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Prognosis Factors for In-hospital Mortality in Spontaneous Intracerebral Hemorrhage

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Abstract:

Background: Spontaneous intracerebral hemorrhage has the highest mortality of cerebrovascular disease. Previous studies have examined factors contributing to death using binary outcomes but have not analyzed time to death.

Objective: To study prognostic factors for in-hospital mortality in spontaneous intracerebral hemorrhage.

Method: This retrospective cohort design of prognostic research included patients with spontaneous intracerebral hemorrhage from January 2018 to January 2023. Study variable factor and follow time to death refer to the number of days from diagnosis until death within 90 days of hospitalization. Statistical analysis included proportional hazard (PH assumption), then univariable and multivariable Cox's PH regression analysis; results were presented using the Hazard Ratio, 95% CI, p-value < 0.05, and Kaplan-Meier survival curve.

Results: 799 patients were eligible during the period; 153 patients were excluded, and 646 patients were included in the analysis. The mortality rate was 20.7%. Most of the patients were male, with an average age of 60. Multivariable analyses demonstrated that the prognostic factors of mortality included the Glasgow Coma Scale ≤ 8. [mHR 6.33 (95% CI 3.86-10.37), p < 0.001], intraventricular hemorrhage [mHR 5.31 (95% CI 2.94-9.58), p < 0.001], infratentorial location [mHR 2.73 (95% CI 1.51-4.94), p = 0.001], midline shift ≥ 5mm [mHR 2.08 (95% CI 1.04-4.16 p = 0.038], stroke in the young (age ≤ 45 years) [mHR 2.21 (95% CI 1.40-3.47), p = 0.001] and male sex [mHR 1.86 (95% CI 1.25-2.77), p = 0.002]. The prognostic factor for decreased mortality included surgery [mHR 0.25 (95% CI 0.15-0.41), p < 0.001] and door to target SBP in 1 hour [mHR 0.62 (95% CI 0.41-0.93), p = 0.020]. 138 (21.4%) patients underwent a neurosurgical intervention; 106 (76.8%) patients among the survivors compared with 32 (23.2 %) patients who died. Independent predictors of mortality included intraventricular hemorrhage [mHR 6.31 (95% CI 1.49-26.83), p = 0.013] and midline shift > 10 mm [mHR 4.25 (95% CI 1.17-15.39 p = 0.027]

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Conclusion: Glasgow Coma Scale ≤ 8, intraventricular hemorrhage, infratentorial location, midline shift ≥ 5 mm, stroke in the young (age ≤ 45 years), and male sex were significant predictors of in-hospital mortality in a spontaneous intracerebral hemorrhage, whereas surgical therapy and reducing blood pressure to target within 1 hour decreased the in-hospital mortality. Intraventricular hemorrhage and midline shift > 10 mm were predictors of in-hospital mortality in patients who underwent neurosurgical intervention. To reduce death, management for spontaneous intracerebral hemorrhage cases needed to focus on targeting these factors.

Keywords: Prognostic factors, Intracerebral hemorrhage, In-hospital mortality

Introduction

Cerebrovascular diseases remain a significant burden in Thai healthcare; they are the second leading cause of death after cancer.[1] The incidence of intracerebral hemorrhage accounts for 20% of cerebrovascular diseases.[2] Spontaneous intracerebral hemorrhage (SICH) has the highest 30-day mortality rate of cerebrovascular diseases at 30-40%.[3,4] In Thailand, hemorrhagic stroke was associated with the highest estimated mean annual costs, which could be because hemorrhagic strokes are associated with a poorer prognosis and require more resources, such as more extended hospitalizations.[5,6] Death in the hospital after a stroke probably reflects the interface of challenges in optimizing the overall health system. Stroke care teams should effectively estimate prognosis.[7]

Hematoma volume, lower Glasgow Coma Scale (GCS) on admission, and medical comorbidities were critical factors in determining mortality and a poorer prognosis.[4,8] The ICH score is a prognostic model for mortality; it is a simple clinical grading scale that allows risk stratification on presentation with SICH and incorporates measures of symptom severity, age, hematoma volume, hematoma location, and intraventricular hemorrhage (IVH).[9] However, this model only accounts for disease severity factors that cannot be modified. Ignoring treatments in the prognostic model may lead to care limitations in cases with severe initial symptoms, perhaps inappropriately.

SICH causes cerebral tissue damage through two mechanisms. The first mechanism is the direct pressure effect, which can be treated with antihypertensive medications in the acute phase. Antihypertensives are safe and can reduce hematoma expansion in mild to moderate severity patients. The second mechanism comes from the secondary physiologic and cellular pathways. Surgical treatment reduces direct pressure effects and secondary physiologic and cellular pathway damage.

Nonetheless, the benefits of surgical treatment compared to medical therapy alone are still unclear.[3] Hematoma expansion (HE) also presents a poor prognosis and is the aim of acute blood pressure control.[10] The current recommendations are based on data from the two most extensive trials (Intensive Blood Pressure Reduction in Acute Cerebral Hemorrhage Trial [INTERACT2] and Antihypertensive Treatment of Acute Cerebral Hemorrhage II [ATACH-2]) for early intensive blood pressure lowering (EIBPL) after SICH, but also have a knowledge gap and need to better delineate the prognostic significance of the magnitude of blood pressure (BP) reduction during the first few hours.[3] Despite the unclear value of craniotomy in improving overall functional benefit or mortality, limited data suggest that craniotomy for hematoma evacuation might be considered a lifesaving measure in patients who are deteriorating.[3]

The goal of treating SICH is to reduce mortality rates. Thus, identifying treatable prognostic factors for mortality is beneficial in assessing patients and effective treatment planning. This study aims to study the prognostic factors of in-hospital mortality in patients with SICH.

Materials and method

Study design and population

This study is prognostic research using an exploratory model, with data collection done as a retrospective cohort design. Data collection retrieved the patients with a primary diagnosis of SICH, using the 10th revision of the International Classification of Diseases (ICD-10) codes I61.0-I61.9) and received treatment at Phayao Hospital, Phayao Province, from January 1, 2018 to January 1, 2023. A total of 799 patients with abnormal acute neurological symptoms who underwent a computed tomography scan of the brain (CT brain) were diagnosed with hemorrhagic stroke and were at least 18 years of age were included in the study. One hundred fifty-three patients were excluded from the study, including 1) patients with secondary causes of intracerebral bleeding such as an intracranial aneurysm or subarachnoid hemorrhage, cerebral arteriovenous malformation, cerebral venous sinus thrombosis, tumors, and trauma. (95 patients); 2) patients with an abnormal international normalized ratio (INR) ≥ 1.5 or patients taking warfarin (32 patients); 3) patients with a platelet count of < 100,000/mm^3 (19 patients); 4) patients who do not have a brainstem reflex (3 patients); and 5) patients with incomplete medical records (4 patients). A total of 646 patients were included in the study, as shown in Figure 1.

Patients received care according to guidelines on the management of intracerebral hemorrhage[11,12], under the care of a multidisciplinary team, until death or survival on discharge from the hospital. Variables that may be contributing factors to mortality and were included in the study include 1) sex, 2) age, 3) GCS on arrival to the emergency department (ED), 4) location of hematoma, 5) IVH; 6) volume of hematoma measured using the ABC/2 method; 7) midline shift (MLS), measuring the distance of convexity of the corpus callosum at the level of the foramen of Monro, 8) Depth measured from the cortical surface to the outermost border of the SICH, 9) Achieving the target systolic blood pressure (SBP) of 130-150 mmHg in 1 hour (door-to-target SBP in 1 hour) with antihypertensive medication, either nicardipine or labetalol, 10) surgery or neurosurgical intervention was defined as having an operative neurosurgical procedure with craniotomy or craniectomy with blood clot removal or ventriculostomy with external ventricular drainage per indication for surgical treatment. Indications for surgery include a volume of hematoma ≥30 ml, cerebellum hematoma diameter > 3 cm or volume ≥ 15 ml, MLS ≥ 5 mm, and IVH with obstructive hydrocephalus.[11-14] Operation time is initially from the anesthesia procedure until the closure of the scalp. The decision to undergo surgery also depends on an agreed-upon decision and planning between the surgeon, the patient, and the patient's relatives. Once the patient's clinical condition has stabilized, they undergo rehabilitation and intermediate care until discharge. Time to death, which refers to the number of days from diagnosis until death, was followed, with two types of event status: death or censoring within 90 days of hospitalization. This study has the approval of the ethics committee of Phayao Hospital (COA no. 194, PYHREC no. 10/2566).

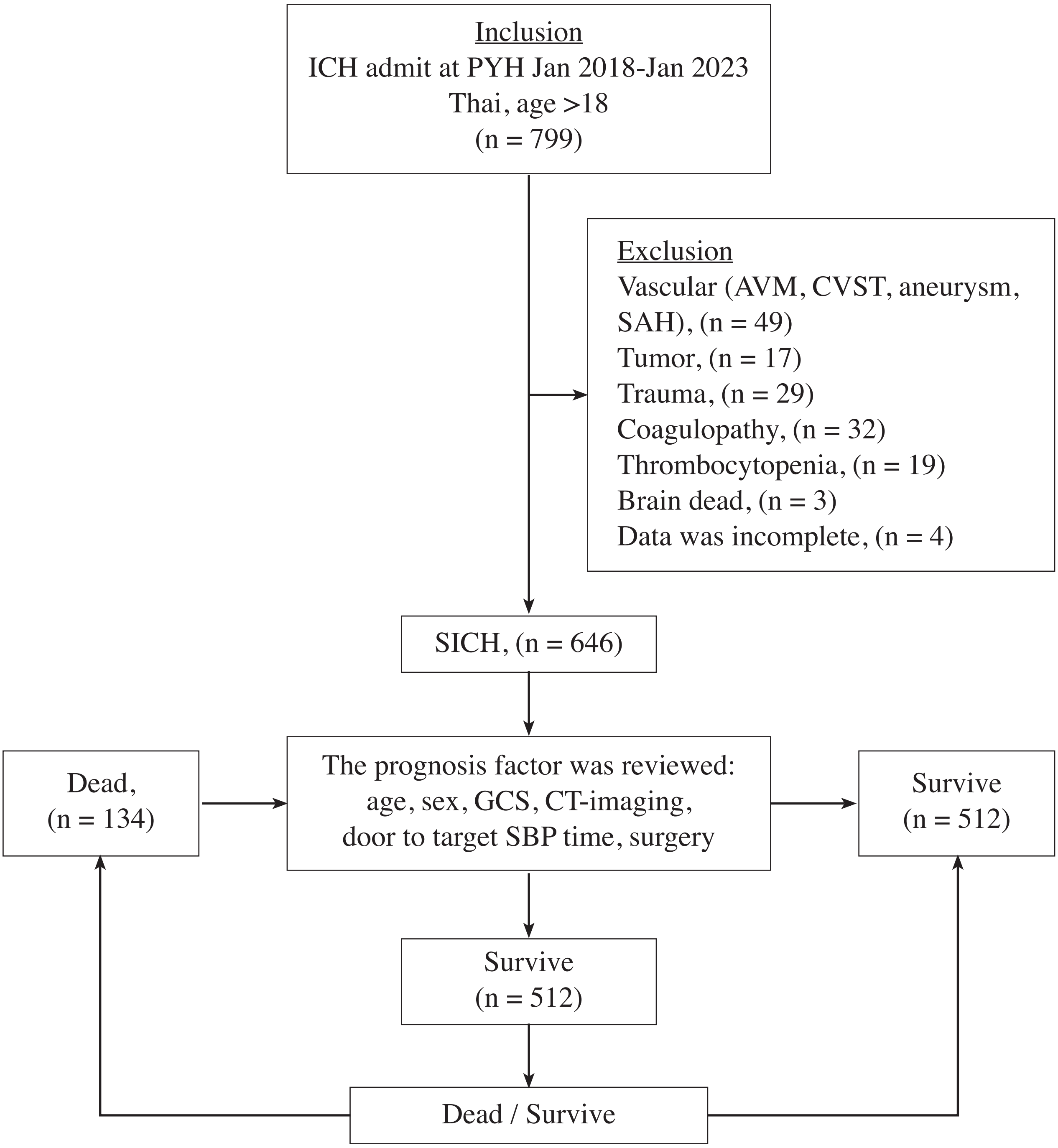

Figure 1 Study flow diagram

Sample size calculation

The sample size was calculated based on a pilot study of 60 cases among patients with SICH at Phayao Hospital. There were 11 cases in the death group and 49 cases in the survival group. Because this study is an exploratory model, it was necessary to calculate the sample size for every predictive factor that was expected to affect death. Calculate sample size using STATA version 18 (licensed) (study size estimation for the Cox proportional hazard model) with alpha error < 5%, power 80%, maximum sample size, and the possibility to collect data, including the variable MLS of ≥ 5 mm, which calculates a hazard ratio equal to 1.68 times, results in the number of death events similar to 117 cases. The pilot study found four times the proportion of patients who survived to those who died (N2/N1). Therefore, it is necessary to use 117 surviving patients x 4 times = 468 patients, for a total of 585 patients. This sample size can cover factors predicting age ≤ 45 years, GCS ≤ 8, ICH volume, IVH, MLS ≥ 5 mm, door-to-target SBP in 1 hour, and surgery, respectively.

Nonetheless, a larger sample size with more events is a better representation and has better statistical power. As such, the researchers included all patients in the study from January 1, 2018, to January 1, 2023; after exclusion, 646 patients remained.

Statistical analysis

Patients included in all SICHs were divided into two groups: in-hospital deaths and survivors (censoring). Categorical variables were analyzed by Fisher's exact test and assessed as counts and percentages. Continuous variables were analyzed by the Student's t-test or Mann-Whitney U test and considered mean or median with a standard deviation or interquartile range, depending on the data distribution. First, the univariate Cox proportional hazards ratio was used to identify the possible independent risk factors for mortality. The clinically significant variables and all variables with a p-value less than 0.1 were included in the multivariable analysis model. Second, multivariable Cox proportional hazards ratio analysis and the step-backward method were used to identify the independent prognostic factors for mortality. A multicollinearity test was performed. Prognostic factors for decreased mortality were expressed using the Kaplan-Meier survival curve.

Results

This study includes a total of 646 patients with SICH: 134 patients died in the hospital, and 512 patients survived on discharge. The percentage of in-hospital deaths was 20.7, with the majority of patients male, with an average age of 60 years, bleeding in the supratentorial region, a depth > 10 mm, and taking longer than 1 hour to achieve the SBP goal of 130-150 mmHg. In the in-hospital death group, a majority of patients had GCS ≤ 8, and 90% of patients had an IVH, with an average volume of hemorrhage of 38.2 ml (IQR 16.2-91.3 ml) and an average MLS of 5.5 mm (IQR 0–11 mm) (table 1.1). One hundred thirty-eight patients underwent neurosurgical intervention, while 508 underwent conservative treatment. The majority of patients who underwent neurosurgical intervention were male. The average age is about 58 years, and the average GCS is 10.2 ± 3.9. The most bleeding was at the supratentorial location, and the average hematoma volume was 30 ml, with a midline shift of 4 mm (IQR 0–7 mm). 56.5% of patients underwent a craniotomy, 20.3% had a craniectomy, and 23.2% had a ventriculostomy. Thirty-two patients died in the hospital, while 106 survived at discharge. The in-hospital mortality among patients who underwent surgery was 23.2% (table 1.2).

Analysis of prognostic factors for morality was done using a univariable Cox proportional hazard ratio; results showed prognostic factors for increased risk of in-hospital mortality included male sex, stroke in the young (age ≤ 45 years), GCS ≤ 8, infratentorial, IVH, the volume of hematoma > 30 ml, MLS > 5 mm, depth ≤ 10 mm, and prognostic factors for decreased risk of in-hospital mortality included door-to-target SBP in 1 hour and surgery. Subgroup analysis in neurosurgical intervention showed prognostic factors for increased risk of in-hospital mortality included GCS ≤ 8, IVH, volume of hematoma > 60 ml, and MLS > 10 mm (Table 2).

Table 1.1 Characteristics of patients

Clinical characteristics	Death n = 134 (20.7%)	Survival n = 512 (79.3%)	p-value
	n (%)	n (%)	
Gender, n (%)			
Female	35 (26.1)	197 (38.5)	0.008
Male	99 (73.9)	315 (61.5)	
Age (years), mean ± SD.	59.8 ±15.6	62.4 ± 13.2	0.053
> 45	107 (79.8)	458 (89.4)	0.005
≤ 45	27 (20.2)	54 (10.6)	
GCS, mean ± SD	6.6 ±3.8	12.1 ± 3.7	< 0.001
9-15	34 (25.4)	419 (81.8)	< 0.001
3-8	100 (74.6)	93 (18.2)	
Location			
Supratentorial	99 (73.9)	452 (88.3)	< 0.001
Infratentorial	35 (26.1)	60 (11.7)	
Intraventricular hemorrhage	119 (88.8)	203 (39.7)	< 0.001
Volume of hematoma (ml.), median (IQR)	38.2 (16.2, 91.3)	12.3 (5.3, 29.1)	< 0.001
< 30	58 (43.3)	390 (76.2)	< 0.001
30-60	22 (16.4)	71 (13.9)	
> 60	54 (40.3)	51 (9.9)	
Midline shift (mm.), median (IQR)	5.5 (0, 11)	0 (0, 3)	< 0.001
< 5	60 (44.8)	410 (80.1)	< 0.001
5-7	16 (11.9)	46 (9.0)	
8-10	18 (13.4)	16 (3.1)	
> 10	40 (29.9)	40 (7.8)	
Depth (mm.)			
> 10	92 (68.7)	390 (76.1)	0.094
≤ 10	42 (31.3)	122 (23.9)	
Door to target SBP (hour)			
> 1	97 (72.4)	328 (64.1)	0.082
≤ 1	37 (27.6)	184 (35.9)	
Treatment			
Conservative	102 (76.1)	406 (79.3)	0.410
Surgery	32 (23.9)	106 (20.7)	

GCS: Glasgow Coma Scale; SBP: Systolic blood pressure

Table 1.2 Characteristics of patients who had neurosurgical intervention

Clinical characteristics	Death n = 32 (23.2%)	Survival n = 106 (76.8%)	p-value
	n (%)	n (%)	
Gender, n (%)			
Female	10 (31.3)	42 (39.6)	0.415
Male	22 (68.7)	64 (60.4)	
Age (years), mean ± SD	58.5 ± 16.4	58.4 ± 11.8	0.960
> 45	25 (78.1)	91 (85.9)	0.285
≤ 45	7 (21.9)	15 (14.1)	
GCS, mean ± SD	8.6 ± 4.5	10.6 ± 3.6	0.008
9-15	14 (43.7)	73 (68.9)	0.013
3-8	18 (56.3)	33 (31.1)	
Location			
Supratentorial	28 (87.5)	98 (92.5)	0.473
Infratentorial	4 (12.5)	8 (7.5)	
Intraventricular hemorrhage	30 (93.8)	62 (58.5)	< 0.001
Volume of hematoma (ml.), median (IQR)	32.3 (12.2, 75.7)	28.8 (15.9,50.0)	0.247
< 30	15 (46.8)	56 (52.8)	0.129
30-60	6 (18.8)	31 (29.3)	
> 60	11 (34.4)	19 (17.9)	
Midline shift (mm.), median (IQR)	5 (0,11)	3 (0,6)	0.055
< 5	13 (40.6)	67 (63.2)	0.054
5-7	6 (18.8)	18 (17.0)	
8-10	3 (9.4)	7 (6.60)	
> 10	10 (31.2)	14 (13.2)	
Procedure			
Craniotomy	15 (46.9)	63 (59.4)	0.393
Craniectomy	8 (25.0)	20 (18.9)	
Ventriculostomy	9 (28.1)	23 (21.7)	
Operation time (minute), median (IQR)	120 (75,158.5)	107 (80,150)	0.316

GCS: Glasgow Coma Scale; SBP: Systolic blood pressure

Table 2 Univariate Cox's proportional hazard regression analysis

Variables	uHR	95% CI	p-value
Male	1.65	1.12-2.44	0.011
Age ≤ 45 years	1.92	1.25-2.96	0.003
GCS ≤ 8	9.37	6.31-13.92	< 0.001
Infratentorial	2.04	1.37-3.04	< 0.001
Intraventricular	8.36	4.87-14.34	< 0.001
Volume of hematoma (ml.)			
30-60	1.66	1.00-2.74	0.047
> 60	5.01	3.46-7.37	< 0.001
Midline shift (mm.)			
5-7	2.03	1.16-3.54	0.013
8-10	5.22	3.03-8.99	< 0.001
> 10	5.56	3.70-8.37	< 0.001
Depth ≤ 10 mm.	1.46	1.00-2.10	0.047
Door to target SBP in 1 hour	0.71	0.48-1.04	0.075
Surgery	0.62	0.41-0.95	0.030
GCS ≤ 8	2.12	1.04-4.33	0.039
Infratentorial	0.87	0.29-2.59	0.809
Intraventricular	7.15	1.70-30.09	0.007
Volume of hematoma (ml.)			
30-60	0.88	0.34-2.29	0.800
> 60	2.27	1.01-5.10	0.047
Midline shift (mm.)			
5-7	2.07	0.76-5.62	0.152
8-10	2.17	0.28-16.94	0.462
> 10	3.75	1.67-8.43	0.001
Procedure			
Craniotomy	1		
Craniectomy	1.34	0.56-3.23	0.510
Ventriculostomy	1.28	0.55-2.96	0.572
Operation time (minute)	1.00	0.99-1.00	0.512

GCS: Glasgow Coma Scale; SBP: Systolic blood pressure; uHR: Univariable hazard ratio

Multivariable cox proportional hazards ratio analysis was conducted and presented using a multivariable hazard ratio (mHR); results showed prognostic factors for increased in-hospital mortality included GCS ≤ 8 [mHR 6.33 (95% CI 3.86-10.37), p < 0.001], IVH [mHR 5.31 (95% CI 2.94-9.58), p<0.001], MLS > 10 mm [mHR 3.36 (95% CI 1.58-7.36), p = 0.002], MLS 8-10 mm [mHR 3.75 (95% CI 1.60-8.82), p = 0.002], MLS 5-7 mm [mHR 2.08 (95% CI 1.04-4.16), p = 0.038], infratentorial [mHR 2.73 (95% CI 1.51-4.94), p = 0.001], stroke in the young (age ≤ 45 years) [mHR 2.21 (95% CI 1.40-3.47), p = 0.001], male [mHR 1.86 (95% CI 1.25-2.77), p=0.002]. The prognostic factor for decreased in-hospital mortality included surgery [mHR 0.25 (95% CI 0.15-0.41), p < 0.001] and door-to-target SBP in 1 hour [mHR 0.62 (95% CI 0.41-0.93), p = 0.020] (table 3). Furthermore, among patients treated with neurosurgical intervention, variables that predicted increased risk of in-hospital death were IVH [mHR 6.31 (95% CI 1.49–26.83), p = 0.013] and MLS >10 mm. [mHR 4.25 (95% CI 1.17–15.39), p = 0.027] (table 3). Prognostic factors for reducing the risk of death were presented using the Kaplan-Meier survival curve (Figure 2 and 3).

Table 3 Multivariable Cox's proportional hazard regression analysis

Variables	mHR	95% CI	p-value
Male	1.86	1.25-2.77	0.002
Age ≤ 45 years	2.21	1.40-3.47	0.001
GCS ≤ 8	6.33	3.86-10.37	< 0.001
Infratentorial	2.73	1.51-4.94	0.001
ICH volume (ml.)			
30-60	0.64	0.36-1.13	0.125
> 60	0.84	0.42-1.66	0.613
Intraventricular	5.31	2.94-9.58	< 0.001
Midline shift (mm.)			
5-7	2.08	1.04-4.16	0.038
8-10	3.75	1.60-8.82	0.002
> 10	3.36	1.58-7.14	0.002
Depth ≤10 mm.	0.95	0.62-1.44	0.799
Door to target SBP in 1 hour	0.62	0.41-0.93	0.020
Surgery	0.25	0.15-0.41	< 0.001
GCS ≤ 8	1.79	0.71-4.50	0.217
ICH volume (ml.)			
30-60	5.00	0.17-1.45	0.201
> 60	0.45	0.11-1.85	0.267

Table 3 Multivariable Cox's proportional hazard regression analysis (cont.)

Variables	mHR	95% CI	p-value
Intraventricular	6.31	1.49-26.83	0.013
Midline shift (mm.)			
5-7	2.25	0.80-6.34	0.125
8-10	2.96	0.35-25.20	0.320
>10	4.25	1.17-15.39	0.027

GCS: Glasgow Coma Scale; SBP: Systolic blood pressure; mHR: Multivariable hazard ratio

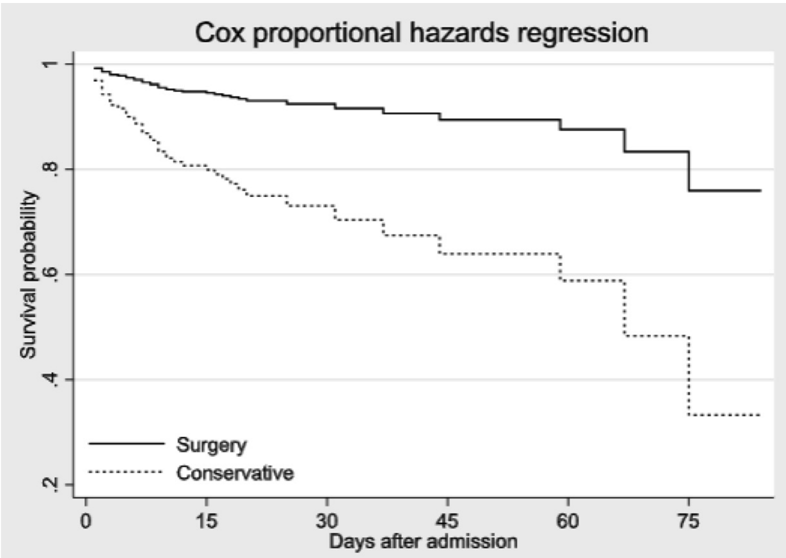

Figure 2 Survival of SICH patients who underwent surgery or conservative treatment

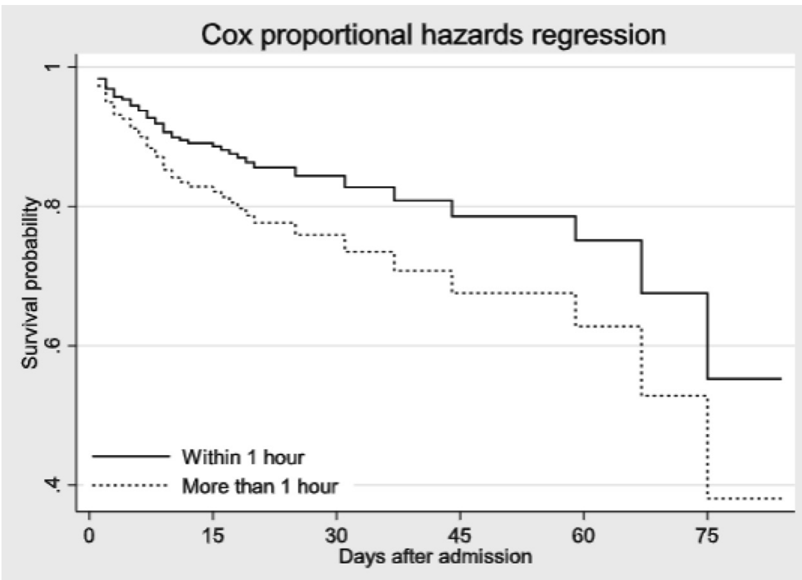

Figure 3 Survival of SICH patients who achieved a target SBP of 130–150 mmHg within or after 1 hour

Discussion

SICH is a life-threatening emergency condition. This retrospective cohort study found that prognostic factors for increased mortality included male sex, stroke in the young (age ≤ 45 years), GCS ≤ 8, IVH, infratentorial location, and MLS ≥ 5 mm; meanwhile, prognostic factors for decreased mortality included the use of intravenous antihypertensive drugs, including nicardipine or labetalol to achieve a target SBP in 1 hour, and surgical treatment.

This study found the in-hospital mortality rate of patients with SICH at 20.7%, lower than a previous study with an in-hospital mortality rate of 24%[15] and a study in Thailand that found it at 26–28%.[16] Nonetheless, this study excluded patients with brain stem death, patients with abnormal INR ≥ 1.5 or patients using warfarin, and patients with a platelet count < 100,000/mm^3 from analysis, which may contribute to a lower mortality rate.

This study reported that men have high mortality; this is in line with previous studies.[17,18] It may be a consequence of behavioral risks such as smoking and alcohol consumption, which contribute to comorbidities such as hypertension, dyslipidemia, and myocardial infarction, contributing to higher mortality compared to women. However, a study by Gokhale et al.[19] found that after adjusting for confounding factors, both sexes have no differences in mortality risk.

We found that patients with stroke in the young (age ≤ 45 years) have a higher mortality risk. However, prior studies have shown that elderly age confers a higher mortality risk[9] can be explained by chronic conditions associated with increased age[20]; as such, old age has a higher mortality risk. Nevertheless, in developing countries, stroke in the young was found to have an increasing mortality risk.[21] A major cause of hemorrhagic stroke in the young is hypertension[22], which has a slower rate of initial diagnosis and poorer control.[23] Furthermore, more youthful age is associated with prolonged hospitalization, which is associated with increased rates of medical complications and worse functional outcomes.[24]

This study found that GCS ≤ 8, IVH, MLS ≥ 5 mm, and infratentorial location were prognostic factors for increased mortality in SICH; this may be because GCS ≤ 8, IVH, and MLS were found to be associated with increased intracranial pressure (ICP), causing decreased cerebral perfusion pressure, consequently leading to poorer treatment outcomes.[25-27]

GCS ≤ 8 was the most vital prognostic factor for in-hospital mortality, similar to the previous study.[28, 29] The GCS is a scale widely used to assess the level of consciousness. An earlier occurrence of more consciousness disturbance may, therefore, suggest more significant damage to the involved cerebral structures as well as a greater mortality rate.

IVH causes severe ICP elevations associated with herniation and ischemia. IVH volume and blood breakdown products that promote inflammatory meningitis and hydrocephalus. In the present study, IVH was a prognostic factor for in-hospital mortality. These findings are similar to those of a Qureshi AI et al. study, as hemorrhage volume and ventricular extension are the best predictors of in-hospital mortality.[30] The amount of blood in the ventricles relates directly to the degree of injury and likelihood of survival.[31]

MLS indicates increased intracranial pressure, indicating reduced brain perfusion caused by an intracranial mass or mass effect.[32] Our findings aligned with the previous study[33], which reported that MLS ≥ 5 mm was a prognostic factor for in-hospital mortality.

Infratentorial location, including brain stem or cerebellar hemorrhage, conferred a higher risk of mortality; despite the smaller volume of hematoma in this area, there is a higher severity, and it is more life-threatening.[34]

This study showed that reducing SBP to 130–150 mmHg within 1 hour after the patient's arrival at the ED helps reduce mortality risk. The findings corresponded to new recommendations for acute BP lowering and recommendations to initiate EIBPL. Initiating treatment within 2 hours of ICH onset and reaching the target within 1 hour.[3] Nevertheless, success in BP reduction to target levels depends on cerebral pathophysiology, or the Cushing reflex, where increased ICP leads to a systemic hypertension response. As such, patients with severe SICH present with higher BP, and reducing BP to target levels is more difficult in this group of patients. A previous study reported that BP reduction decreased HE but did not decrease mortality.[35] However, a prospective study may be required to confirm the importance of various BP measures and the prognostic significance of the magnitude of BP reduction during the first few hours, and the fast-track protocol may play a significant role in controlling the target time.

Theoretically, surgery for blood clot removal confers the benefit of reducing the mass effect and cellular toxicity from residual hemoglobin breakdown. However, a large randomized clinical trial[36] did not find that early surgery has improved treatment outcomes compared to conservative treatment. Nonetheless, there was a crossover from the conservative group to the surgical treatment group if the patients deteriorated. This study found that the in-hospital mortality rate in patients treated with neurosurgical intervention was 23%. It is lower than previous studies that found the in-hospital mortality rate in patients treated with neurosurgical intervention was approximately 30–50%.[36–38] This was a retrospective study, and the selection of patients treated with surgery was based on the joint decision of the neurosurgeon, patients, and patient relatives. Most patients who received neurosurgical intervention corresponding to the indications for surgery had a mean GCS of 10, a volume of hematoma of 30 ml, and an MLS of 4 ml. They almost had IVH and supratentorial lesions. This study found that surgery is a prognostic factor for a decrease in hospital mortality [mHR 0.25 (95% CI 0.15-0.41), $p < 0.001$]. It suggests that neurosurgical intervention in patients with life-threatening conditions helps reduce death in patients with intracerebral hemorrhage. Findings also correspond to the current recommendation[3], which recommended lifesaving surgery in patients with ICH that had deteriorated. A subgroup analysis of patients with intracerebral hemorrhage who received neurosurgical intervention showed that factors predicting in-hospital mortality include GCS ≤ 8, volume of hematoma > 60 ml, IVH, and MLS > 10 mm. During multivariable analysis, it was found that IVH and MLS > 10 mm were predictive factors for in-hospital mortality. Increasing the number of study samples may reveal more correlations among these factors. The current recommends that external ventricular drainage plus thrombolytics is safe and reasonable compared with external ventricular drainage alone to reduce mortality.[3] This retrospective study has not yet used intraventricular thrombolysis in IVH patients; it was a significant predictive factor for death in this study. Decompressive hemicraniectomy may reduce mortality in patients with supratentorial ICH who are in a coma and have large hematomas with midline shifts. The MLS-to-volume ratio showed a significant negative linear correlation with age and higher parenchymal compliance in older individuals due to increased brain atrophy.[39] MLS, which is better than using the hematoma volume alone to represent increased intracranial pressure.

This study found that MLS > 10 mm was a significant prognostic factor for in-hospital mortality. Consideration for decompressive hemicraniectomy in patients with MLS > 10 mm may help reduce mortality in this group of patients. The IVH with intraventricular thrombolysis and MLS > 10 mm with decompressive craniectomy are factors that should be studied further.

This study shows that neurosurgical intervention in patients with intracerebral hemorrhage may help reduce in-hospital mortality in patients with the following factors: GCS > 8, volume of hematoma 30–60 ml, MLS 5–10 mm. However, in patients with IVH, MLS > 10 mm remains an important prognostic factor for hospital mortality in patients undergoing craniotomy, craniectomy, or ventriculostomy.

The limitations of this study included incomplete data as this was a retrospective study. Decisions on surgery, BP control, and supportive care depended on decision-making between the neurosurgeon, patient, and relatives, which may have varied from case to case and may have been influenced by the family's and long-term caretakers' socioeconomic factors. In patients with older age, the family tended to favor conservative treatment despite fulfilling indications for surgery; the family grew to select palliative and supportive care, and cases were transferred to intermediate care facilities.

Conclusion

GCS ≤ 8, IVH, infratentorial location, midline shift ≥ 5 mm, stroke in the young (age ≤ 45 years), and male sex were significant predictors of in-hospital mortality in a spontaneous intracerebral hemorrhage. In contrast, surgical therapy and reducing blood pressure to target within 1 hour may decrease in-hospital mortality. IVH, MLS > 10 mm, remains an important prognostic factor for mortality in patients undergoing surgery. To reduce death, management for spontaneous intracerebral hemorrhage cases needed to focus on targeting these factors.

Conflict of interest

The authors declare they have no conflict of interest related to this research.

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Author contribution

K.C.: concept design, data grouping, data collection, data calculation, data analysis, and manuscript writing;

S.T.: concept design and data collection,

C.K.: data collection.

All authors reviewed this manuscript.

Data sharing statement

The data supporting this study's findings are available from the corresponding author upon reasonable request.

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