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Short Communication

Predicting early in-hospital mortality in acute hemorrhagic stroke: Implications for improving stroke care and health outcomes in low-income settings

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Abstract

Stroke is a leading cause of death and disability worldwide, and mortality in acute intracerebral hemorrhagic (ICH) stroke is influenced by many factors, and early identification of high-risk patients is crucial for guiding clinical management. This study aimed to evaluate the role of blood pressure, blood glucose level, and Glasgow coma scale (GCS) on admission as predictors of 10-day in-hospital mortality and to develop a predictive scoring system in patients with acute ICH stroke. A cross-sectional study was conducted at Dr. Zainoel Abidin Hospital, a provincial referral hospital in Banda Aceh, Indonesia, in 2025. Patients with acute ICH were consecutively recruited. Clinical parameters on admission, including systolic and diastolic blood pressure, random blood glucose level, and GCS, were recorded. Associations with 10-day mortality were assessed with a Chi-squared test, and a predictive scoring system was developed based on independent predictors. A total of 62 patients were included in this study. Higher systolic blood pressure (≥140 mmHg), diastolic blood pressure (≥90 mmHg) and GCS <9 on admission were significantly associated with 10-day mortality (p=0.031, p=0.023 and p<0.001, respectively). Multivariate analysis identified that GCS <9 was the only independent predictor. A predictive scoring system assigned 8 points for GCS <9, 5 points for systolic ≥140 mmHg, 4 points for diastolic ≥90 mmHg, and 1 point for random blood glucose ≥200 mg/dL, estimating patient-specific mortality risk, highest when all risk factors were present. This study indicates that GCS <9 and elevated blood pressure on hospital admission are key predictors of 10-day mortality in acute ICH. The developed scoring system may assist in early risk stratification and management, and further exploration of predictive models is warranted to optimize clinical outcomes.

Keywords: Acute intracerebral hemorrhagic, mortality, blood pressure, Glasgow coma scale, random blood glucose level

Introduction

Stroke remains a major global health problem and is the second leading cause of death and disability worldwide [1]. The stroke-related disability-adjusted life years (DALYs) increased from 91.5 million in 1990 to 125 million in 2019, with the greatest burden in low- and middle-income countries [1]. In the United States, stroke ranked fifth as a cause of death in 2019 and rose to fourth in 2022–2023, with stroke-related deaths increasing from 150,005 to 162,639 [2]. The

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2019 Global Burden of Disease (GBD) study reported 10.4 million stroke cases annually in Southeast Asia, with the highest prevalence in India, followed by Indonesia and Bangladesh [3]. According to the 2018 Basic Health Research (*Riskesdas*), stroke prevalence in Indonesia was 10.9 per 1,000 individuals, and 10.9 per 1,000 individuals in Aceh Province [4].

Intracerebral hemorrhage (ICH) is the most severe subtype of hemorrhagic stroke and accounts for about one-third of all stroke cases [5, 6]. In low- and middle-income countries, ICH represents 29.5% of strokes—twice the proportion seen in high-income countries—and carries a poor prognosis, with a 30-day mortality rate reaching 50% [7, 8]. Despite advances in stroke care, ICH remains a condition with high morbidity and mortality. Clinical predictors such as the Glasgow Coma Scale (GCS), hematoma volume, and location are routinely used, while recent studies have identified blood pressure and blood glucose as additional prognostic markers [9-12]. Hypertension is the main risk factor for ICH, found in 60–70% of patients and persistent high blood pressure during the acute phase contributes to hematoma expansion and poor outcomes [10]. Similarly, hyperglycemia, whether due to diabetes or stress response, occurs in 43–59% of ICH patients and is associated with cerebral edema, neuronal apoptosis, and higher mortality [11-16]. In addition, low GCS scores strongly correlate with unfavorable outcomes and early death in ICH [9, 12, 17].

Given the high early mortality and the need for rapid bedside assessment, simple and accessible predictors are essential for clinical decision-making. This study aimed to evaluate the predictive value of blood pressure, random blood glucose level, and GCS for 10-day in-hospital mortality and to construct a simple clinical scoring model for patients with acute ICH stroke.

Methods

Study design, setting and sampling

A cross-sectional study was conducted at Dr. Zainoel Abidin Hospital in Banda Aceh, Indonesia, between January and May 2025. The consecutive sampling method was employed. The minimum sample size was calculated using the Slovin formula with a 10% margin of error from an estimated population of 120 patients, resulting in 54 patients. After adding 10% to anticipate dropouts, the final sample size was set at 60 patients.

Patients

This study included adult patients (aged ≥18 years) diagnosed with acute ICH stroke within 24 hours of onset, confirmed by a non-contrast head CT scan and evaluated by a neurologist. Patients with subarachnoid or intraventricular hemorrhage, systemic infection, autoimmune disease, previous stroke, prior intracranial surgery, or those discharged against medical advice before completing 10 days of hospitalization were excluded from the study.

Data collection and variables

Upon admission, each eligible patient underwent direct clinical examination and bedside measurements following standardized procedures. Demographic and clinical data, including sex, age, education level, history of diabetes mellitus, ICH treatment type, ICH lesion location, and hematoma volume, were recorded at baseline. Systolic and diastolic blood pressure were measured using a calibrated sphygmomanometer, with the patient in a sitting or supine position after adequate rest. Systolic pressure was categorized into two groups: <140 mmHg and ≥140 mmHg, while diastolic pressure was divided into <90 mmHg and ≥90 mmHg.

Venous blood samples were collected at admission to determine random blood glucose level using hexokinase enzymatic method, expressed in mg/dL and classified as <200 mg/dL or ≥200 mg/dL. The level of consciousness was assessed using the GCS, based on eye, verbal, and motor responses, and recorded immediately after admission by a neurologist, categorized as <9 or ≥9.

The dependent variable, mortality, was defined as the permanent cessation of all vital signs during hospitalization, recorded based on direct observation and verification by the attending neurologist. Mortality assessment was conducted within 10 days of hospitalization and was categorized as alive or deceased. Neurologists performed all measurements to ensure consistency and accuracy across all observations.

Statistical analysis

The Chi-squared test was conducted to examine the association between blood pressure severity, random blood glucose level, and GCS with 10-day in-hospital mortality. Multivariate logistic regression analysis was then performed to calculate the odds ratio (OR) and *p*-value for each independent variable and to identify the most strongly associated variable with mortality. Logistic regression modeling was further used to develop a predictive score for 10-day mortality among patients with ICH stroke. Data were analyzed using the Statistical Package for the Social Sciences (SPSS) version 26.0 (IBM Corp., Armonk, NY, USA).

Results

Characteristics of the patients

A total of 62 patients with acute ICH stroke were included in this study, as presented in **Table 1**. The majority were female (54.8%) and aged ≥45 years (79.0%), with a mean age of 52.36±14.85 years. Most participants had completed secondary education (37.1%) and had no history of diabetes mellitus (59.7%). Non-operative management was the predominant treatment approach (74.2%), while 17.7% underwent craniotomy. The most common lesion site was the brainstem-cerebellar region (51.6%), and the mean hematoma volume was 12.6±4.2 cc.

The average systolic and diastolic blood pressures were 174.16±27.84 mmHg and 93.53±16.81 mmHg, respectively, indicating that the majority of patients presented with elevated blood pressure. The mean random blood glucose was 155.33±63.06 mg/dL, ranging from 83 to 400 mg/dL, while the mean HbA1c level was 5.8±2.28%, suggesting that most patients did not have evidence of chronic hyperglycemia. The GCS score on admission ranged from 3 to 15, with an average value of 11.74±3.68, reflecting a wide spectrum of neurological impairment at presentation.

Table 1. Characteristics of patients with acute intracerebral hemorrhagic (ICH) stroke included in this study (n=62)

Variable	n (%)
Sex	
Male	28 (45.2)
Female	34 (54.8
Age (years), mean±SD	52.36±14.85
<45	13 (21.0)
≥45	49 (79.0)
Education level	
Primary school	16 (25.8)
Junior high school	10 (16.1)
Senior high school	23 (37.1)
Diploma	4 (6.5)
Bachelor’s degree	9 (14.5)
History of diabetes mellitus	
Yes	25 (40.3)
No	37 (59.7)
ICH treatment type	
Non-operative	46 (74.2)
Craniectomy	1 (1.6)
Craniotomy	11 (17.7)
VP shunt	4 (6.5)
ICH lesion location	
Ventricular	5 (8.1)
Brainstem-cerebellar	32 (51.6)
Cortical-subcortical	25 (40.3)
Hematoma volume (cc), mean±SD	12.6±4.2
Clinical parameters on admission	
Systolic blood pressure (mmHg), mean±SD (min–max)	174.16±27.84 (118–240)
Diastolic blood pressure (mmHg), mean±SD (min–max)	93.53±16.81 (40–143)
Random blood glucose (mg/dL), mean±SD (min–max)	155.33±63.06 (83–400)
HbA1c (%), mean±SD (min–max)	5.8±2.28 (0.5–17.7)
Glasgow Coma Scale (GCS), mean±SD (min–max)	11.74±3.68 (3–15)

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Association between clinical parameters and 10-day mortality

The relationship between clinical parameters on admission and 10-day mortality is presented in **Table 2**. Systolic blood pressure, diastolic blood pressure and GCS were significantly associated with mortality (p=0.031, p=0.023 and p<0.001, respectively), whereas random blood glucose was not (p=0.408). Patients with systolic blood pressure ≥140 mmHg and diastolic pressure ≥90 mmHg had lower mortality rates compared to those with lower values. Mortality was highest among patients with GCS 3–8 (58.8%), while patients with GCS 13–15 mostly survived at 10 days (90.3%) (**Table 2**).

Table 2. Association between clinical parameters on admission and 10-day mortality in patients with acute intracerebral hemorrhagic (ICH) stroke (n=62)

Parameter	Category	Total, n (%)	Alive, n (%)	Deceased, n (%)	*p*-value
Systolic blood pressure	<140 mmHg	7 (11.3)	3 (42.9)	4 (57.1)	0.031
	≥140 mmHg	55 (88.7)	44 (80.0)	11 (20.0)	
Diastolic blood pressure	<90 mmHg	22 (35.5)	13 (59.1)	9 (40.9)	0.023
	≥90 mmHg	40 (64.5)	34 (85.0)	6 (15.0)	
Random blood glucose	<200 mg/dL	54 (87.1)	40 (74.1)	14 (25.9)	0.408
	≥200 mg/dL	8 (12.9)	7 (87.5)	1 (12.5)	
GCS	3–8	17 (27.4)	7 (41.2)	10 (58.8)	<0.001
	9–12	14 (22.6)	12 (85.7)	2 (14.3)	
	13–15	31 (50)	28 (90.3)	3 (9.7)	

Multivariate analysis of independent predictors of mortality

Multivariate logistic regression was performed to identify independent predictors of 10-day mortality among patients with acute ICH stroke (**Table 3**). Patients with systolic blood pressure ≥140 mmHg had 4.96 times higher odds of mortality, and those with diastolic blood pressure ≥90 mmHg had 3.41 times higher odds. Elevated blood glucose (≥200 mg/dL) was associated with a 1.42-fold increased risk. However, only a GCS score <9 was statistically significant (OR 3.41; p<0.001), indicating that impaired consciousness at admission is an independent predictor of mortality in this patient population.

Table 3. Multivariate logistic regression analysis of independent predictors of 10-day mortality in acute intracerebral hemorrhagic (ICH) stroke patients (n=62)

Independent variable	Regression coefficients (B)	Odds ratio	*p*-value
Systolic blood pressure ≥140 mmHg	1.610	4.95	0.123
Diastolic blood pressure ≥90 mmHg	1.226	3.40	0.143
Random blood glucose ≥200 mg/dL	0.350	1.41	0.785
GCS <9	2.804	3.41	<0.001
Constant	-3.364	0.03	0.010

Predictive model and scoring system development

Using the regression coefficients (B values) from the multivariate analysis, a probabilistic model for predicting 10-day mortality was constructed. The probabilities of mortality for all possible combinations of risk factors at admission are presented in **Table 4**. The highest predicted probability of mortality (93.25%) was observed in patients with all risk factors present, while the lowest probability (3.34%) was observed in patients with no risk factors. Among individual risk factors, GCS <9 was associated with the highest risk when present alone (36.35%).

Table 4. Multivariate logistic regression analysis of independent predictors of 10-day mortality in acute intracerebral hemorrhagic (ICH) stroke patients

Systolic blood pressure ≥140 mmHg (n)	Diastolic blood pressure ≥90 mmHg (n)	Random blood glucose ≥200 mg/dL (n)	GCS <9 (n)	Predicted mortality (%)
1	1	1	1	93.25
1	1	1	0	90.69
1	1	0	1	45.56
1	1	0	0	37.10
1	0	1	1	80.22
1	0	1	0	74.08

Systolic blood pressure ≥140 mmHg (n)	Diastolic blood pressure ≥90 mmHg (n)	Random blood glucose ≥200 mg/dL (n)	GCS <9 (n)	Predicted mortality (%)
1	0	0	1	19.72
1	0	0	0	14.75
0	1	1	1	73.42
0	1	1	0	66.06
0	1	0	1	14.33
0	1	0	0	10.55
0	0	1	1	44.77
0	0	1	0	36.35
0	0	0	1	4.68
0	0	0	0	3.34

Note: 1 = high risk; 0 = low risk

To simplify clinical application, the regression coefficients were converted into a scoring system (**Table 5**). Each variable was assigned points proportional to its B coefficient: systolic blood pressure ≥140 mmHg = 5 points, diastolic blood pressure ≥90 mmHg = 4 points, random blood glucose ≥200 mg/dL = 1 point, and GCS <9 = 8 points.

Table 5. Scoring system based on regression coefficients

Risk factor	Regression coefficient (B)	Assigned score
Systolic blood pressure ≥140 mmHg	1.610	5
Diastolic blood pressure ≥90 mmHg	1.226	4
Random blood glucose ≥200 mg/dL	0.350	1
GCS <9	2.804	8
Total score		18

Finally, the cumulative score for each patient can be used to estimate the probability of 10-day mortality. The predicted mortality according to the total risk score is presented in **Table 6**, providing a practical tool for clinicians to stratify patient risk at admission.

Table 6. Predicted mortality according to total risk score

Total score	Predicted mortality (%)
0	3.34
1–4	4.68–36.35
5–9	10.55–45.56
10–13	66.06–74.08
14–17	90.69
18	93.25

Discussion

This study aimed to determine the role of systolic and diastolic blood pressure, random blood glucose level, and GCS at admission as predictors of 10-day mortality in patients with acute ICH stroke. The findings demonstrated that higher systolic (≥140 mmHg) and diastolic (≥90 mmHg) blood pressure and a GCS score <9 were significantly associated with increased mortality. Multivariate analysis identified GCS as the only independent predictor, and a predictive scoring model was developed based on these variables to estimate individual mortality risk.

Elevated blood pressure on admission is a common finding in patients with acute ICH and is associated with poor outcomes [18-20]. In this study, both systolic and diastolic pressures were significantly related to mortality, consistent with previous evidence indicating that uncontrolled hypertension increases the risk of hematoma expansion, secondary edema, and early neurological deterioration. Chronic hypertension leads to vascular wall remodeling, lipohyalinosis, and microaneurysm formation, which predispose small intracerebral vessels to rupture [21]. Although another study suggests that aggressive blood pressure reduction may worsen cerebral perfusion, maintaining systolic pressure below 140 mmHg in the acute phase has been shown to reduce hematoma expansion and improve functional outcomes [22]. Thus, careful and early blood pressure management remains a critical component in reducing mortality in ICH patients.

This study did not find a significant association between random blood glucose and 10-day mortality; however, elevated levels have been linked to poor outcomes in several stroke studies.

The timing of glucose measurement may explain this discrepancy, as stress-induced hyperglycemia typically occurs within the first hours of stroke onset and may normalize by the time patients reach referral centers [23-25]. The majority of patients in this study did not exhibit chronic hyperglycemia, as indicated by a mean HbA1c level of 5.8%, suggesting that the hyperglycemia observed was more likely transient. Despite its lack of significance here, previous studies indicate that acute hyperglycemia can exacerbate neuronal injury through oxidative stress, blood–brain barrier disruption, and increased lactic acidosis [24, 26].

GCS below 9 emerged as the strongest independent predictor of mortality, highlighting the importance of neurological status at presentation. Decreased GCS reflects the extent of brain injury, hematoma volume, and elevated intracranial pressure, which together contribute to poor perfusion and herniation risk [27]. Several studies have similarly identified GCS ≤8 as a strong predictor of in-hospital mortality in ICH patients [28-30]. The consistency of this finding across studies underscores its clinical value as a rapid and practical prognostic tool for early risk stratification.

The logistic regression model developed in this study incorporated systolic and diastolic blood pressure, random blood glucose, and GCS to estimate mortality probability. Scoring weights were assigned based on regression coefficients: GCS <9 (8 points), systolic ≥140 mmHg (5 points), diastolic ≥90 mmHg (4 points), and random blood glucose ≥200 mg/dL (1 point) (**Table 5**). Patients with all risk factors had a mortality probability of 93.25%, whereas those without any risk factors had a probability of 3.34% (**Table 6**). This simple, bedside scoring system can aid clinicians in identifying high-risk patients early, guiding decisions for intensive monitoring, early intervention, and family counseling.

This study has several limitations. The single-center design and limited sample size may restrict generalizability. The timing of data collection, particularly for random blood glucose, could have affected its association with mortality, as delayed measurements may not accurately reflect acute physiological responses. Imaging variables such as hematoma size and location, which are known to influence outcomes, were not included in the model. Future studies should validate this predictive model in larger, multicenter populations and incorporate imaging and laboratory biomarkers to enhance predictive accuracy.

Conclusion

Higher systolic (≥140 mmHg) and diastolic (≥90 mmHg) blood pressure and a GCS score <9 on admission were associated with increased 10-day mortality in acute ICH stroke, with GCS <9 identified as the only independent predictor. The developed scoring system estimated patient-specific mortality, which was highest when all risk factors were present. Further exploration of early assessment and predictive models is warranted to improve risk stratification and management.

Ethics approval

The study protocol was reviewed and approved by the Ethical Committee of Dr. Zainoel Abidin Hospital, Banda Aceh, Indonesia (approval number: 070/ETIK-RSUDZA/2025). Written informed consent was obtained from all patients prior to enrollment.

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Competing interests

All the authors declare that there are no conflicts of interest.

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Underlying data

Derived data supporting the findings of this study are available from the corresponding author on request.

Declaration of artificial intelligence use

This study utilized artificial intelligence (AI) tools (ChatGPT and QuillBot) to support language enhancement. We confirm that all AI-assisted processes were critically reviewed by the authors to ensure the integrity and reliability of the results. The final decisions and interpretations presented in this article were solely made by the authors.

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