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Original Research Paper

Relationship of acid–base imbalance with hemorrhage volume and mortality in intracerebral stroke hemorrhage

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Abstract
This study aimed to evaluate the relationship between acid-base balance disturbances and intracerebral hemorrhage volume with mortality rates in hemorrhagic stroke cases. The research used an observational analytic design with a cross-sectional approach and was conducted at Dr. Soeratno Gemolong General Hospital, Sragen, from September to November 2024. The study population consisted of medical records of patients diagnosed with hemorrhagic stroke at the hospital between August 2021 and August 2024 who met the inclusion criteria. A total of 50 samples were selected using a purposive sampling technique. Data analysis included univariate analysis, bivariate analysis using the Chi-Square test, and multivariate analysis using logistic regression. The results showed a significant relationship between acid–base balance disturbances and intracerebral hemorrhage volume with mortality in hemorrhagic stroke cases (p=0.001). In addition, intracerebral hemorrhage volume was significantly associated with mortality (p=0.007). Multivariate analysis confirmed that both acid–base imbalance and hemorrhage volume significantly influence mortality outcomes. These findings indicate that acid–base imbalance and intracerebral hemorrhage volume greater than 30 ml are strong predictors of mortality in hemorrhagic stroke patients. Therefore, strict monitoring of arterial blood gases, neurological status, and hemodynamic stability is essential during the acute phase of care. Early detection of physiological deterioration and prompt intervention may help reduce the risk of adverse outcomes. Future research is recommended to use prospective multicenter designs with larger sample sizes to further clarify causal relationships and evaluate whether early correction of acid–base disturbances can improve mortality outcomes in hemorrhagic stroke patients.

Keywords: Acid-base disorders; intracerebral hemorrhage volume; mortality; hemorrhagic stroke

1. Introduction

Hemorrhagic stroke namely a condition where cerebral blood flow is disrupted due to blood vessels in the brain broken (Sitepu, 2024). Hemorrhagic stroke can be caused by several conditions, including high blood pressure, aneurysm brain, and injury heavy head. Symptoms of hemorrhagic stroke can vary adjusting the location of bleeding, including paralyzed on one side face, difficult uttering the words, the pain great headache, vomiting, increase blood pressure, signs neurological develop rapid, convulsive, even become no self-awarness (Park et al., 2022).

According to data from the World Stroke Organization in 2021, every year there are 13.7 million strokes, new cases of stroke worldwide. Based on Research National Basic Health Survey, prevalence of stroke in Indonesia diagnosed by doctors recorded a figure of 7 per mile of people. This increase to 10.9 per thousand people in 2018 (Sitepu, 2024). The death rate due to hemorrhagic stroke known to be higher If compared to ischemic stroke, which results in more severe symptoms and a greater risk of complications, such as improvement pressure potential intracranial cause death sudden.

Hypertension, diabetes mellitus, and dyslipidemia is a major risk factor for stroke known. Risk factors for hemorrhagic stroke divided two category: modifiable factors as well as non-modifiable

factors. Modifiable risk factors covers habit smoking, hypertension, diet, acid base imbalance, and level activity. In contrast, non-modifiable risk factors includes age, gender, and race or ethnicity (Nindrea & Hasanuddin, 2023). Acid base imbalance also has influence on the occurrence of stroke. Balance disorders acid base grouped into four types, namely metabolic alkalosis, respiratory alkalosis, acidosis respiratory, as well as acidosis metabolic. Reaction process acid bases in the body can affect various physiological functions and play a role as risk factors or to worsen condition medical certain conditions, including hemorrhagic stroke (Riasmini et al., 2024).

Previous research mention that there is connection significant in acid disorders base on normal blood gas analysis occurs in stroke patients in the form of respiratory alkalosis which can cause death. Meanwhile, other studies have stated that acid reflux disorders base no too influential significant with incident mortality of hemorrhagic stroke, where there is condition clinical patients and management medical conditions that may have a greater impact on acid-base disorders and disorders with incident hemorrhagic stroke mortality (Szerlip & Carolina, 2023).

Other factors that are also associated with mortality in hemorrhagic stroke patients namely the volume of intracerebral hemorrhage. The occurrence of hemorrhage intracerebral causing loss oxygen from brain as well as give pressure on nearby tissue. So it can cause damage fast brain or may result in death (Jahan, 2016). Intracerebral hemorrhage also causes the formation of edema which can cause death due to herniation and severe neurological deficits in the surrounding parenchyma. The results of study found that the volume of intracerebral hemorrhage affected the death of ICH stroke patients (Aulia et al., 2023).

2. Research Methods

An observational method with a cross-sectional design was utilised in the study. The study took place at Dr. Soeratno Regional Hospital Gemolong, Sragen, during period September to November 2024. The population study covers all recorded data of medical patients diagnosed with hemorrhagic stroke at Dr Soeratno Regional Hospital Gemolong, Sragen, from August 2021 to August 2024, which is a sufficient criterion for inclusion. A total of 50 samples were used, namely as many as 50, who were selected using the purposive sampling method. Inclusion criteria are predefined characteristics that determine whether individuals are eligible to participate in a research study. These criteria ensure that the selected participants are appropriate for answering the research question and help maintain internal validity. In clinical studies, such as those involving Intracerebral Hemorrhage, inclusion criteria may include a confirmed diagnosis based on neuroimaging, a specific age range, a defined hospitalization period, and the availability of complete medical records relevant to the variables being analyzed. The variables in this study were operationally defined and classified prior to analysis to ensure measurement consistency. Acid–base status was determined based on arterial blood gas (ABG) examination results and categorized into two main groups: normal (arterial pH 7.35-7.45) and acid-base disorder (pH <7.35 or >7.45 and/or abnormal $PaCO_2$ and HCO_3^- values). Acid-base disorders were further classified into four types according to standard physiological criteria: metabolic acidosis (decreased pH with decreased HCO_3^-), metabolic alkalosis (increased pH with increased HCO_3^-), respiratory acidosis (decreased pH with elevated $PaCO_2$), and respiratory alkalosis (increased pH with decreased $PaCO_2$). Intracerebral hemorrhage volume was classified based on neuroimaging findings into <30 ml and ≥30 ml categories, while mortality was categorized as survival or death during hospitalization. These classifications were used to facilitate bivariate and multivariate statistical analyses. Total sample used namely as many as 50 of the total population, who were selected with using purposive sampling method. Data analysis was applied with utilise technique univariate, bivariate through the Chi-Square test, and multivariate use analysis regression logistics. This study has obtained ethical approval from the Health Research Ethics

Committee of dr. Soeratno Gemolong Hospital, with letter number 800.2.2.1/1579/05.1.2/IX/2024 and was declared ethically feasible to be implemented.

3. Results and Discussion

3.1.Characteristic of Respondents

In this study, it was found that the majority of respondents were female (54%) and male (46%). The majority of respondents were in the age range of 45-59 years (32%). While for respondents who experienced acid-base disorders were the same as normal sufferers (50%). The overall characteristics of the respondents are presented in **Table 1** below:

Table 1. Characteristics of Respondents

Variables	Frequency	Percentage (%)
Age		
<45 years	3	6,0
45-59 years	16	32,0
60-69Ears	17	34,0
>70 years	14	28,0
Gender		
Male	23	46,0
Female	27	54,0
Acid & Base Disorder		
Normal	25	50,0
Disturbance	25	50,0
Types of Acid & Base Disorder		
Metabolic Alkalosis	5	20,0
Respiratory Alkalosis	10	40,0
Respiratory Acidosis	8	32,0
Metabolic Acidosis	2	8,0
Bleeding Volume		
<30 ml	29	58,0
> 30 ml	21	42,0
Patient Mortality		
Life	30	60,0
Mortality	20	40,0

Table 1 indicates that the majority of patients are between 60-69 years old with a total of 17 patients (34%). Based on the gender category, it is known that the majority of patients found were female with a total of 27 patients (54.0%). Based on the assessment of acid & base disorders, it is known that the number of patients experiencing acid & base disorders is the same as the number of patients who do not experience disorders, namely 25 patients (50%). Based on the type of disorder , the majority Respondents experienced acid & base disorders in the form of respiratory alkalosis with amount as many as 10 patients (40%). Based on the category of intracerebral hemorrhage volume, it is known that the majority of patients have an intracerebral hemorrhage volume < 30 ml with a total of 29 patients (58%). Then, based on the incidence of mortality, it is known that the majority of hemorrhagic stroke patients did not experience mortality with a total of 30 patients (60%).

3.2.Relationship Between Acid-Base Disorders and Mortality

The results in **Table 2** showed that the number of patients who did not experience acid-base disorders and survived was 21 people (42%). Patients who did not experience acid-base disorders but experienced mortality were 4 people (8%). Meanwhile, there were 9 patients (18%) who experienced acid-base disorders but survived, and 16 patients (32%) who experienced acid-base disorders and mortality. Based on the analysis, the P-Value value from the Chi Square test was 0.001 ($p<0.05$).This indicates a significant correlation between acid-base disorders and mortality in cases of hemorrhagic stroke at RSUD dr. Soeratno Gemolong, Sragen.

Table 2. Relationship Between Acid-Base Disorders and Mortality

Acid Base Disorders	Hemorrhagic Stroke Mortality,						*P-value*
	Life		Mortality		*Total*		
	n	%	n	%	N	%	
Normal	21	42.0	4	8.0	25	50.0	
Disturbance	9	18.0	16	32.0	25	50.0	0.001
Amount	30	60.0	20	40.0	50	100.0	

Research result indicates there is connection significant between balance disorders acid bases and mortality in cases of hemorrhagic stroke, which is proven with a p-value of 0.001 ($p<0.05$). This is leading to the conclusion that acid base imbalance own significant influence on mortality in cases of hemorrhagic stroke at Dr. Soeratno Regional Hospital Gemolong, Sragen. Acid base imbalance refers to a condition in which the amount of hydrogen ions produced comparable with the number of hydrogen ions that come out of cells. There are three mechanism key in the setup process balance acid-base in the body, namely buffer system, system breathing, as well as kidneys. Acid base imbalance body can be measured with pH, which is generally range between 7.35 to 7.45 (Shaw & Gregory, 2022).

The occurrence of an imbalance of acids and bases causes several disorders, one of which is acidosis metabolic. Acidosis metabolic is factors that can to worsen outcome in haemorrhagic stroke through various mechanisms, including improvement damage mobile, worsening brain edema, disorder perfusion brain, and multisystem organ failure. In haemorrhagic stroke, acidosis metabolic can cause vasodilation vessels blood the brain that is paradox can increase pressure intracranial and reduce perfusion brain. Acidosis metabolic can cause decline contractility myocardial and disorders rhythm heart, which reduces perfusion systemic and oxygenation brain, worsening condition patients and improve risk mortality (Windiyanto et al., 2016). In addition to acidosis metabolic, the occurrence of disorders in the form of acidosis respiratory in haemorrhagic stroke also can to worsen condition patient through improvement pressure intracranial, disorders oxygenation brain, dysfunction cardiovascular, and increased risk herniation brain. In haemorrhagic stroke, acidosis respiratory can to worsen condition patients and related with improvement risk mortality. Acidosis respiratory increase risk edema more brain critical because vasodilation increase blood volume in the brain, worsening compression network brain due to hematoma, and increase pressure on structure brain (Atypical, 2016).

Metabolic alkalosis in patients with haemorrhagic stroke can to worsen condition through cerebral vasoconstriction, disturbance of function cardiovascular, and increased risk brain edema. Metabolic alkalosis cause vasoconstriction vessels blood brain. Vasoconstriction This reduce flow blood to brain, which in patients with haemorrhagic stroke can to worsen condition the brain that has experience pressure consequence bleeding. Decrease perfusion This can to aggravate ischemia secondary to the hematoma. Condition This often shows existence imbalance serious physiological problems, which are associated with a worse prognosis. bad as well as improvement risk mortality. The results of this study are in line with the results of the study conducted by (Szerlip & Carolina, 2023) which indicates that

there is connection significant on disturbance acid base on normal blood gas analysis occurs in stroke patients in the form of respiratory alkalosis which can cause death.

3.3.Relationship Between Intracerebral Hemorrhage Volume and Mortality

The results of the **Table 3** showed that the number of patients with intracerebral hemorrhage volume <30 ml who survived was 22 people (44%). Patients with intracerebral hemorrhage volume <30 ml who experienced mortality were 7 people (14%). Meanwhile, 8 patients (16%) had intracerebral hemorrhage volume >30 ml and survived, while 13 patients (26%) with intracerebral hemorrhage volume >30 ml experienced mortality. Based on the analysis, the P-Value value from the Chi Square test was 0.001 (P<0.05). This shows a significant correlation between intracerebral hemorrhage volume and mortality in cases of hemorrhagic stroke at RSUD dr. Soeratno Gemolong, Sragen.

Table 3. Relationship Between Intracerebral Hemorrhage Volume and Mortality

Intracerebral Hemorrhage Volume	Hemorrhagic Stroke Mortality,						*P-value*
	Life		Mortality		*Total*		
	n	%	n	%	n	%	
< 30 ml	22	44.0	7	14.0	29	58.0	
> 30 ml	8	16.0	13	26.0	21	42.0	0.007
Amount	30	60.0	20	40.0	50	100.0	

Research results also show that there is connection significant between the volume of bleeding intracerebral and mortality in cases of hemorrhagic stroke, which is proven with p-value of 0.007 (P<0.05). With Thus, it can be concluded that the volume of bleeding intracerebral relate in a way significant with Mortality in cases of hemorrhagic stroke at Dr. Soeratno Regional Hospital Gemolong, Sragen. Bleeding Intracerebral Hemorrhage (Intracerebral Hemorrhage) is bleeding that occurs in the blood vessels of the brain that directly enters the brain tissue. The severity of the bleeding This influenced by location, speed leakage, bleeding volume, and blood pressure which can cause brain edema (Schrag & Kirshner, 2020).

Survival in patients with Intracerebral Hemorrhage is primarily determined by hematoma size, location, and the rapidity of acute management. Patients with smaller hemorrhage volumes, absence of brainstem involvement or intraventricular extension, and preserved consciousness (higher GCS) are more likely to survive because intracranial pressure and secondary brain injury remain limited. In addition, early stabilization of blood pressure, adequate oxygenation, maintenance of acid-base balance, and timely medical or surgical intervention help prevent hematoma expansion and preserve cerebral perfusion, thereby improving survival outcomes (Greenberg et al., 2022).

3.4.Relationship Between Acid base disorders and intracerebral hemorrhage volume with mortality in cases of hemorrhagic stroke

The results of the **Table 4** showed that the P-value for the intracerebral hemorrhage volume variable was 0.014 ($p<0.05$), with an odds ratio (Exp B) of 6.413. This finding indicates a significant relationship between intracerebral hemorrhage volume and mortality in hemorrhagic stroke cases at RSUD dr. Soeratno Gemolong, Sragen. Hemorrhagic stroke patients with intracerebral hemorrhage volume > 30 ml had a 6.413 times higher risk of experiencing mortality compared to patients with intracerebral hemorrhage volume < 30 ml. In addition, the results of the multivariate test also showed that the P-value for the acid-base disorder variable was 0.002 $p<0.05$, with an odds ratio (Exp B) of 11.216. This shows a significant relationship between acid-base disorders and mortality in hemorrhagic stroke cases,

where patients with acid-base disorders have a 11.216 times greater risk of experiencing mortality compared to patients without acid-base disorders.

Table 4. Relationship Between Acid base disorders and intracerebral hemorrhage volume with mortality in cases of hemorrhagic stroke

Variables	*P-value*	(*Exp B*)	*95% CI for EXP(B)*		*Nagelkerke R Square*
			Lower	*Upper*	
Bleeding Volume	0.014	6,413	1,453	28,312	0.438
Acid Base Disorders	0.002	11,216	2,450	51,356	

Hemorrhagic stroke is a type of stroke that occurs due to a ruptured blood vessel, which causes bleeding. This condition occurs when a blood vessel in the brain ruptures or leaks, causing blood to seep into the cell spaces in the brain (Ayundari, 2021). Usually, hemorrhagic stroke occurs in individuals who have a history of hypertension. Hypertension is a major risk factor for hemorrhagic stroke, both in men and women, and can lead to mortality. Stroke mortality refers to the rate death caused by stroke, either it is ischemic stroke or haemorrhagic stroke. The stroke mortality rate reflects severity disease, efficiency system maintenance health in handle it, and awareness and prevention factor risk in society. Mortality of haemorrhagic stroke very significant, with almost 40% of patients die in 30 days time after attack (Siti Hanifah et al., 2024). Stroke mortality is influenced by several factors including the size and volume of hematoma, location of bleeding, patient awareness, age, comorbidities, stroke severity and general health and support (Rangamani et al., 2024).

The results of this study found that acid-base disorders and intracerebral haemorrhage volume are two related factors and can be used as predictors of mortality in hemorrhagic stroke cases. The occurrence of acid-base imbalance causes several disorders including metabolic acidosis, respiratory acidosis, metabolic alkalosis and respiratory alkalosis which can result in mortality in hemorrhagic stroke patients (Azizah & Arofiati, 2023). Another factor that is also associated with mortality in hemorrhagic stroke patients is the volume of intracerebral hemorrhage. The occurrence of intracerebral hemorrhage causes loss of oxygen from the brain and puts pressure on nearby tissue. So that it can cause rapid brain damage or can result in death. The severity of this bleeding depends on the location of the bleeding, the speed of leakage, the volume and blood pressure due to bleeding that causes brain edema (Szerlip & Carolina, 2023).

Intracerebral hemorrhage occurs due to the rupture of small blood vessels in the brain, which can be caused by trauma or occur spontaneously, resulting in a hematoma. The presence of a hematoma provides effect mass, increase pressure intracranial, and causes damage to the network brain and the surrounding area. In addition that, toxicity spilled blood together with factors inflammation released can cause injury secondary on the network brain, which triggers death cells brain (Awanis et al., 2021). In addition, intracerebral hemorrhage also causes loss of oxygen from the brain and puts pressure on nearby tissue. So it can cause rapid brain damage or can result in death.

4. Conclusion

This study concludes that acid–base imbalance and intracerebral hemorrhage volume ≥30 ml are significant independent predictors of mortality in patients with Intracerebral Hemorrhage. Acid-base disorders were identified as the strongest predictor, indicating that physiological instability substantially contributes to early mortality in hemorrhagic stroke. Therefore, both metabolic and radiological parameters should be considered essential components of early risk stratification. These findings emphasize the critical role of nurses in early detection and management of physiological deterioration. Comprehensive monitoring of arterial blood gases, neurological status, oxygenation, and hemodynamic

parameters is essential in the acute phase. Prompt recognition and timely intervention for acid-base disturbances, along with vigilant assessment for increased intracranial pressure, may help reduce the risk of clinical worsening and mortality. Future studies should adopt prospective, multicenter designs with larger sample sizes to strengthen causal inference and improve generalizability. Additionally, interventional research is recommended to evaluate whether early, protocol-driven correction of acid–base imbalance can significantly improve survival outcomes in hemorrhagic stroke patients.

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