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Original Article

Prognosis of Surgical Management for Intracerebral Hemorrhage: Insights from Indonesia's National Brain Center Hospital

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Abstract

Background and Objective: Intracerebral hemorrhage (ICH), a stroke subtype that can be managed surgically, exhibits varying prognoses amongst countries. However, data for the Indonesian population are currently lacking.
Subject and Methods: In a retrospective cohort study, medical records of post-surgical ICH cases in Rumah Sakit Pusat Otak Nasional from January 2021 to April 2023 were obtained. Prognostic data includes hospitalization duration, in-hospital mortality, and dependency upon discharge. Multivariate analysis was performed on sociodemographic and medical data to determine prognostic factors.
Results: A total of 157 cases were obtained. Procedures performed include hemorrhage evacuation craniotomies (58.6%), burr holes (29.9%), ventriculoperitoneal shunts (24.2%), and decompressive craniectomies (5,1%), with 15.9% patients undergoing multiple surgical sessions. In-hospital mortality and total dependency occurred in 31.2% and 54.6% of patients, respectively. Average hospitalization is 16.32 days. Predictors for in-hospital mortality are age ≥ 50 years (p=0.002), male (p=0.014), hematoma volume > 40mL (p=0.012), multiple surgical sessions (p=0.034), and presenting Glasgow Coma Scale (GCS) < 9 (p=0.015). Predictors for total dependency are supratentorial lesions (p=0.025) and presenting GCS 9-12 (p=0.008) and < 9 (p=0.002). Predictors for hospitalization > 2 weeks are stroke onset > 3.5 hours (p=0.008) and multiple surgical sessions (p=0.001).
Conclusion: Surgical management of ICH in Indonesia reveals similar outcomes to other countries. However, differences in prognostic factors indicate potential variations between countries.

Keywords: Indonesia, intracerebral hemorrhage, prognosis

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I. Introduction

Intracerebral hemorrhage (ICH), a subtype of stroke, is caused by the rupture of small penetrating arteries supplying the brain. Globally, ICH accounts for 10-20% of all stroke incidents. However, studies have shown variability between countries, with Western countries reporting incidences of 8-15%, whereas Japan and Korea report 18-24%. Epidemiological studies also reveal interracial differences in incidence, with Asians being the highest, followed by Caucasians, Blacks, and Hispanics.[1] Mortality rates of ICH are approximately 40% in 1 month and 54% in a year. However, case fatality rates, just like incidence, vary between countries, with Japan being the lowest and the United Kingdom being one of the highest.[2] Poststroke functional status has also been shown to have inter-country differences, with Italy having 39% of their ICH patients live independently, whereas Estonia has 12%.[2] Similarly, the duration of hospitalization for ICH is different between races, with Caucasians generally having a shorter length of stay.[3] However, it should be emphasized that the majority of the currently available data for ICH prognosis are from European countries, the United States, and Australia, along with a few studies from Asian countries, i.e. India, China, and Japan. Prognostic data for ICH patients in

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Indonesia is not yet available. Further, not all ICH patients will be managed surgically. As a subpopulation of ICH, the prognosis of patients undergoing surgery has been shown to differ from those treated conservatively. Decompressive craniectomies and hematoma evacuation through craniotomies have lower mortality rates comparing to conservative strategies.[4,5] However, data for this subpopulation in Indonesia are also currently lacking. Prognostic factors, such as sociodemographic aspects, medical history, and therapies administered, have been explored in previous studies.[4,5] However, very few researches have been done on the Indonesian population. Moreover, one of the most commonly used prognostic scoring, i.e. the ICH Score, is based on the US population and validity studies have shown suboptimal implementation in other populations.[6] Considering the substantial impact of ICH towards mortality and disability, along with evidence of international variations, this study is conducted to bridge the knowledge gap regarding the prognosis of surgically managed ICH in Indonesia.

II. Methods

This study is a retrospective cohort study including all patients presenting with a diagnosis of ICH who underwent surgical management from January 2021 to April 2023 in Rumah Sakit Pusat Otak Nasional, a tertiary referral center for neurological conditions in Indonesia. Data were obtained from the hospital's medical records with the following inclusion criteria: (1) the patient is over 18 years of age; (2) the patient is diagnosed with ICH confirmed on CT imaging of the brain; (3) the patient underwent general anesthesia; and (4) the patient underwent at least one of the following surgical procedures: hematoma evacuation through craniotomy, decompressive craniectomy, burr holes, and/or ventriculoperitoneal shunts. Patients with secondary hemorrhagic strokes due to tumors and those with unclear diagnosis and/or surgical management strategies were excluded.

Parameters of prognosis included in this study are functional status at discharge, measured by the modified Rankin Scale (mRS), in-hospital mortality, and duration of hospitalization. For prognostic factor analysis, patients' functional statuses are grouped into those with total dependency (mRS 5) and those with partial dependency (mRS $\leq$4). Duration of hospitalization is also categorized into those who stay hospitalized for more than 2 weeks and those who have a shorter length of stay. Prognostic factors analysis include patients' sociodemographic data, previous medical history, and clinical characteristics, i.e. duration from onset to admission, number of surgical sessions (one or multiple sessions), Glasgow Coma Scale (GCS) at presentation, along with hematoma volume and location from CT scan measurements.

Categorical variables are presented as proportions, whereas numerical variables are presented as means along with their standard deviations. Prognostic factors for each outcome were determined through logistic regression. Bivariate analyses were initially performed and were followed by multivariable logistic regression that adjusted for sociodemographic data and other factors that initially met a preset P-value cut off of less than 0.10 from the bivariate analysis. Their respective odds ratios were then calculated and P-values of $\leq$ 0.05 were considered as statistically significant. This study has been approved by the ethical review board of Rumah Sakit Pusat Otak Nasional.

III. Results

Sociodemographic Data and Medical History
From January 2021 until April 2023, 157 ICH cases were treated surgically. Patients' average age is 54.91 years. The majority of the patients were male, married, employed, and had not attained university education. Hypertension was the most commonly found comorbidity (92.4%), while atrial fibrillation was only identified in 3 patients (1.9%). Data on the sociodemographic characteristics and overall medical history of the patients are presented in Table 1.

Clinical Characteristics
Among all intracerebral hemorrhage patients, 131

Table 1. Sociodemographic Data and Medical History of Patients

Variable	Result
Sociodemographic data	
Age, mean ± SD, years	54.91 ± 11.02
Male, n (%)	108 (68.8)
Married, n (%)	130 (82.8)
Employed, n (%)	81 (60)
University graduate, n (%)	33 (36.7)
Medical history	
Previous stroke, n (%)	27 (17.2)
Hypertension, n (%)	145 (92.4)
Type 2 diabetes, n (%)	24 (15.3)
Dyslipidemia, n (%)	27 (17.2)
Atrial fibrillation, n (%)	3 (1.9)
Acute or chronic coronary syndromes, n (%)	8 (5.1)
Obesity, n (%)	82 (52.9)

Table 2. Clinical Characteristics of ICH Patients

Variable	Result
Intracerebral Hemorrhage Characteristics	
Hemorrhage volume, mean ± SD, mL	34.32 ± 24,42
Supratentorial lesion, n (%)	131 (86.8)
Type of Surgical Procedure, n (%)	
Hemorrhage evacuation through craniotomy	92 (58.6)
Burr hole	47 (29.9)
Ventriculoperitoneal shunt	38 (24.2)
Decompressive craniectomy	8 (5.1)
Number of surgical sessions, n (%)	
1 session	137 (87.3)
≥ 2 sessions	20 (12.7)
Presenting GCS	
13-15	46 (29.3)
9-12	50 (31.8)
3-8	61 (38.9)

cases (86.8%) exhibit lesions in the supratentorial region, with an average hemorrhage volume of 34.32 mL. The most frequently performed surgical procedure were hemorrhage evacuation through craniotomies (58.6%), followed by burr holes (29.9%), ventriculoperitoneal shunts (24.2%), and decompressive craniectomies (5.1%). The majority of patients (87.3%) underwent only one surgical session. There were 38.9% of patients presenting with GCS of 3-8, followed by those with GCS of 9-12 (31.8%) and 13-15 (29.3%). The clinical characteristics of patients are presented in Table 2.

Prognosis

Table 3 presents ICH patients' prognosis, including mortality, functional status, and duration of hospitalization. Overall, the in-hospital mortality rate is 31.2%, with decompressive craniectomy being the highest at 50%, followed by burr holes (44.7%), hemorrhage evacuation craniotomies (26.1%), and ventriculoperitoneal shunts (21.1%).

Further, in surviving patients, 54.6% exhibit total dependency upon discharge. Decompressive craniectomies also yield the highest rate of total dependency as 100% of surviving patients had an mRS score of 5, followed by burr holes, ventriculoperitoneal shunts, and hemorrhage evacuation craniotomies with 61.5%, 53.3%, and 51.1%, respectively.

The average duration of hospitalization for the entire sample is 16.32 days. The procedure with the longest duration of hospitalization is the ventriculoperitoneal shunt, at 22.23 days, followed by burr holes, hemorrhage evacuation craniotomies, and decompressive craniectomies, each with averages of 17.85, 16, and 15.75 days, respectively.

Prognostic Factors

Table 4 presents bivariate and multivariate associations of patients' sociodemographic factors, medical history, and clinical characteristics with their prognosis. The multivariate analysis of in-hospital mortality is adjusted for sociodemographic data, previous history of stroke, existence of multiple comorbidities, blood volume, and presenting GCS. The analysis revealed that the mortality risk is higher in male patients and those aged ≥ 50 years. Neither a history of previous stroke nor the existence of multiple comorbidities is found to be a predictor for mortality. Clinically,

Table 3. Prognosis of Surgically-Managed ICH Patients

Variable	Result
In-Hospital Mortality, n (%)	
Overall	49 (31,2)
Type of surgical procedure	
Hemorrhage evacuation through craniotomy	24 (26,1)
Burr hole	21 (44,7)
Ventriculoperitoneal shunt	8 (21,1)
Decompressive craniectomy	4(50)
Total Dependence upon Discharge (mRS 5), n (%)	
Overall	59 (54,6)
Type of surgical procedure	
Hemorrhage evacuation through craniotomy	35 (51,5)
Burr hole	16 (61,5)
Ventriculoperitoneal shunt	16 (53,3)
Decompressive craniectomy	4 (100)
Length of Stay, mean ± SD, days	
Overall	16,32 ± 10,01
Type of surgical procedure	
Hemorrhage evacuation through craniotomy	16,00 ± 10,96
Burr hole	17,85 ± 11,11
Ventriculoperitoneal shunt	22,42 ± 11,12
Decompressive craniectomy	15,75 ± 12,62

patients with a hemorrhage volume of more than 40 mL, those undergoing multiple surgeries, and those presenting with a GCS of less than 9 have a higher risk of mortality. Other factors, i.e. onset, lesion location, and number of surgical sessions were not statistically significant. After adjusting for age, sex, stroke onset, and number of surgical sessions, prolonged length of stay (>2 weeks) is more common in patients whose stroke onset is more than 3.5 hours and those with more than 1 surgical session. Further, in surviving patients, multivariate analysis revealed that those with supratentorial lesions and those presenting to the hospital with a GCS < 13 are more likely to have total dependency upon discharge. Other clinical characteristics, medical history, and sociodemographic factors were not significant predictors for prolonged length of stay or total dependency.

IV. Discussion

The prognosis of surgically-managed ICH patients in Indonesia is not well described in the literature. This study collected and analyzed data from 157 patients admitted to Indonesia's national referral hospital. The results show that, overall, mortality rates were quite high and, in those who survive, more than half are discharged with total functional dependence. Furthermore, patients were, on average, hospitalized for more than two weeks. Analysis of sociodemographic data, medical history, and clinical characteristics revealed various prognostic factors related to the outcomes mentioned.

Surgically managed ICH patients in Indonesia reveal similar baseline characteristics to other countries. Sociodemographic data show that a majority of patients were male, married, employed, and had yet to receive a university education. These findings are similar to populations in previous studies from other countries.[4,5,7] On average, patients in this study were 54.91 years old, which is younger than the results of a previous meta-analysis.[4] Another meta-analysis, however, showed more similar patient characteristics, with the average age ranging from 45 to 61 years old.[5] The medical history of patients in this study revealed hypertension as the most common comorbidity, similar to the STICH II trial results.[8] Clinically, there are 70.7% of patients in this study with presenting GCS < 13, also similar to previous studies.[4] Further, the majority (87%) of cases were supratentorial ICHs, similar to the 83% found found by a previous study in Japan.[9] However, the average hematoma volume in this study is 34.32 mL, which is lower than previous studies which range from 49 to 81 mL.[5] This can be explained by the differences in surgery indication used in different institutions,

Table 4. Prognostic Factors for In-Hospital Mortality, Length of Stay, and Functional Status upon Discharge

Prognostic Factors	Bivariate Analysis		Multivariate Analysis*	
	Crude OR (95% CI	P-value	Adjusted OR (95% CI)	P-value
In-Hospital Mortality				
Sociodemographic factors				
Age ≥ 50 years	3.39 (1.39 - 8.27)	0.005	5.27 (1.87 - 14.83)	0.002
Male	2.20 (1.00 - 4.90)	0.049	3.35 (1.28 - 8.81)	0.014
Medical history				
History of previous stroke	2.43 (1.04 - 5.66)	0.037	1.10 (0.40 - 3.01)	0.85
Comorbidities ≥ 2	2.31 (0.93 - 5.72)	0.065	2.95 (0.98 - 8.88)	0.055
Clinical characteristics				
Onset > 3.5 hours	1.67 (0.84 - 3.32)	0.14	1.23 (0.54 - 2.80)	0.62
Blood volume > 40 mL	1.97 (0.97 - 4.02)	0.059	3.00 (1.26 - 6.81)	0.012
Supratentorial lesion	1.47 (0.50 - 4.30)	0.48	0.94 (0.24 - 3.80)	0.94
Surgical sessions > 1	0.51 (0.16 - 1.62)	0.25	5.00 (1.13 - 22.23)	0.034
Presenting GCS (reference: GCS 13-15)				
GCS 9-12	2.04 (0.77 - 5.39)	0.15	1.95 (0.67 - 5.65)	0.22
GCS < 9	3.53 (1.41 - 8.82)	0.007	3.66 (1.29 - 10.38)	0.015
Length of Stay > 2 Weeks				
Sociodemographic factors				
Age ≥ 50 years	1.15 (0.57 - 2.29)	0.70	1.05 (0.49 - 2.23)	0.91
Male	1.19 (0.60 - 2.36)	0.61	0.96 (0.45 - 2.04)	0.91
Medical history				
History of previous stroke	1.92 (0.83 - 4.50)	0.13	1.57 (0.63 - 3.94)	0.34
Comorbidities ≥ 2	0.87 (0.42 - 1.83)	0.72	0.68 (0.31 - 1.50)	0.34
Clinical characteristics				
Onset > 3.5 hours	2.47 (1.28 - 4.76)	0.006	2.58 (1.28 - 5.22)	0.008
Blood volume > 40 mL	0.58 (0.30 - 1.15)	0.12	0.74 (0.35 - 1.55)	0.42
Supratentorial lesion	1.07 (0.41 - 2.74)	0.90	1.58 (0.52 - 4.90)	0.42
Surgical sessions > 1	8.45 (2.36 - 30.21)	<.001	9.06 (2.47 - 33.27)	0.001
Presenting GCS (reference GCS 13-15)				
GCS 9-12	1.12 (0.50 - 2.51)	0.79	0.97 (0.40 - 2.35)	0.95
GCS < 9	1.47 (0.68 - 3.18)	0.33	1.38 (0.60 - 3.18)	0.45
Total Dependency (mRS 5) upon Discharge				
Sociodemographic factors				
Male	1.71 (0.77 - 3.77)	0.18	2.37 (0.93 - 6.01)	0.07
Age ≥ 50 years	0.64 (0.29 - 1.43)	0.28	0.64 (0.24 - 1.69)	0.36
Medical history				
History of previous stroke	1.58 (0.49 - 5.08)	0.44	1.65 (0.45 - 6.12)	0.45

Continue Table 4

Prognostic Factors	Bivariate Analysis		Multivariate Analysis*	
	Crude OR (95% CI	P-value	Adjusted OR (95% CI)	P-value
Comorbidities ≥ 2	0.50 (0.21 - 1.21)	0.12	0.52 (0.19 - 1.42)	0.20
Clinical characteristics				
Onset > 3.5 hours	0.92 (0.42 - 2.03)	0.84	0.91 (0.36 - 2.28)	0.84
Blood volume >40 mL	1.41 (0.61 - 3.27)	0.42	1.28 (0.47 - 3.49)	0.63
Supratentorial lesion	3.80 (1.12 - 12.84)	0.025	4.71 (1.21 - 18.29)	0.025
Surgical sessions > 1	1.64 (0.56 - 4.81)	0.36	2.06 (0.53 - 8.03)	0.30
Presenting GCS (reference: GCS 13-15)				
GCS 9-12	3.67 (1.39 - 9.66)	0.009	4.42 (1.49 - 13.15)	0.008
GCS < 9	5.42 (1.99 - 14.77)	0.001	5.42 (1.85 - 15.91)	0.002

Odds ratio is calculated after adjusting for age, sex, and other factors with a P-value < 0.1 from the initial bivariate analysis in each respective outcome. Abbreviations: OR = odds ratio; CI = confidence interval; GCS = Glasgow Coma Scale; mRS = modified Rankin Scale.

which has been previously mentioned in several meta-analyses.[4,5,10] These indications may also differ in Indonesia, thus explaining the variability in baseline sociodemographic and clinical characteristics.

This study reveals an in-hospital mortality rate of 31.2%, similar to the 33% found in a previous meta-analysis which included studies from Germany and the United States.[4] This study further revealed the varying mortality rates of different surgical procedures. Previous studies directly comparing the prognosis among different surgical procedures for ICH are uncommon. However, past studies of individual procedures revealed a slight variability of mortality rates to the ones this study found. Mortality rates of hemorrhage evacuation craniotomies and ventriculoperitoneal shunts were similar to the rates found in previous studies.[11,12] Nonetheless, a more recent study revealed a much lower mortality rate for craniotomies and burr holes.[13] These findings suggested possible differences in techniques used by each institution and differences in the patient population. Older (≥ 50 years old) and male patients were found to have a higher mortality risk. Previous history of stroke and presenting GCS were also statistically significant prognostic factors. There has been a wide array of prognostic tools developed for mortality in ICH.[14] A meta-analysis showed that age and gender are commonly incorporated sociodemographic predictors for mortality. Further, the same meta-analysis showed that patients' level of consciousness and hematoma volume are the first and second most frequently used predictors for mortality, respectively.[14] Thus, in general, previous studies showed similar prognostic factors for mortality. However, the existence of comorbidities has been regarded as a possible predictor of mortality in previous studies.[14] Our study does indicate a trend that mortality is higher in patients with multiple comorbidities but this finding is not statistically significant (p=0.055), which might be due to a lack of statistical power.

Another more rarely incorporated prognostic factor for mortality is history of previous stroke.[14] Similarly, our analysis found history of stroke as a statistically significant predictor from bivariate analysis, but adjustment for sociodemographic and other clinical factors revealed that it is not a significant predictor. Additionally, our study also found that patients who underwent multiple surgical sessions are at a higher risk of mortality. This is a novel finding as no previous studies have incorporated this variable for mortality prediction. This study showed that 54.6% of patients were

completely dependent (classified as mRS 5) upon discharge, which is higher than that found in a previous study. (36%).[15] However, it should be considered that their study was conducted in an intensive rehabilitation hospital, different from this study's setting. Another study also revealed a lower rate, i.e. 29% of surgically-managed ICH patients had an mRS 5.[4] However, their study followed-up patients at 12 months post-surgery, thus explaining the difference as patients may have improved during that time.

Further analysis shed light on the differences in functional status between surgical interventions. To the best of the authors' knowledge, no previous studies have collected such data. Analysis of prognostic factors revealed that supratentorial lesions and patients with GCS <13 are at a higher risk of being completely dependent upon discharge, which is in line with previous findings that functional status can be predicted by location of bleeding and level of consciousness.[14] Previous studies also suggested that age and hematoma size are a couple of the most commonly used predictors for functional status,14 different from the result of this study. However, none of the studies focuses solely on surgically-managed ICH, hence indicating possible differences between the more "general" ICH population with those that require surgery.

Lastly, the average length of stay in this study is 16.32 days. Previous studies evaluating the length of stay in post-surgery ICH patients are rare. One study in South Korea. In South Korea revealed that ICH patients who underwent surgery had an average hospitalization duration of 33.1 days, much higher than the result of this study.[16] However, a meta-analysis that evaluates ICH in general revealed a study in the US where patients' length of stay averages between 6 to 8 days, much lower than this study's findings.[3] Further, studies in China and Singapore revealed an average length of stay between 15.6 to 21 days, much more similar to the results of this study.[3] These variabilities may be explained by the differences in healthcare systems between studied countries and, thus, this study provides new data from the perspective of Indonesian health care.

Previous studies have established that surgically managed ICH patients have longer hospitalization duration compared to those treated conservatively.[16] This study provides additional information regarding the length of stay based on surgical procedures, varying between an average of 15.75 days for decompressive craniectomies to 22.42 days for ventriculoperitoneal shunts. Moreover, factors associated with longer stays of more than 2 weeks include patients whose stroke onset occurred more than 3.5 hours before hospitalization and those with more than 1 surgical session. The lack of sociodemographic factors as prognostic factors is similar to the findings of a study in China. Their study also found that the number of surgical procedures is associated with length of stay.[17] However, no previous study has analyzed the association between stroke onset and length of stay.

This study managed to complete its objective of obtaining the prognostic data of surgically managed ICH patients in Indonesia, as previous studies in this population were scarce. However, some limitations of this study include its relatively small sample size comparing to other international population-based studies. Also, follow-up was limited to the duration of patients' stay. Further studies can incorporate longer follow-up periods to have a better understanding of patients' long-term outcomes.

V. Conclusion

This study was conducted to address the current lack of data on the prognosis of ICH patients undergoing surgery in Indonesia. Overall, this study found that mortality rates were quite high and, in surviving patients, more than half were discharged with total functional dependence. Patients' length of stay was also quite long, with hospitalization duration averaging more than 2 weeks. Nonetheless, these results are similar to the studies conducted in other countries. Furthermore, this study provided novel data that indicates possible differences in prognosis between surgical procedures. Multivariate analysis revealed several key prognostic factors. Mortality is affected by

age, sex, hematoma volume, number of surgical sessions, and presenting GCS; functional status is affected by stroke location and presenting GCS; and hospitalization duration is affected by the number of surgical sessions and stroke onset. These findings are mostly in line with previous studies in other populations. However, several differences were noted when comparing these results with findings of previous studies. Thus, the possibility of inter-country differences in prognosis should not be excluded. This study acts as the foundation for future ICH studies in Indonesia. These findings warrant new studies designed prospectively with extended follow-up periods, using larger sample sizes, and a broader range of prognostic variables to yield an even more accurate representation of ICH prognosis in Indonesia and how to optimize it.

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