
	Comorbidities	0,812	0,409	3,941	1	0,047	2,253
	Surgery	-2,335	0,534	19,147	1	<0,001	0,097
	Constant	-1,978	1,118	3,131	1	0,077	0,138
Variables entered: ICH, PLR, Hypertension, MAP, Comorbidities, Surgery.							

adjusting for confounding variables, the ICH score's exp(B) value increased to 2.360, demonstrating that it was still a significant predictor of death, according to the results of the logistic regression study. PLR was not important in this approach. Hypertension and MAP were not significant (p = 0.085 and 0.056), while management (surgery or not) and comorbidities had significant effects among the confounding variables (p values of 0.000 and 0.047, respectively). These results suggest that the association between the ICH score and mortality may be significantly influenced by comorbidities and therapy.

The idea that some of these variables may have an impact on how strongly the ICH score and mortality are associated is supported by the rise in exp(B) for the ICH score following the control of confounding variables. Potential collinearity should be taken into account, though, as there was no significant link between the ICH score and the four confounding variables, with the exception of a substantial correlation between MAP and hypertension. Because it can provide a more accurate estimate of the effect of the ICH score and PLR on mortality while also accounting for the influence of clinically relevant external factors, a logistic regression model with confounding variables is deemed a more valid model to be used as a basis for final interpretation based on these overall results.

Evaluation of the Accuracy of Patient Outcome Prediction Models with ROC Curves

A Receiver Operating Characteristic (ROC) curve was used to assess the prediction model's accuracy after it was determined that the ICH score is a major factor in predicting death in ICH patients. The purpose of the ROC curve analysis is to assess how well the ICH score can differentiate between individuals who are at high risk of dying and those who are not. This approach can assist physicians in identifying patients who are at high risk of mortality so that medical intervention can begin earlier by calculating the ideal cut-off value. Sensitivity, specificity, area under the curve (AUC), positive predictive value (PPV), negative predictive value (NPV), and specificity are also included in the evaluation's findings to gauge how accurate the prediction model was. The following figure displays the findings of the ROC curve analysis of patient mortality based on the ICH score.

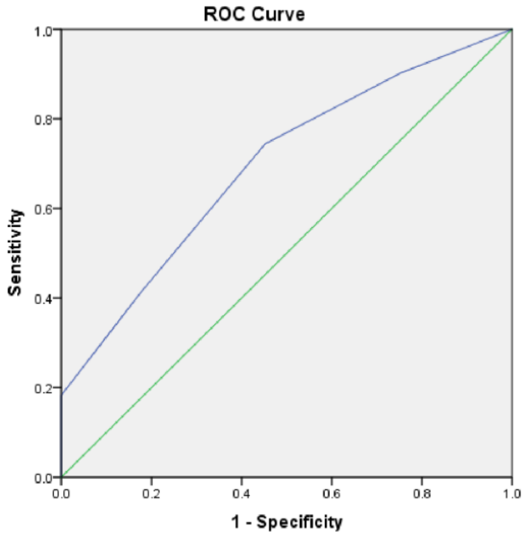


Figure 3. ROC Curve of ICH Patient Mortality based on ICH Score

Based on the ROC curve in **Figure 3**, the diagonal line and not very close to the upper left corner. This suggests that the mortality prediction model for ICH patients based on the ICH Score is not particularly effective at predicting ICH patient mortality. To confirm this, see the Area Under Curve (AUC) table below.

Table 16. Area Under Curve (AUC)

Variable test results: ICH score				
Area	Standard error	p-value	Confidence interval 95%	
			Lower Bound	Upper Bound
0,695	0,042	0,000	0,613	0,776

The model's AUC value is 69.5%, or less than 70%, as can be seen from the AUC table above. An AUC value in the range of 60-70% indicates that the ICH score has weak (poor) discriminatory ability in predicting mortality in ICH patients. However, the predictive model based on the ICH score can still be used, but its performance is quite low, and may require improvements such as parameter optimization or better feature selection.

Optimal Cut Off Value

The ideal cut-off value is one of the outcomes of the ROC curve study. This optimal cut-off value is used as a threshold (delimiter) that separates high-risk and low-risk patients. The point on the curve that serves as the cut-off point is the point with high sensitivity, but also high specificity. This point is determined based on the closest distance between the curve and the upper left corner point, which is the point with 100% sensitivity and 100% specificity. The results of calculating the distance between the coordinate points on the ROC curve and the point (0,1) for the ICH Score variable are presented in the following **Table 17**.

Table 17. Coordinate points on the ROC curve based on the ICH Score and their distance from the point (0,1)

Positive if ≥Toa	Sensitivity	1–Specificity	Specificity	Distance to (0,1)
-1,0	1,000	1,000	0,000	1,000
0,5	0,902	0,753	0,247	0,759
1,5	**0,744**	**0,452**	**0,548**	**0,519**
2,5	0,415	0,178	0,822	0,611
3,5	0,183	0,000	1,000	0,817

4,5	0,037	0,000	1,000	0,963
6,0	0,000	0,000	1,000	1,000

The ideal cut-off value for the ICH score was 1.5, with a sensitivity of 0.744 (74.4%) and a specificity of 0.548 (54.8%), based on the curve's closest distance to the point (0.1) in **Table 5.14**. This optimal cut-off value was used as a threshold value that separates high-risk and low-risk patients. Patients with a high ICH score (ICH score > 1.5) were predicted to not survive or die (high-risk patients), while patients with a low ICH score (ICH score < 1.5) were predicted to survive (low-risk patients). Because the ICH score uses single digits or none of them use decimal numbers, the ICH score cut-off was rounded up, namely with an ICH score cut-off of 2.

Crosstabs – Chi Square Test

Based on the optimal cut-off value obtained, a cross-tabulation can then be made between the ICH score classification and ICH patient mortality as follows.

Table 18. Cross Tabulation of Patient Classification Based on ICH Score Cut Off Value with ICH Patient Mortality

Patient Classification		Mortality		Total
		Died	Alive	
ICH score	High (ICH score ≥ 2)	61 (64,89%)	33 (35,11%)	94
	Low (ICH score < 2)	21 (34,43%)	40 (65,57%)	61
Total		82	73	155

The Chi Square Test can be used to examine the degree of correlation between the ICH score classification and ICH patient mortality based on the cross tabulation in **Table 18** above.

Table 19. Outcomes of the Chi Square Test Analysis of the Association between ICH Score and ICH Patient Death

Statistical test	**Value**	**df**	p-value
Pearson Chi-Square	13,782	1	0,000
Continuity Correction	12,587	1	0,000
Likelihood ratio test	13,963	1	0,000
Linear by linear relationship	13,693	1	0,000
Number of valid cases	155		

The p-value is extremely small or near zero (p < 0.05), as can be seen from the Chi-Square test results in **Table 5.19** above. The mortality of ICH patients is thus strongly correlated with the classification of patients according to the ideal cut-off value of the ICH score. Stated differently, the mortality rate of ICH patients is strongly correlated with the ICH score, whether it is high or low. The risk of death is higher for ICH patients with a high ICH score (ICH score > 2) than for those with a low ICH score (ICH score < 2).

Table 20. Cross Tabulation of Patient Classification Based on PLR with ICH Patient Mortality

Outcomes	PLR		p-value
	ICH score < 2	ICH score ≥2	
Died	154,06	219,30	0,024
Alive	203,74	207,25	

With p = 0.024 and degrees of freedom (df) = 1, the chi-square test results for the most recent data display a chi-square statistic value of 5.12. There is a statistically significant correlation between the patient outcome (dead or alive) and PLR classification based on ICH score because the p value is less than 0.05. This indicates that ICH patient mortality is substantially correlated with both PLR and ICH score.

Sensitivity

From the cross-tabulation in **Table 20** above, the model's sensitivity can be calculated. Based on the patient's ICH score, the sensitivity of this model can be understood as its capacity to identify ICH patients who subsequently passed away. The sensitivity of the prediction model using the optimal cut-off value (ICH score = 2) was 74.4%. This sensitivity figure of 74.4% can be interpreted as meaning that 74.4% of the total ICH patients who died were correctly predicted to die (because they had an ICH score > 2), while the remaining 25.4% of the total ICH patients who died were predicted to survive. In other words, if there are 100 ICH patients who died, 74-75 of them were predicted to die (correctly) and 25-26 of them were predicted to survive (incorrect prediction or false negative). ICH patients are predicted to die if they have an ICH score > 2.

Spesifisity

In addition to sensitivity, the cross-tabulation above can also calculate the specificity of the model. This model's specificity can be interpreted as the model's ability to detect patients who are able to survive (do not die). The specificity of the prediction model using the optimal cut-off value (ICH Score = 2) is 54.8%. 54.8% of the total number of surviving ICH patients were properly predicted to survive, according to this specificity percentage, whereas 45.2% of the total number of surviving ICH patients were predicted to die. Stated differently, out of 100 ICH patients who are still alive, 55 were projected to live (right prediction) and 45 to die (false prediction). If an ICH patient's ICH Score is less than 2, they are expected to survive.

Validity of ICH score

The test's ability to correctly identify whether death or survival occurred (using an ICH score cut off value of 2) is what determines the validity of the ICH score. The percentage of accurate death and survival estimates relative to the total number of ICH patients is known as validity. The validity value obtained from the ROC curve study was 65.2%. This indicates that 65.2% of ICH patients had their deaths or lives accurately predicted. It was erroneously projected that the remaining 34.8% would either be alive or dead. In other words, if 100 patients were examined and their ICH scores calculated, 65 of them were correctly predicted to be either dead or alive, while the remaining 35 patients were not.

LR+, LR- and Odds Ratio

An LR+ value of 1.65 and an LR-value of 0.47 were obtained from the ROC curve analysis. Patients with an ICH score more than two had a 1.65-fold higher chance of dying than those with an ICH score less than two, according to an LR+ value of 1.65. In contrast, patients with an ICH score of less than two had a 2.14-fold higher chance of surviving than those with an ICH score more than two, as indicated by an LR-value of 0.47 (47%) or 1/LR- of 2.14.

The LR+ and LR-values can also be used to compute the odds ratio. The odds ratio is 3.52 when the LR+ value is divided by the LR-value. The outcome of ICH patients can be predicted using a prediction model that uses an ICH score with a cutoff value of 2 if the odds ratio value is more than 1. Nevertheless, the fact that the odds ratio value is insufficiently large suggests that the prediction model's accuracy in forecasting the course of ICH patients is not very high (relatively low).

4. DISCUSSION

Demographic Data

This study showed that in both the deceased and surviving groups, there were more male subjects than female subjects. The average age of ICH patients with a deceased outcome was older than that of the surviving group. Older age, male gender, and Asian ethnicity have been widely studied as risk factors for intracranial hemorrhage, and are even considered non-modifiable risk factors.[9] According to a study, the incidence of ICH rose in people over 75, and it even tripled if anticoagulant usage was also present. [11]. Demographic data on skin color or race also shows that dark-skinned men are more at risk of developing ICH than white men, rather than age factors.[12] According to a meta-analysis, men are 60% more likely than women to develop ICH, and the incidence of ICH was 25.67 per 100,000 in men and 19.17 per 100,000 in women, with an odds ratio of 1.6.[13] According to an Australian study by Gokhale et al., men were more likely to have ICH, particularly in the 45–84 age range (RR=1.46; 95% CL: 1.01-2.10).[14] According to the aforementioned data and a number of scientific studies, men are more likely than women to acquire ICH and have distinct clinical traits and risk factors. This could be because men are more likely to smoke, drink too much alcohol, and have other risk factors like hypertension that raise the chance of developing ICH. Meanwhile, women are said to tend to experience ICH at an older age, with different etiologies, such as cerebral amyloid angiopathy.[13]

The mean body weight of the surviving and deceased groups did not differ significantly. The deceased group's temperature, pulse, and respiration rate upon arrival at the emergency room (ER) did not differ significantly from the surviving group's. Systolic and diastolic blood pressure, MAP, and GCS all showed a discernible change. Compared to the surviving group, the mean and range systolic, diastolic, and MAP blood pressures were higher in the deceased group. Several studies have demonstrated that better results are obtained when blood pressure is properly managed, both in individuals with ICH and those with a diagnosis of hypertension. Aggressive blood pressure control during the first 24 hours of an acute ICH can actually enhance outcomes and lower the likelihood of neurological deterioration. [15]

The deceased group's mean GCS score was lower than that of the surviving group, according to a GCS measurement of consciousness. According to Hemphill's research, there was a substantial correlation between a low GCS score and a higher chance of death. ICH patients with a GCS score of 13–15 had a 0% chance of 30-day mortality, but those with a score of 3–4 had a 97% risk. According to the data, patients in the surviving group spent less time in the intensive care unit (ICU) than those in the deceased group, with the longest stays lasting between one and three days. With 4–14 days, the died group had the most ICU stays. In the meantime, hospital stays were about equal for both groups, with the longest hospitalizations lasting 4–14 days. The length of hospital and intensive care unit stays for ICH patients is influenced by numerous factors. Among these factors are pre-existing underlying illnesses or comorbidities, medical complications that can arise during treatment, such as infection, fever, and acute respiratory failure, which can lead to the need for a ventilator or other breathing aids. Despite strict ICU care protocols, medical complications remain a major cause of increased length of stay, necessitating strategies to reduce complications and length of stay.[16]

Elevated blood pressure is the most significant risk factor for ICH, and its reasons have been the subject of numerous investigations. This study, which included both the surviving and the dying, discovered that the most prevalent comorbidity among patients was hypertension, which was followed by metabolic conditions such diabetes mellitus. A history of a prior CVA was the second most prevalent comorbidity in the died group, which was much higher than in the surviving group. In patients with ICH, elevated mortality and severe morbidity are linked to high blood pressure at hospital admission and insufficient blood pressure control during the first few hours. The biggest risk factor for ICH is hypertension. According to Brott et al., people with a history of hypertension were nearly four times more likely to develop ICH than those without such a history (RR 3.9; 95% CI: 2.7-5.7).[17] A study analyzed 1,828 patients who survived ICH and found that over 60% had uncontrolled hypertension three months after the event[18]. Uncontrolled hypertension is linked to a higher risk of death and subsequent stroke. This study emphasizes how crucial it is to continue managing blood pressure following the acute period of ICH.[18]

According to other research, the incidence of ICH is rising in older people, and hypertension may be a modifiable risk factor for ICH.[11] The highest risk of ICH was found in patients with extremely high systolic blood pressure (175–179 mmHg), indicating that inadequate long-term blood pressure management raises the risk of ICH.[19] Elderly patients often have comorbidities. Some even have more than one, the most common being hypertension and diabetes mellitus. These comorbidities can worsen a patient's condition and lead to poor outcomes. According to one study, high mean arterial blood pressure upon hospital admission and a history of diabetes were independent predictors of early death following ICH.[17] Through a number of processes, including tiny blood vessel destruction, concomitant diabetes mellitus (DM) can raise the risk of ICH. The brain's tiny blood arteries become more prone to bleeding due to structural alterations brought on by diabetes mellitus. Because high blood glucose levels increase inflammation and oxidative stress, they can further worsen brain damage following ICH.[20]

DM was linked to a higher risk of ICH, according to a meta-analysis that included 22 trials. The odds ratio (OR) was 1.27 (95% CI: 0.98–1.65). Prospective cohort studies demonstrated that DM increased the incidence of ICH with a hazard ratio (HR) of 1.56 (95% CI: 1.19–2.05), despite the fact that this increase did not reach statistical significance.[19] Another study revealed a correlation between HbA1C and the risk of ICH, showing that the risk of ICH rose with the length of DM and the quantity of glycated hemoglobin (HbA1C).[21] Even after controlling for baseline variables and ICH score, a prospective study revealed that patients with diabetes mellitus had inferior functional results one year following ICH.[22] The causes of ICH in this study were separated into two groups: traumatic (such as from traffic accidents) and non-traumatic (also known as spontaneous) ICH. The deceased and surviving groups both had the majority of individuals with spontaneous or non-traumatic ICH. Operative and non-operative treatment were separated. The bulk, or 89%, of the survivors had surgery, including aneurysm clipping, EVD, VP shunt, and craniotomy. 59% of the deceased group had surgery. Patients in the deceased group who had significant ICH and a low GCS score of three probably did not have surgery because of their dismal prognosis.[23]

Data of ICH score and ICH patient outcomes

According to statistical research utilizing logistic regression analysis, the probability of a patient dying rose by 0.906 (1.906 – 1 = 0.906) for every point increase in the ICH score when compared to individuals with a lower ICH score. To put it another way, those who scored higher on the ICH were at a higher risk of dying than those who scored lower. These findings support the notion that the ICH score is a significant risk factor for ICH patient outcome or mortality prediction. In order to help physicians treat patients more effectively, this ICH score can be used as a clinical tool to evaluate the risk of ICH patients receiving intensive care unit treatment.[24] The ICH score with a cut-off value of 2 has a relatively low level of accuracy in predicting the outcome (mortality) of ICH patients, as evidenced by its 65.2% test validity, 74.4% sensitivity, and 54.8% specificity. Patients with an ICH score more than two had a 1.65-fold increased risk of passing away compared to those with a score less than two. Patients with an ICH score of less than two, on the other hand, had a 2.14-fold higher chance of surviving than those with a value greater than two.

Twenty-one patients had an ICH score less than two, according to data on deceased patients. These patients were examined and found to have a single score, including advanced age, moderate consciousness (GCS 9–12), and the site of an infratentorial hemorrhage. Numerous comorbidities, including hypertension, diabetes mellitus, renal failure, asthma, and a history of stroke, were present in the majority of these patients. Numerous investigations evaluated the predictive power of the ICH score on mortality in ICH patients, including one conducted in Bangladesh by Rahmani et al. According to the findings, a 30-day death prediction with an ICH score >2 exhibited 87% sensitivity and 63% specificity.[1] Likewise, Hemphill et al. said that the ICH score can be used to classify long-term functional outcomes up to 6-12 months after intracerebral hemorrhage.[25] Accordingly, the ICH score is a straightforward and reliable predictive tool for predicting mortality and functional outcomes in patients with ICH, and its application in clinical practice can facilitate communication with the patient's family and decision-making.

PLR data and ICH patient outcomes

According to testing, the Platelet Lymphocyte Ratio (PLR) variable had no discernible impact on ICH patients' death ($p>0.05$). Stated differently, PLR is not a reliable indication for predicting or estimating the mortality rate of patients with ICH. However, statistical analysis showed a significant difference between PLR data in patients with low ICH scores (<2) and PLR in patients with ICH scores >2. PLR in patients with ICH scores <2 and ICH scores >2 is therefore associated with patient outcomes, it can be concluded. In patients with high ICH scores, a higher PLR also results in a higher death rate. Both the surviving and deceased groups' mean and median PLR levels were determined for this investigation. The findings indicated that while the median in the died group was lower than in the surviving group, the mean in the deceased group was greater by comparison. This suggests that the PLR values in the deceased group were distributed unevenly, with many values being either too high or too low. In contrast, the median and average PLR values for the alive group were 170.83 and 195.64, respectively.

A nonlinear link between PLR and 90-day mortality in ICH patients has been proposed by a number of studies and journals. A low chance of death is indicated by PLR readings between 120.9 and 189.8.[6] Increased PLR was also found to be substantially linked to worse results and higher mortality in a meta-analysis of 2992 patients, suggesting that it may be a predictor of the clinical outcomes of patients suffering from intracerebral hemorrhage. [26] A greater proportion of ICH patients who survive than those who pass away is indicated by a PLR value between 200 and 400. Conversely, a PLR value less than 200 and a PLR value greater than 500 suggest that a greater proportion of ICH patients pass away than live. Consequently, this study's PLR value range is different from the one that was acquired.[26]

A higher PLR was substantially linked to hematoma enlargement and poor functional outcomes three months after ICH in a research including 520 ICH patients.[27] According to this study, PLR may be a useful early predictor of HE and unfavorable clinical outcomes in ICH patients. In contrast, a meta-analysis conducted in 2024 found no significant correlation between PLR and poor outcomes or death in individuals with ICH.[28] OR 1.00 (95% CI: 0.99-1.01; $p=0.749$) for poor outcomes and OR 1.00 (95% CI: 0.99-1.01; $p=0.750$) for mortality. But this analysis also pointed out how few studies are currently available.[29] A high PLR may be a predictor of poor outcomes and death in ICH patients, according to a number of studies. A recent meta-analysis's findings, however, indicate that this link might not be substantial. Consequently, more investigation is required to ascertain the precise function of PLR in forecasting clinical outcomes in individuals with ICH.

5. CONCLUSION

The data analysis allows for the following deductions to be made. First, ICH patients' outcomes are greatly influenced by their ICH score. The chance of dying increases with the ICH score. Second, ICH patients' outcomes are not much impacted by their PLR value. Stated differently, the mortality of ICH patients is not much impacted by a patient's PLR. Third, the ICH score for this study had a cutoff value of 2. Fourth, there is a substantial difference in patient outcomes between a PLR in patients with an ICH score of less than two and a PLR in patients with an ICH score of more than two. A higher death rate is indicated by a higher PLR in patients with a high ICH score. According to the study's findings, we advise that when ICH occurs, the ICH score should not be determined just on day 0 or when the patient first arrives at the hospital or emergency department. On days three or seven, the score computation might be repeated. In addition to day 1, we advise repeating the PLR evaluation in ICH patients on days 3 or 7. To get more trustworthy data, more studies with a bigger sample size are required.

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