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Prediction of factors influencing hemorrhagic stroke death with brain herniation in teaching hospitals

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ABSTRACT

Objectives: The purpose of this study was to identify and analyze the predictors of mortality in the cases of hemorrhagic stroke with brain herniation of hospitalized patients.

Methods: In this retrospective cohort study, we analyzed 1,330 cases of hemorrhagic stroke with brain herniation from January 2015 to October 2020, and used logistic regression to identify the cause of death of hemorrhagic stroke with brain herniation.

Results: A total of 1,330 stroke patients with brain herniation were identified. The mean age was 63.40±61.00 years and 56.50% of them were male. A total of 78.80% of the observed patients were discharged directly after recovery, 2.00% were discharged at the personal/family request, and number of patients who died after being treated 19.20% died (30.90% died after being treated for <48 hours, and 69.10% died after being treated for ≥48 hours). Patients who were ≥65 years old had more tendency to die than those who were younger, with a 95% confidence interval (CI) 6,859-26,486; p=0.001). The higher the systolic and diastolic blood pressure was, the greater the probability of dying after hospitalization (odds ratio [OR] 2.340, CI 1.334-4.104, p=0.022, OR 2.110, CI 1.042-4.273, p=0.026), the lower Glasgow coma scale (GCS) score at admission (<5), the more tendency for a patient to die (OR 1.376, CI 0.816–2.320, p=0.038) would be.

Conclusions: Patient's age ≥65 years, high systolic blood pressure, high diastolic blood pressure, and GCS score <5 are predictors associated with the mortality of hemorrhagic stroke with brain herniation. The implications of these findings, if confirmed in prospective studies, would raise important policy considerations both in hospitals and at the overall health level, particularly regarding post-acute care.

Keywords: brain, herniation, mortality, hemorrhagic stroke, stroke

INTRODUCTION

Stroke is a serious public health problem, which occurs suddenly with a risk of disability, adds to the burden of health expenditures, causes significant death, and results in a decrease in quality of life. The incidence of stroke is increasing in the aging population. Young people who have had a stroke are generally found in low- and middle-income countries. Ischemic stroke is more common but hemorrhagic stroke causes more death and disability. The incidence and mortality of stroke differ between countries, geographic regions, and ethnic groups. In high-income countries, improvements in prevention, acute care, and neurorehabilitation have led to a substantial reduction in the burden of stroke over the past 30 years [1]. The annual number of strokes and fatalities from stroke increased dramatically between 1990 and 2019 despite large declines in age-standardized rates, notably among people over 70. The highest rates of disability-adjusted life years (DALYs) and age-standardized stroke-related mortality were found in the World Bank's low-income category [2]. According to DALYs, stroke continues to be the second-leading cause of death worldwide and the third-leading cause of death and disability combined. Over $721 billion is the projected total cost of stroke worldwide (0.66% of the global burden of disease) [3]. In Indonesia, according to basic health research (Riskesdas), it was reported that the prevalence of stroke nationally was 2.1 million. Provinces with the highest prevalence of stroke in Indonesia were East Kalimantan (14.70%) and Yogyakarta (14.60%), and the incidence of stroke was more found in the 55-64-year age group, both in women and men. The main behavioral risk factors that are a challenge in efforts to control stroke in the Indonesian population include smoking, a lack of physical activity, alcohol consumption, and a lack of fruit and vegetable consumption. The behavioral factors mentioned above are the causes of physiological risk factors, or risk factors such as hypertension, diabetes mellitus, dyslipidemia, obesity, etc., which can cause stroke [4].

Hemorrhagic stroke carries higher risk than ischemic stroke. Presence of a herniation syndrome and a low Glasgow

coma scale (GCS) score (≤8) have increased risk of in-hospital death. Young age, GCS score at admission, and small hematoma volume have a protective effect in patients with hemorrhage and are important predictors of functional outcome [5]. Risk factor for hemorrhagic stroke patients with brain herniation is very important to determine mortality rate. Death in acute stroke patients attributed to neurological damage due to brain edema is associated with high baseline blood pressure values [6]. One of efforts to prevent strokes is to implement health promotion in various ways to prevent strokes from an early age through healthy living behaviors like regular exercise (helping to keep blood pressure stable). Where rising blood pressure is one trigger for occurrence of strokes, quit smoking, reduce foods high in salt, have regular health checks, etc. But prognostic model for predicting mortality from hemorrhagic stroke with brain herniation after hospitalization is limited. Our purpose is to identify and analyze predictors of mortality in cases of hemorrhagic stroke with brain herniation after being admitted to teaching hospital in Indonesia.

OBJECTIVES & METHODS

Design of Study & Patient Selection

The purpose of this study was to identify and analyze the predictors of mortality in the cases of hemorrhagic stroke with brain herniation after being admitted to teaching hospital in Indonesia. The sampling method uses a total sample. We retrospectively reviewed 1,330 hemorrhagic stroke patients with brain herniation who were admitted to Dr. Moewardi Teaching Hospital, Surakarta, Indonesia, between January 2015 to October 2020. This retrospective study uses secondary data (medical records). The clinical diagnosis of hemorrhagic stroke with brain herniation was obtained from a neurologist who had written medical records. Patients aged 18-75 years with hemorrhagic stroke with first acute brain herniation within 14 days of symptom onset were included. Any stroke patient with intracerebral hemorrhage (ICH) secondary to arterial aneurysm rupture, trauma, arteriovenous malformation, subarachnoid hemorrhage or primary intraventricular hemorrhage was excluded from this study.

Data Collection

Data were collected using observation sheet. Demographic characteristics of participants were sex, age, and education. Clinical characteristics consist of systolic blood pressure, diastolic blood pressure, history of stroke, and location of bleeding. Classification of pre-hypertension defined by blood pressure ≥120/80 mmHg includes stage I hypertension if the blood pressure is between 95th and 99th percentiles plus 5 mmHg; or stage II hypertension if it is >99th percentiles plus 5 mmHg. The classifications of the bleeding and brain herniation locations based on the results of computed tomography comprise of cerebrum (temporal lobe, occipital lobe, frontal lobe, and basal ganglia), cerebellum, and brain stem (thalamus, ventricle, and pons). GCSs were classified as 14-15 (coma), 12-13 (apathetic), 10-11 (somnolent), 8-9 (stupor), 6-7 (pre-coma), and <5 (coma), which were further categorized into coma if GCS value <8 and not coma if GCS value ≥8.

Statistical Analysis

Statistical analysis was performed using SPSS software. Standard deviation, mean, median, and interquartile range were used to describe the distribution of continuous variables, and percentages for categorical variables. Pearson Chi-square or Fisher-exact test for categorical variables and one-way ANOVA for continuous variables was utilized to assess baseline characteristics in patients. A p-value of 0.05 was used to determine the statistical significance of the observed effects. Multivariable logistic regression was developed to identify the factors that were independently associated with all mortality cases in hemorrhagic stroke patients with brain herniation after hospitalization. The two-tailed difference $p<0.05$ was considered statistically significant. The results were expressed as odds ratio (OR) and 95% confidence interval (CI).

RESULTS

Basic Characteristics

The basic characteristics of hemorrhagic stroke with brain herniation and clinical factors related to gender, education, age, hypertension systolic blood pressure, GCS value, and bleeding location are presented in **Table 1**.

Table 1. Characteristics of patients on admission

Characteristics	Cases (=1,330)	Men (n=752)	Women (n=578)	p-value
Age (years)				
Average±SD	64.30±11.30	63.28±12.69	63.77±14.40	0.041
Age <65 years	730 (54.90)	417 (31.40)	313 (23.50)	0.028
Age ≥65 years	600 (45.10)	335 (25.20)	265 (19.90)	0.027
Education				0.219
Elementary school	764 (57.40)	425 (32.00)	339 (25.50)	
Junior high school	139 (10.50)	82 (6.20)	57 (4.30)	
Senior high school	350 (26.30)	206 (15.50)	144 (10.80)	
Bachelor	77 (5.80)	39 (2.90)	38 (2.90)	
History of stroke				0.730
First time	1149 (86.40)	645 (48.50)	504 (37.90)	
Recurrent	181 (13.60)	107 (8.00)	74 (5.60)	
Systolic blood pressure at admission	158.33±159.50	159.54±160.00	156.83±158.00	0.044
120-139 mmHg (pre-hypertension)	442 (33.20)	242 (18.20)	200 (15.00)	
140-159 mmHg (stage 1 hypertension)	228 (17.10)	124 (9.30)	104 (7.80)	
160 mmHg (stage 2 hypertension)	660 (49.60)	386 (29.00)	274 (20.60)	
Diastolic blood pressure at admission	93.06±95.00	93.40±95.00	92.64±95.00	0.018
80-90 mmHg (pre-hypertension)	461 (34.70)	250 (18.80)	211 (15.90)	
90-99 mmHg (stage 1 hypertension)	527 (39.60)	295 (22.20)	232 (17.40)	

Table 1 (Continued). Characteristics of patients on admission

Characteristics	Cases (=1,330)	Men (n=752)	Women (n=578)	p-value
>100 mmHg (stage 2 hypertension)	342 (25.70)	207 (15.60)	135 (10.20)	
GCS value at admission	2.97±3.00	3.00±3.00	2.94±3.00	0.875
14-15 (composmental)	432 (32.50)	237 (17.80)	195 (14.70)	
12-13 (apathetic)	120 (9.00)	67 (5.00)	53 (4.00)	
10-11 (somnolent)	140 (10.50)	82(6.20)	58 (4.40)	
8-9 (stupor)	193 (14.50)	106 (8.00)	87 (6.50)	
6-7 (pre-coma)	140 (10.50)	84 (6.30)	56 (4.20)	
<5 (coma)	305 (22.90)	176 (13.20)	129 (9.70)	
Location of intracerebral hemorrhage				0.669
Thalamus	132 (9.90)	71(5.30)	61 (4.60)	
Bilateral intraventricular	144 (10.80)	72 (5.40)	72 (5.40)	
Temporal lobe	367(27.60)	208 (15.60)	159 (12.00)	
Occipital lobe	131 (9.80)	70 (5.30)	61 (4.60)	
Frontal lobe	132 (9.90)	81(6.10)	51 (3.80)	
Cerebellum	102 (7.70)	59 (4.40)	43 (3.20)	
Pons	122 (9.20)	72 (5.40)	50 (3.80)	
Basal ganglia	200 (15.00)	119 (8.90)	81 (6.10)	
Herniation of type				0.007
Subfalcine	909 (68.30)	513 (56.40)	396 (43.60)	
Tonsilar	152 (11.40)	84 (55.30)	68 (44.70)	
Transtentorial	269 (20.20)	155 (57.60)	114 (42.40)	
Bleeding volume	Not recorded	Not recorded	Not recorded	
Area of the herniation				0.028
Subfalcine <1 cm to the right	449 (33.80)	245 (54.60)	204 (45.40)	
Subfalcine 1-2 cm to the right	84 (6.30)	52 (61.90)	32 (38.10)	
Subfalcine >2 cm to the right	50 (3.80)	28 (56.00)	22 (44.00)	
Subfalcine <1 cm to the left	248 (18.60)	132 (53.20)	116 (46.80)	
Subfalcine 1-2 cm to the left	54 (4.10)	33 (61.10)	21 (38.90)	
Subfalcine >2 cm to the left	15 (1.10)	9 (60.00)	6 (40.00)	
Tonsilar <1 cm	95 (7.10)	58 (61.10)	37 (38.90)	
Tonsilar 1-2 cm	50 (3.80)	29 (58.00)	21 (42.00)	
Tonsilar >2 cm	0 (0.00)	0 (0.00)	0 (0.00)	
Transtentorial <1 cm	237 (17.70)	141 (59.50)	96 (40.50)	
Transtentoria 1-2 cm	38 (2.90)	17 (44.70)	21 (55.30)	
Transtentorial >2 cm	10 (0.80)	8 (80.00)	2 (20.00)	
Complications during hospitalization				0.012
No complications	997 (75.00)	571 (57.30)	426 (42.70)	
Brain atrophy	144 (10.80)	73 (50.70)	71 (49.3)	
Hidrocepalus obstruktif	165 (12.40)	93 (56.40)	72 (43.6)	
Hidrocepalus non komunikans	6 (0.50)	6 (100)	0 (0.00)	
Spondyloarthrosiscervikalis	6 (0.50)	3 (50.00)	3 (50.00)	
Chronic cerebral infarct	12 (0.90)	6 (50.00)	6 (50.00)	
Length of stay in hospital				0.022
<10 days	1023 (76.90)	575 (56.20)	448 (43.80)	
10-20 days	251 (18.90)	143 (57.00)	108 (43.00)	
21-30 days	46 (3.50)	26 (56.50)	20 (43.50)	
>30 days	10 (0.80)	8 (80.00)	2 (20.00)	
Discharge after hospital treatment				
Discharged safely from hospital treatment	1048 (78.80)	599 (45.00)	449 (33.80)	
Discharged at personal/family request	27 (2.00)	14 (1.10)	13 (1.00)	
Number of patients who died after being treated	256 (19.20)	139 (54.30)	117 (45.70)	0.016
< 8 hours	79 (30.90)	45 (17.60)	34 (13.30)	
≥48 hours	177 (69.10)	94 (36.70)	83 (32.40)	

Note. SD: Standard deviation; GCS: Glasgow coma scale; & Statistically significant p<0.05

Of 1,330 cases of hemorrhagic stroke with brain herniation identified, 1,048 (78.80%) patients were discharged safely from hospital care, 27 (2.00%) were discharged at personal/family request, and 256 (19.20%) died. Mean age of observed patients was 64.30±11.30 years, 56.60% of whom were male. Women were older than men (63.77±14.40 vs. 63.28±12.69). Primary school education (57.40%) dominated education background of participants, and more male participants were found than women (32.00% vs. 25.50%). **Table 1** shows characteristics of initial clinical conditions of treated patients. Men experienced a stroke for first time at a higher rate than women (48.50% vs. 37.90%). Mean systolic blood pressure was 158.33±159.50 and higher than women (159.54±160.00 vs. 156.83±158.00), and men had a systolic blood pressure of 160 mmHg more than (29.00% vs. 20.60%). Mean diastolic blood pressure was 93.06±95.00, and men had significantly higher diastolic blood pressure than women (93.40±95.00 vs. 92.64±95.00). More men had a diastolic blood pressure of 90-99 mmHg, compared to women (22.20% vs. 17.40%). Average GCS score at hospital admission was 2.97±3.00. Location of bleeding was in temporal lobe (27.60%). Most common type of herniation is subfalcine (68.30%), most extensive subfalcine herniation to dextra is less than 1 cm (33.80%). Volume of bleeding was not recorded in medical record. Length of hospitalization was less than 10 days (76.90%) and were treated without complications (75.00%).

Table 2. Risk of death

Risk factor	Death cases	Death time <48 hours	Death time ≥ 48 hours
Total subjects	256 (19.2)	79 (30.9)	177 (69.1)
Sex			
Men	139 (54.3)	46 (18.0)	93 (36.3)
Women	117 (45.7)	33 (12.9)	84 (32.8)
p-value	0.399	0.174	0.454
Age	66.57 ± 66.00	57.89 ± 59.00	74.51 ± 73.50
Age<65 years old	124 (48.4)	34 (13.3)	90 (35.2)
Age≥65 years old	132 (51.6)	44 (17.2)	88 (34.4)
p-value	0.198	0.258	0.001
History of recurrent stroke			
Yes	49 (19.1)	19 (7.4)	30 (11.7)
No	207 (80.9)	59 (23.0)	148 (57.8)
p-value	0.110	0.074	0.611
High systolic blood pressure (hypertension)	156.79 ± 158.00	157.79 ± 160.00	155.59 ± 155.00
Yes	165 (64.5)	48 (18.8)	117 (45.7)
No	91 (35.5)	29 (11.3)	62 (24.2)
p-value	0.001	0.001	0.024
High diastolic blood pressure (hypertension)	92.89 ± 95.00	93.47 ± 95.00	92.20 ± 92.00
Yes	154 (60.2)	42 (16.4)	112 (43.8)
No	102 (39.8)	35 (13.7)	67 (26.2)
p-value	0.004	0.001	0.112
Low GCS (<5/coma)	3.14±3.00	3.31±4.00	3.07±3.00
Yes	171 (66.8)	49 (19.1)	122 (47.70)
No	85 (33.2)	28 (10.9)	57 (22.3)
p-value	0.163	0.004	0.497
Bleeding site			
Cerebrum	159 (621)	47 (18.4)	112 (43.8)
Cerebellum	20 (7.8)	9 (3.5)	11 (4.3)
Brainstem	77 (30.1)	21 (8.2)	56 (21.9)
p-value	0.297	0.109	0.001
Herniation of type			
Subfalcine	158 (61.7)	52 (66.7)	106 (59.6)
Tonsilar	29 (11.3)	6 (7.7)	23 (12.9)
Transtentorial	69 (27.0)	20 (25.6)	49 (27.5)
p-value	0.694	-	-
Bleeding volume (not recorded in medical record)	-	-	-
Area of the herniation			
Subfalcine <1 cm to the right	81 (31.6)	23 (29.5)	58 (32.8)
Subfalcine 1-2 cm to the right	16 (6.3)	5 (6.4)	11 (6.2)
Subfalcine >2 cm to the right	10 (3.9)	5 (6.4)	5 (2.8)
Subfalcine <1 cm to the left	49 (19.1)	15 (19.2)	34 (19.1)
Subfalcine 1-2 cm to the left	12 (4.7)	6 (7.5)	6 (3.4)
Subfalcine >2 cm to the left	4 (1.6)	1 (1.3)	3 (1.7)
Tonsilar <1 cm	18 (7.0)	4 (5.1)	14 (7.9)
Tonsilar 1-2 cm	7 (2.7)	2 ()	5 (2.8)
Tonsilar >2 cm	0	0	0
Transtentorial <1 cm	46 (18.0)	13 (16.6)	33 (18.5)
Transtentoria 1-2 cm	8 (3.1)	3 (3.8)	5 (2.8)
Transtentorial >2 cm	5 (2.0)	1 (1.3)	4 (2.2)
Pp-value	0.488	-	-
Length of stay in hospital			
<10 days	205 (80.1)	62 (87.2)	143 (80.3)
10-20 days	42 (16.4)	15 (19.2)	27 (15.2)
21-30 days	8 (3.1)	1 (1.3)	7 (3.9)
>30 days	1 (0.4)	0 ()	1 (0.6)
p-value	0.679		
Complications			
No complications	31 (12.1)	7 (9.0)	24 (13.5)
Brain atrophy	71 (27.7)	25 (32.1)	46 (25.8)
Hidrocepalus obstruktif	78 (30.5)	23 (29.5)	55 (30.9)
Hidrocepalus non komunikans	4 (1.6)	1 (1.3)	3 (1.7)
Spondyloarthrosiscervikalis	72 (28.1)	22 (28.2)	50 (28.1)
p-value	0.910	-	-

Note. *Statistically significant p<0.05;CI: Confidence interval; OR: Odds ratio; & GCS: Glasgow coma scale

Risk of Death After Hospitalization

The risk of death after hospitalization related to age, sex, hypertension systolic blood pressure, GCS value, and bleeding location is presented in **Table 2**.

The five-year mortality rate was 19.20% (n=256). There was no significant difference between gender, age, history of stroke, and location of bleeding on the mortality rate after receiving treatments in a hospital.

Table 3. Multivariable logistic regression of factors associated with mortality after hospitalization

Model	Univariate analysis		Multivariate analysis	
	OR (95% CI)	p-value	OR (95% CI)	p-value
Age ≥65 years old	0742 (0.433-1.270)	0.276	6.126 (6.859-26.486)	0.001**
Sex	1.179 (0.688-2.020)	0.549	1.180 (0.765-1.819)	0.445
History of recurrent stroke	0.660 (0.342-1.274)	0.215	0.342 (0.072-1.254)	0.217
High systolic blood pressure (hypertension) at admission	1.140 (0.655-1.985)	0.643	2.340 (1.334-4.104)	0.022*
High diastolic blood pressure (hypertension) at admission	1.393 (0.811–2.393)	0.230	2.110 (1.042-4.273)	0.026*
GCS at admission	0.658 (0.385–1.126)	0.127	1.376 (0.816–2.320)	0.038*
Bleeding site	2.110 (1.042–4.273)	0.297	0.275 (0.060–1.257)	0.287
Hosmer & Lemeshow			0.718	

Note. *Statistically significant p<0.05;CI: Confidence interval; OR: Odds ratio; & GCS: Glasgow coma scale

Men were at risk for a higher mortality rate than women (54.30% vs. 45.70%), but this difference was not significant. The average age of patients at risk of a five-year mortality rate was 66.57±66.00. Significantly, patients who were at risk of dying later (<48 hours) were higher than those who died earlier (<48 hours) (74.51±73.50 vs. 57.89±59.00, p=0.001). A history of recurrent stroke had a higher mortality rate than a first stroke (80.97% vs. 19.03%, but not significant). The mean systolic and diastolic blood pressures at risk contributed to the mortality rate after hospitalization at five years (156.79±158.00 mmHg vs. 92.89±95.00). Patients with high systolic blood pressure (hypertension) were more likely to die earlier (<48 hours) than 48 hours (157.79±160.00 vs. 155.59±155.00; p=0.001). Significantly, patients with high diastolic blood pressure (hypertension) were at risk of early death (<48 hours) than 48 hours (93.47±95.00 vs. 92.20±92; p=0.001). Patients with decreased consciousness (coma) had a higher risk of death than those who did not experience decreased consciousness (66.80% vs. 33.20%). The mean low GCS score (coma) at risk of having an earlier death (<48 hours) was higher (3.31±4.00) than that of <48 hours (vs. 3.07±3.00; p=0.001). Bleeding location in cerebrum has a higher risk of death than that in cerebellum and brainstem (62.10% vs. 7.80%, 30.10%), but not significant.

Factors Associated with Mortality After Hospitalization

Multivariate analysis of independent predictors is presented in **Table 3**. Patients older than 65 years at the time of hospitalization were at a higher risk of death than those who were younger. The mortality rate of hemorrhagic stroke patients was influenced by age, 6.126 times with a CI of 6.859 to 26,486; p-value=0.001. The higher the systolic and diastolic blood pressure (hypertension) at admission, the more likely the patients were to die after hospitalization (OR 2.340, CI 1.334-4.104, p=0.022; OR 2.110, CI 1.042-4.273, p=0.026). Moreover, the lower GCS score at admission (<5), the more likely the patients were to die after hospitalization (OR 1.376, CI 0.816–2.320, p=0.038). There was no association between gender, history of stroke, or bleeding site and mortality in hemorrhagic stroke patients with brain herniation.

DISCUSSION

The mortality rate of stroke with brain herniation in this study was 19.20%, which was lower than 36.00%, reported by another study of the Swedish population [7]. This can be explained in part by the different sample characteristics and research designs. In this study,

(1) the patients were from a teaching hospital and had more tendency to have a hemorrhagic stroke with fewer complications,

(2) the patients were relatively younger with a mean age of 64.30±11.30 years, and only 45.10% of patients were 65 years old, and

(3) the exclusion criteria were a history of brain trauma, arterial ischemic stroke, and tumor bleeding.

The results of our study revealed that older age is a risk factor for the mortality of hemorrhagic stroke with brain herniation. This finding supports the results of several other studies. Previous studies have shown that older age (≥65 years) is correlated and serves as a predictor of hemorrhagic stroke mortality [8, 9].

This study depicted that the men have a higher risk of death due to hemorrhagic stroke with brain herniation than women. This is following the outcomes of several other studies. Men have higher three-month mortality than women in patients with ICH [10]. Men are independently associated with ninety-day mortality in patients with ICH [11]. In the present study, although men have a higher mortality rate than women, this difference in multivariate analysis is not significant. In other literature, these sex differences are inconsistent. One study in Finland found that men have better survival than women after a hemorrhagic stroke [12]. No gender difference is associated with mortality within 12 and 36 months after ICH [13].

A history of repeated strokes has a higher risk of death within five years than a first attack. The results of this study are following those of previous studies. Recurrent stroke has poorer prognosis for the last five years [14]. Although a history of recurrent stroke in this study has a higher mortality rate than the first attack, this difference in multivariate analysis is not significant. The relative risk of death after recurrent stroke is lower [15].

High systolic and diastolic blood pressure (high blood pressure) is a risk factor for early death in hemorrhagic stroke in patients with brain herniation. The results of this study are following those of several other studies, that high blood pressure is significantly correlated with mortality at admission [16]. High systolic blood pressure is associated with the risk of death and is a predictor of poor results in hemorrhagic stroke patients [17-19]. High systolic blood pressure was reported to be associated with death in ICH stroke patients with chronic hypertension [20]. An increase in blood pressure during the first few hours to days after ICH leads to higher mortality and disability rates [21]. However, in other literature, this difference in high systolic blood pressure is inconsistent. One study in a Brazilian intensive care unit found that high systolic blood pressure is not associated with mortality in hemorrhagic stroke patients [22].

Patients who are hospitalized with a low GCS are more likely to die than hemorrhagic stroke patients with brain

herniation who arrive with a GCS in the excellent range. One might surmise that in stroke patients with significant lesions, this lowers the perfusion pressure and blood flow to the brain, which creates an irreversible infarction and ceases brain tissue activity. The death of brain tissue happens when the perfusion pressure falls below a certain threshold. The patient's awareness will be automatically thrown off if there are lesions near the cerebral hemispheres and the reticular formation, which controls the defense of consciousness. This result is following that of previous studies showing that decreased consciousness at the time of hospital admission is associated with predictors and increased risk of death in hemorrhagic stroke patients [23-26].

Cerebral hemorrhage sites carry a higher risk of death than the cerebellum and brain stem. However, this study has not found a significant relationship between bleeding sites and short-term or long-term mortality due to the lack of data collection regarding the history of using coagulant therapy during hospitalization. The results of this study follow those of other studies, which show that the location of bleeding is an independent predictor of early death in patients with ICH [27, 28]. However, in other literature, this difference in the bleeding sites is inconsistent. The location of bleeding does not have a significant relationship with mortality, but the volume of bleeding has a significant relationship with mortality in patients with ICH [29].

This study has identified several important risk factors for predicting mortality in hemorrhagic stroke patients with brain herniation; however, our study has some limitations. First, due to the retrospective nature of this study, some clinical data may be missing or may be omitted, resulting in incomplete study data collection and affecting the results of the analysis of this study. Second, compared with previous studies, this study has involved hemorrhagic stroke patients with brain herniation who have a history of the first or second stroke, younger people with fewer comorbidities that can lead to a favorable outcome bias. Third, drug use during hospitalization, hematoma volume, and presence of ventricular blood were not recorded in this study so we have not determined the association of these factors and outcomes after hemorrhagic stroke with brain herniation. Lastly, we did not record functional outcomes, such as the modified Rankin Score during follow-up. Thus, we were unable to analyze long-term predictors of functional outcome in a retrospective cohort study of hemorrhagic stroke patients with brain herniation. Some of the strengths of our study are the large sample size and the inclusion of patients from various regions.

CONCLUSIONS

This retrospective cohort concludes that we have found that age, systolic blood pressure, high diastolic blood pressure, and GCS scores are the factors associated with post-discharge mortality, which validate previous studies. These findings, if confirmed in prospective studies, will raise important policy considerations both at the hospital and at the level of overall health, particularly regarding post-acute care. These findings can be used as input for evaluation by policy makers and health workers in order to improve the quality of health service practices to ensure safety for stroke patients, especially in formulating health promotion programs related to early detection and prevention of stroke. Future research with larger data sets may be able to separate modifiable factors (such as blood pressure, diabetes mellitus, healthy lifestyle habits, etc.) and non-modifiable factors (age, gender, genetics, etc.), which predominantly influence mortality rates and intervention levels. In addition, future research uses a prospective design to obtain comprehensive data and ensure that the research data more accurately reflects real solutions.

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Ethical statement: The authors stated that the ethical consideration for this retrospective study was obtained from the Health Research Ethics Committee of Dr. Moewardi General Hospital, Faculty of Medicine, Universitas Sebelas Maret, Surakarta, with the issuance number 849/VII/HERC/2020. Any information attained through the survey was kept confidential and would only be used for scientific purposes. The authors further stated that participation on the study was voluntary and respondents were maintained anonymity. A detailed description of the methodological expectations, anonymity, and confidentiality was discussed in the written agreement.

Declaration of interest: No conflict of interest is declared by authors.

Data sharing statement: Data supporting the findings and conclusions are available upon request from the corresponding author.

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