ORIGINAL ARTICLE

Time to Treatment and Outcomes of Hemorrhagic Stroke, Comparing Patients Entering Surgery before and after 120 Minutes Upon Arrival at the Emergency Department Pattani Hospital

Kittipong Thongnual, MD[1], Laddawan Ratapaibool, MNS[1]

[1] Pattani Hospital, Office of the Permanent Secretary Ministry of Public Health, Pattani, Thailand

Background: The duration between a patient's hospital arrival and the point at which they enter surgery for hemorrhagic stroke affects survival, length of stay, health care costs, and outcome (Glasgow Outcome Scale). Therefore, a study to explore the effects of time on these outcomes is warranted.

Objective: To compare treatment outcomes of patients with hemorrhagic stroke having entered surgery before and after 120 minutes upon arrival at the emergency department.

Materials and Methods: A therapeutic and interventional study with a retrospective observational cohort design at Pattani Hospital in patients with hemorrhagic stroke who received treatment between October 2018 and April 2023. A retrospective review of medical records, which collected clinical characteristics and the time to treatment. Glasgow Outcome Scale was evaluated at 72 hours, two weeks, one month, and date of hospital discharge. Length of stay, health care costs, and survival status at date of hospital discharge were analyzed. Comparative analysis was performed by Fisher's exact probability test and t-test, and prognostic analysis was performed by risk ratio.

Results: Of all the patients in the present study, 49 and 182 received treatment before and after 120 minutes, respectively, upon arrival at the emergency department. Clinical characteristics of gender, age, underlying conditions, regular medications, and level of consciousness were not significantly different between the two groups. Patients who entered surgery within 120 minutes of arrival had more occurrences of basal ganglia hemorrhage compared with those who received surgery thereafter. Furthermore, patients who received surgery within 120 minutes had a 11.4% increased chance of survival. The number needed to treat (NNT) hemorrhagic stroke patients with a time to treatment of under 120 minutes is 9. However, there was an associated increase in complications, health care cost, and length of stay. The Glasgow Outcome Scale improvement was greater only in the two-week follow-up period. These results were similar when subarachnoid hemorrhage and anticoagulating medication used were excluded.

Conclusion: Patients with hemorrhagic stroke who receive early surgical treatment have lower mortality rates. Adequate provision of personnel and facilities for delivering prompt care should be made available. Measures should be taken to reduce the complications of patients who receive surgical treatment after 120 minutes upon arrival at the emergency department.

Keywords: Hemorrhagic stroke; Prognosis; Survival; Glasgow Outcome Scale; Length of stay; Health care costs

Received 21 June 2024 | Revised 28 August 2024 | Accepted 10 September 2024

J Med Assoc Thai 2024;107(10):807-15

Website: http://www.jmatonline.com

Patients suffering from hemorrhagic stroke have a high mortality rate. Even survivors are afflicted with temporary or permanent comorbidities that hinder their ability to live independently. This condition is associated with a heavy social and economic burden at the national level. The development of care for hemorrhagic stroke is of vital importance, especially in improving mortality outcomes.

Data about the recovery rate of hemorrhagic stroke after entering surgical treatment have been well established over the last two decades, suggesting that the survival rate is higher in those who have received surgical treatment during the first month[1,2].

However, the survival rate at six months after the onset of hemorrhagic stroke was not found to be significantly different between the group who received surgery and those who had not[1]. Hence,

Correspondence to:

Thongnual K.
Pattani Hospital, Mueang, Pattani 94000, Thailand.
Phone: +66-87-3904171
Email: thongnualkittipong@gmail.com

How to cite this article:

Thongnual K, Ratapaibool L. Time to Treatment and Outcomes of Hemorrhagic Stroke, Comparing Patients Entering Surgery before and after 120 Minutes Upon Arrival at the Emergency Department Pattani Hospital. J Med Assoc Thai 2024;107:807-15.
DOI: 10.35755/jmedassocthai.2024.10.807-815-1081

the development of adequate care for hemorrhagic stroke patients is needed to reduce mortality rates by increasing accessibility to early care since it is known that the mortality rate worsens in patients treated after three hours[3].

It is known that efficient management of the emergency department can positively impact recovery rates of hemorrhagic stroke patients in the long term[4]. Furthermore, the duration between the time of symptom onset and the point at which the patient receives a brain computerized tomography (CT) scan can affect the 30-day mortality rate[5]. Furthermore, several studies have explored other factors contributing to higher mortality rates following hemorrhagic stroke, such as the level of consciousness at point of entry to the emergency department[1,6,7], increased patient age[8] of more than 65 years[2], more than 65 to 70 years[9], and more than 75 years[10]. Various other factors have also been identified as contributing to higher mortality such as the size of hematoma in the brain[5,6,11], and the presence of intraventricular hemorrhage[2,4,5,11]. This is in addition to the presence of underlying conditions such as hypertension, cardiovascular disease, and diabetes mellitus[7,12-14].

Focusing on literature from Thailand within the same population of the present study, significant factors contributing to increased mortality in hemorrhagic stroke for this population included age over 70, hypertension[9], location of hemorrhage, initial Glasgow Coma Scale (GCS), intracerebral hematoma volume, and secondary infection[7,11]. All of which are in line with international literature.

Despite numerous studies having examined the effect of time to treatment from stroke symptom onset to the point of entering surgery on the rate of survival, in addition to exploring various factors that contribute to rates of mortality, recovery, and duration of hospital admission, those previous studies had yet to examine the relationship between survival rates and outcomes associated with the time to treatment from the point of arrival at the emergency department to the point of surgery. This subtle difference in study outcomes is significant by focusing on the efficiency of the medical system in stroke treatment, which is unconfined by factors that affect the time from symptom onset to arrival at the hospital. Therefore, from a policy-making perspective, the present study is more relevant than previous studies.

Presently, the policy of the Thai healthcare system prioritizes the urgency of surgical care for hemorrhagic stroke at the same level as ischemic coronary artery disease or stroke, with set goals for a time at which patients should receive care. These policies demand greater resources and personnel to meet such goals.

To develop surgical procedures that result in the best patient outcomes, the purpose of the present study was to examine the effect of duration from the point of arrival at the emergency department to the point of arrival at the operating room and its effects on outcomes focused on rate of mortality, recovery, duration of hospital admission, cost of treatment, and resources required for treatment[15].

Objective

To compare the treatment outcomes of hemorrhagic stroke patients with a time to treatment of within 120 minutes versus those treated after 120 minutes upon arrival at the emergency department.

Materials and Methods

A therapeutic and interventional study with a retrospective observational cohort design at Pattani Hospital on patients with hemorrhagic stroke who received treatment between October 2018 and April 2023.

Study population: Patients suspected of having hemorrhagic stroke treated at Pattani Hospital.

Inclusion criteria: Patient with hematoma size greater than 30 cc or midline shift greater than 5 mm.

Exclusion criteria:

1. Denied surgery
2. Brain stem hemorrhage without hydrocephalus
3. Volume of hematoma below 30 and midline shift of less than 5 mm

Sample group and study domain

Patients diagnosed with hemorrhagic stroke from a non-contrast CT scan of the brain that have received treatment from Pattani Hospital between October 2018 and April 2023, and have complete medical records are included in this study.

Glossary

Time to treatment is the duration between arrival at the emergency department at Pattani Hospital and the point of entering surgery.

The Glasgow Outcome Scale (GOS) is an assessment form for recovery outcomes divided into the following five categories:

Level 1: Dead.

Level 2: Persistent vegetative state, the patient is immobile, unable to respond to external stimuli,

and completely dependent on care.

Level 3: Severe disability, the patient is conscious but incapable of basic self-care and requires a high level of 24-hour care.

Level 4: Moderate disability, the patient is capable of self-care and requires minimal care.

Level 5: Good recovery, the patient can return to society and resume work.

Sample size estimation

To study the rate of recovery, cost of treatment, and duration of hospital admission for patients with hemorrhagic stroke that have received surgical treatment.

An assumption was made from the present pilot study findings that patients entering surgery within 120 minutes have favorable GOS levels 4 or 5 in five out of eleven patients at two weeks postoperatively. Those patients are compared with those entering surgery after 120 minutes with favorable GOS levels of 4 or 5 in only three out of sixteen patients at two weeks postoperatively. The sample size estimation was for a two-sided test where a p-value of less than 0.05 was considered significant and a power of 0.80. The ratio of subjects between the two groups was n2/n1=4.50, resulting in a sample size estimate of n1=30 and n2=135.

When estimating the sample size with regards to the cost of treatment, patients entering surgery within 120 minutes had an average health care cost of 229,283 Baht (SD 98,203), and the group that received surgery after 120 minutes had an average cost of 174,524 Baht (SD 155,359). Arriving at a sample size estimate of n1=40 and n2=180.

In estimating the sample size with regards to the duration of hospital admission, the average for patients entering surgery within 120 minutes was 28 days (SD 18.7), compared with the patients who entered surgery after 120 minutes was 20.8 days (SD 27.6), arriving at a sample size estimate of n1=77 and n2=347.

Hence, the authors had chosen a final sample size of n1=40 and n2=180 for the present study.

Data source: Medical records of patients entering treatment for hemorrhagic stroke at Pattani Hospital.

Data collection method: Retrospective data collection.

Tools for data collection: Case record forms.

Variables examined in this study

Determinants consist of time to treatment, gender, age, comorbidities, anticoagulation medication, initial GOS, location of hemorrhage, type of procedure, operation time, estimated blood loss, post-operative complication, re-operation, and the discharge method.

Endpoints consisted of the survival, length of stay, health care cost, and GOS.

Method of follow-up

Follow-up for post-operative recovery (GOS) was carried out in the following periods, less than 72 hours, 72 hours, two weeks, one month, and the discharge date. The length of stay and healthcare costs at the date of discharge from Pattani Hospital were also recorded. The authors also performed analysis with subarachnoid hemorrhage (SAH), or antiplatelet anti coagulation use but they were excluded (Figure 1).

Statistical analysis

A comparison of treatment outcomes in hemorrhagic stroke patients entering surgery within and after 120 minutes upon arrival at the emergency department was made with t-test, risk difference, Poisson mean difference, and multilevel regression analysis. Data analyses were performed by Stata Statistical Software.

Ethical approval

The present study has been certified by the Human Research Ethics Committee of Pattani Hospital, certification number PTN-009-2566 (issue 21 Feb 23).

Results

Two hundred thirty-one patients with hemorrhagic stroke received surgical treatment in the present study and were divided into 49 patients with a time to treatment within 120 minutes and 182 patients with a time to treatment after 120 minutes. The basic characteristics of both populations were not significantly different in gender, age, and the presence of comorbidities from hypertension, diabetes mellitus, and chronic kidney disease in addition to the presence of anticoagulation antiplatelet (Table 1).

As patients were admitted into the healthcare system and initially assessed for consciousness using the initial GCS, it was found that both groups were not significantly different (p=0.247). After subsequent CT scans of the brain, it was revealed that a greater proportion of patients with time to treatment of within 120 minutes were found to have bleeding at the basal ganglion than those who had been treated after

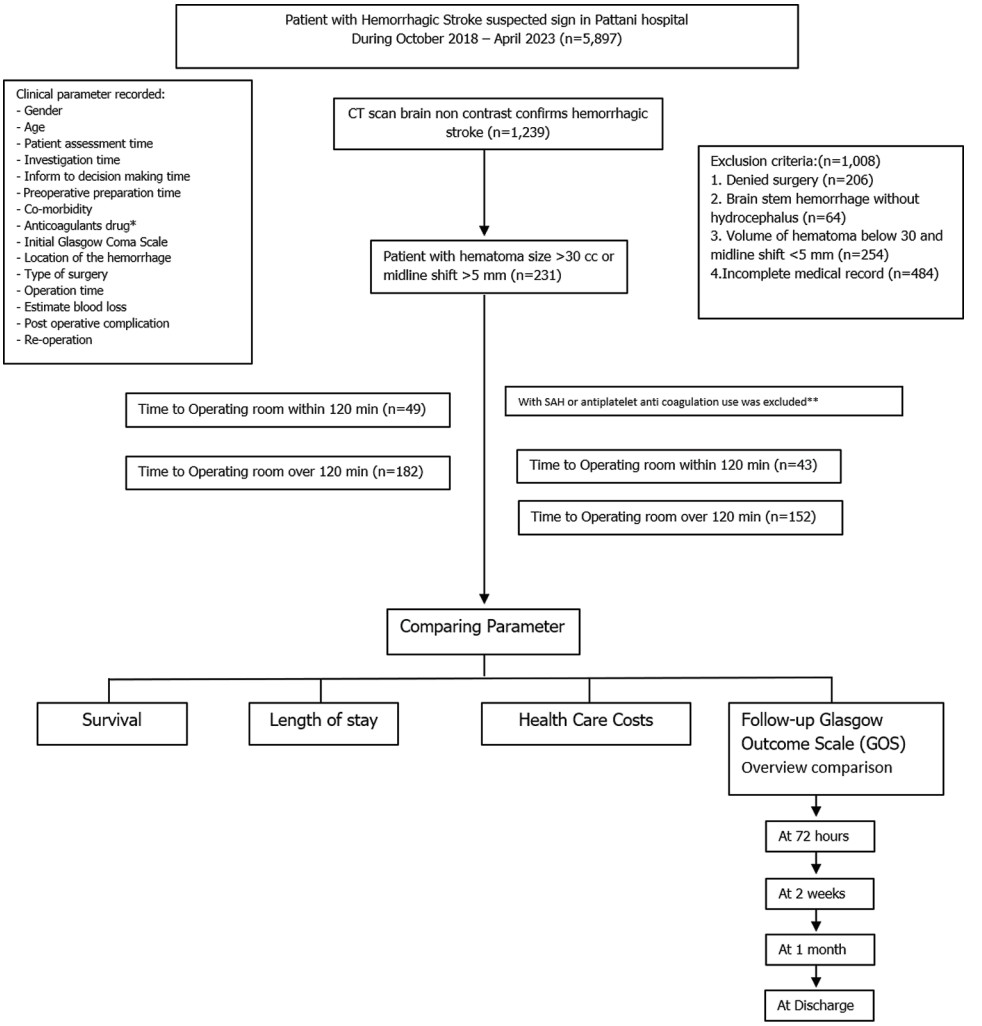

Figure 1. Study flow diagram.

* All patients with Aspirin, Plavix, Warfarin were appropriate corrected before operation.
** Our center had limiting to perform clipping, coiling aneurysm.

120 minutes (p=0.002). The proportion of bleeding in other anatomical regions was not significantly different between the two populations (Table 2).

Subsequently, as the patients underwent surgery, the methods of surgery revealed that a greater proportion of patients with a time to treatment of less than 120 minutes underwent decompressive craniectomy with hematoma removal than those treated after 120 minutes (p=0.046) (Table 2). Operation time, and volume of blood loss were not found to be significantly different. Postoperatively, the population received surgery within 120 minutes had a higher complication rate of 77% compared to 52% of those received surgery after 120 minutes (p=0.001). Regarding these complications, patients entering surgery within 120 minutes experience a higher incidence of pneumonia at 71% compared to 50% in those received surgery after 120 minutes (p=0.006). Furthermore, patients entering surgery within 120 minutes had a longer duration of admission before developing pneumonia of 4.3 days compared to 2.4 days in those entering surgery after 120 minutes (p=0.003). Other complications, such as catheter-associated urinary tract infection (CAUTI), pressure sores, and re-bleeding, were not different between the two groups (Table 2).

When comparing postoperative recovery outcomes between the two populations, at two weeks, GOS significantly improved in individuals who had surgery prior to 120 minutes as opposed to those

Table 1. Patient characteristics

Patient characteristics	Time to OR		p-value
	Within 120 minutes (n=49)	After 120 minutes (n=182)	
Sex; n (%)			0.512
Male	32 (0.65)	108 (0.59)	
Female	17 (0.35)	74 (0.41)	
Age (years); mean±SD	55.9±12.7	57.7±14.2	0.410
Comorbidities*; n (%)			0.624
No	22 (0.45)	91 (0.50)	
Yes	27 (0.55)	91 (0.50)	
History of anticoagulation or antiplatelet**; n (%)			0.791
Yes	45 (0.92)	163 (0.90)	
No	4 (0.08)	19 (0.10)	

OR=operating room; SD=standard deviation

* Hypertension or diabetes or chronic kidney disease or cardiac disease, ** Aspirin or Warfarin or Plavix

Table 2. Perioperative characteristics

Outcome characteristics	Time to OR		p-value
	Within 120 minutes (n=49)	After 120 minutes (n=182)	
Location of the hemorrhage; n (%)			
Basal ganglia hemorrhage	20 (0.51)	47 (0.26)	0.002
Thalamic hemorrhage	11 (0.22)	33 (0.18)	0.540
Lobar hemorrhage	9 (0.18)	59 (0.32)	0.076
Subarachnoid hemorrhage	2 (0.04)	12 (0.06)	0.740
Intraventricular hemorrhage	17 (0.35)	44 (0.24)	0.147
Cerebellar hemorrhage	2 (0.04)	19 (0.10)	0.262
Brain stem hemorrhage	0 (0.00)	3 (0.02)	1.000
Type of operation; n (%)			
Decompressive craniectomy with remove hematoma	37 (0.76)	108 (0.59)	0.046
Decompressive craniectomy without remove hematoma	1 (0.02)	6 (0.03)	1.000
Craniotomy with remove hematoma	0 (0.00)	8 (0.04)	0.208
Ventriculostomy or external ventricular drainage	19 (0.39)	76 (0.42)	0.746
Operation time (minute) mean±SD	106.0±44.4	100.4±40.2	0.401
Estimate blood loss (mL); mean±SD	246.6±214.7	231.8±442.3	0.820
Post operative complication; n (%)			0.001
No	11 (0.23)	88 (0.48)	
Yes	38 (0.77)	94 (0.52)	

OR=operating room; SD=standard deviation

* Each patient may have multiple locations, ** Each patient might have many operations at once

who had it after 120 minutes (p=0.019). However, when SAH and the anticoagulant antiplatelet used group were excluded, the improvement was the same. Neither group was significantly improved in relation to the other periods.

When comparing each level of GOS, patients who had surgery prior to 120 minutes had a significant greater proportion in GOS level 3 at 72 hours (p=0.048). Likewise, when patients who had SAH or were using Aspirin, Plavix, or Warfarin were excluded (p=0.023). At two weeks, individuals who had surgery prior to 120 minutes had a greater proportion of level 4 (p=0.028) and lesser proportion of level 3 (p=0.048). Again, when patients who had SAH or were using Aspirin, Plavix, or Warfarin were excluded, individuals who had surgery prior to 120 minutes had greater proportion of level 4 (p=0.007) (Table 3). However, at one month's follow-up and discharge, there was no significant difference in the GOS (Table 3).

When an analysis with patients who had SAH or were using Aspirin, Plavix, or Warfarin were

Table 3. Treatment outcomes

Outcome characteristics	Time to OR		p-value	Time to OR*		p-value
	Within 120 minutes (n=49)	After 120 minutes (n=182)		Within 120 minutes (n=43)	After 120 minutes (n=152)	
GOS at 72 hours#; n (%)			0.134			0.195
Level 1=dead	1 (2.2)	5 (3.0)	0.770	1 (2.4)	5 (3.6)	0.723
Level 2=vegetative	8 (17.8)	42 (25.6)	0.278	7 (17.1)	34 (24.3)	0.334
Level 3=severe disability	32 (71.1)	84 (51.2)	0.017	29 (70.7)	71 (50.7)	0.023
Level 4=moderate disability	2 (4.4)	8 (4.9)	0.905	2 (4.9)	8 (5.7)	0.837
Level 5=good recovery	2 (4.4)	25 (15.2)	0.056	2 (4.9)	22 (15.7)	0.072
GOS at 2 weeks; n (%)			0.019			0.059
Level 1=dead	1 (2.6)	0 (0.0)	0.104	0 (0.0)	0 (0.0)	.
Level 2=vegetative	8 (20.5)	16 (15.5)	0.483	6 (17.1)	14 (15.4)	0.810
Level 3=severe disability	11 (28.2)	48 (46.6)	0.048	11 (31.4)	42 (46.2)	0.135
Level 4=moderate disability	13 (33.3)	17 (16.5)	0.028	13 (37.1)	14 (15.4)	0.007
Level 5=good recovery	5 (12.8)	22 (21.4)	0.250	5 (14.3)	21 (23.1)	0.278
Survival rate at discharge; n (%)	31 (68.9)	94 (57.0)		28 (65.1)	83 (54.6)	
Length of stay (days); mean±SD	27.4±21.5	21.5±23.5	0.112	27.6±20.3	22.3±24.1	0.187
Health care cost (Baht); mean±SD	226,179.1±130,750.6	183,574.9±155,904.4	0.080	231,427.4±130,186.5	189,489.8±155,453.3	0.108

GOS=Glasgow Outcome Scale; OR=operating room; SD=standard deviation

* Patients who had SAH or were using Aspirin, Plavix, or Warfarin were excluded, # Patients that die before 72 hours will not be calculated

Table 4. Comparison of survival outcomes of hemorrhagic stroke, patients entering surgery within and after 120 minutes upon arrival at the emergency department

Discharge status	Time to treatment		Indicators	Effect	95% CI	p-value
	Within 120 minutes (n=45)	After 120 minutes (n=167)				
Survive	31	96	Risk ratio	1.19	0.95 to 1.52	0.166
Death	14	71	Risk different (%)	11.4	–0.04 to 0.27	
Total	45	167	NNT (to survive)	9		
	Within 120 minutes* (n=43)	After 120 minutes* (n=152)				
Survive	28	83	Risk ratio	1.51	0.88 to 2.59	0.103
Death	15	69	Risk different (%)	14.1	–0.02 to 0.30	
Total	43	152	NNT (to survive)	10		

NNT=number needed to treat; CI=confidence interval

* Patients who had SAH or were using Aspirin, Plavix, or Warfarin were excluded

excluded, comparing outcomes of treatment before to after 120 minutes, according to anatomical locations, there was no significant difference in survival proportion between the two populations. Significantly increased length of stay in all locations of bleeding, except for basal ganglia 22.96±18.10 and 23.88±22.44, respectively (p=0.462). Significant increase health care cost was found in all locations of bleeding (p<0.001).

When patients were discharged from the hospital, those who had surgery within 120 minutes had an insignificantly higher survival rate, with a number needed to survive of 9 and a risk difference of 11.4% (p=0.166). When patients who had SAH or were using Aspirin, Plavix, or Warfarin were excluded, the outcome remained the same, with a number needed to survive of 10 and a risk difference of 14.1% (p=0.103) (Table 4).

When comparing patients entering surgery before to after 120 minutes, length of stay was significantly longer, with a mean difference of 5.9 days (p<0.001) and increase health care cost with a mean difference of 42,604 Baht (p<0.001) (Table 5). When analysis by patients who had SAH or were using Aspirin, Plavix, or Warfarin were excluded, the result remained the same, longer length of stay with a mean difference of 5.3 days (p<0.001), with an increase health care cost with a mean difference of 41,937.6 Baht (p<0.001) (Table 5).

Table 5. Comparison of treatment outcomes of hemorrhagic stroke patients, entering surgery within and after 120 minutes upon arrival at the emergency department

Outcome	Indicators	Effect	95% CI	p-value
Length of stay	Poisson mean different	5.9	4.3 to 7.5	<0.001
Health care costs (Baht)	Poisson mean different	42,604	42,457.2 to 42,751.2	<0.001
Length of stay*	Poisson mean different	5.3	3.6 to 7.1	<0.001
Health care costs* (Baht)	Poisson mean different	41,937.6	41,778.1 to 42,097.2	<0.001

CI=confidence interval

* Patients who had SAH or were using Aspirin, Plavix, or Warfarin were excluded

Discussion

The findings from the present study suggest that hemorrhagic stroke patients entering surgery within 120 minutes of arrival at the emergency department have greater survival rates but increase length of stay and health care cost compared to those entering surgery thereafter. These results are in line with international literature supporting the notion that patients entering surgery after three hours of symptom onset have higher mortality rates[3].

The finding of improving GOS at two weeks, when entering surgery within 120 minutes is in line with previously studies that states that effective management of treatment processes to deliver efficient care will result in improved recovery of hemorrhagic stroke patients in the long term[4]. The processes involved in the emergency department, from symptom onset to the point receiving a brain CT scan, all contribute to a patient's 30-day survival rate[5]. Literature in Thailand pertaining to the same population as the present study found that the important factors contributing to mortality in hemorrhagic stroke patients consist of age over 70 years and hypertension[9]. In addition to the location of the hemorrhage, initial GCS, volume of intracerebral hemorrhage, and secondary infection are contributing to mortality rate[7,11]. The significantly greater complication rate in those who enter surgery within 120 minutes, particularly pneumonia, warrants additional investigation. In the present study, the possible distinction between the groups is the duration to perform a complete preparation for the operation, overcrowding in the emergency department, and a limited number of healthcare workers.

The majority of SAH patients in the present study required additional transfer to a higher center. This condition is typically encountered in general Thai hospitals where there are just a few neurosurgeons per center. Although, patients who use antiplatelet or anticoagulant medications had been corrected before the operation, these patients may have a distinct nature, thus the authors analyzed the outcome separately. Further research may be advantageous by distinctive analysis.

To the authors' knowledge, no study has yet examined the relationship between survival rate and other outcomes in hemorrhagic stroke patients after surgery, specifically looking at the duration from arrival at the emergency department to the point of entering surgery. The present study supports the principles of treatment in cerebral hemorrhage, prioritizing the treatment of viable brain tissue, especially the brainstem, to maximize its functionality. Subsequent preservation of the brain tissue contributes to improved recovery and reduced complications that may follow. Both populations in the main group, in the present study showed a significant improvement at the two-week period when treatment to the patients is within 120 minutes. This is crucial for further study to determine a protocol for continuous progress, despite the fact that there were no significant differences in the Glasgow outcome score during the other follow-up period.

The present study emphasizes the accessibility of surgical treatment for hemorrhagic stroke, from the point of a patient's arrival at the emergency department to the point of entering the operating room. To the authors' knowledge, this point has not yet been studied in existing literature. However, the limitations of this present study differ from other similar studies that also examine time to treatment from the point of hemorrhagic stroke symptom onset. Furthermore, current medical records at Pattani Hospital do not record the Glasgow outcome score. For this reason, data collected in the present study were subsequently interpreted to obtain the Glasgow outcome score and, therefore, subject to interpreter bias.

The increased cost of treatment for patients entering surgery before 120 minutes upon arrival at the emergency department may have occurred from a gross-estimate cost calculation without delving

into details regarding whether the costs have been incurred from actual treatment or related to the treatment of complications. A future continuation of the present study may solve such limitations as the Thai healthcare system has a reimbursement system, with implications that a reduction in unit cost will increase the hospital's financial performance while patients are also receiving high-quality healthcare.

The findings of this present study can be used in policymaking both at the ministerial level and for national health service planning to improve the effectiveness, efficiency, and accessibility of surgical treatment for hemorrhagic stroke patients. Hospitals implementing such policies should keep complete medical records for each process in their care pathway, taking note of obstacles in each step for accurate audits and to improve service time-efficiency for these patients.

Conclusion

Patients with hemorrhagic stroke entering surgery within 120 minutes upon arrival at the emergency department benefit from improved survival rates, but length of stay and healthcare cost may increase due to complication. Comprehensive and meticulous steps of preoperative care are essential, which supports the policies of increasing accessibility to healthcare. Initial policies may focus on the internal management of hospitals before expanding towards the community to develop care from symptom onset, which is expected to improve the outcomes. Although the patients entering surgery earlier have marginally higher health care costs, this issue may be further studied to improve cost efficiency for the benefit of the Thai healthcare system.

What is already known on this topic?

Hemorrhagic stroke carries a high mortality and socioeconomic burden. Therefore, improving survival outcomes is important to society. The known unmodifiable factors affecting treatment outcomes include comorbidities, age, size, and location of the brain hematoma, in addition to the level of consciousness upon arrival at the emergency department. However, the known modifiable factors consist of the efficacy of management in an emergency department, the success rate at which patients arrive at the operating room within three hours of symptom onset, and the waiting time for a CT brain scan affects survival rates at thirty days postoperatively. It is notable that the mortality rate increases if the patients receive treatment later than three hours after the onset of symptoms.

What does this study add?

The authors demonstrated that effective management of modifiable factors affecting hemorrhagic stroke treatment outcomes through adaptations of the time to surgery less than 120 minutes, starting from the point of patient arrival at the emergency department. This can reduce mortality, length of stay, and health care cost. The advantage of adapting the care pathway is that any healthcare provider can adopt these changes flexibly, specific to each hospital's patient logistics. The result of reduction in time to treat hemorrhagic stroke enhances patient care.

Acknowledgement

The authors would like to acknowledge Tharathorn Durongbhandhu MD, Chonburi Research Center, Chote Wongkanong MD, PhD, Pattani Hospital and, Associate Professor Jayantorn Patumanond for their advice and guidance in the statistical analysis of the present study data.

The authors extend their appreciation to Pattani Hospital for providing us with the opportunity to attend the Diploma in Clinical Research course taught by Professor Patumanond.

Conflicts of interest

The authors declare no conflict of interest.

References

1. Gregson BA, Rowan EN, Francis R, McNamee P, Boyers D, Mitchell P, et al. Surgical Trial In Traumatic intraCerebral Haemorrhage (STITCH): a randomised controlled trial of Early Surgery compared with Initial Conservative Treatment. Health Technol Assess 2015;19:1-138.
2. Celikbilek A, Goksel BK, Zararsiz G, Benli S. Spontaneous intra-cerebral hemorrhage: A retrospective study of risk factors and outcome in a Turkish population. J Neurosci Rural Pract 2013;4:271-7.
3. Pinzn RT, Wijaya VO. Complications as poor prognostic factors in patients with hemorrhagic stroke: A Hospital-Based Stroke Registry. Int J Neurol Neurother 2020;7:096. doi.org/10.23937/2378-3001/1410096.
4. Fan JS, Huang HH, Chen YC, Yen DH, Kao WF, Huang MS, et al. Emergency department neurologic deterioration in patients with spontaneous intracerebral hemorrhage: incidence, predictors, and prognostic significance. Acad Emerg Med 2012;19:133-8.
5. Szepesi R, Széll IK, Hortobágyi T, Kardos L,

Nagy K, Lánczi LI, et al. New prognostic score for the prediction of 30-day outcome in spontaneous supratentorial cerebral haemorrhage. Biomed Res Int 2015;2015:961085. doi: 10.1155/2015/961085.
6. Nag C, Das K, Ghosh M, Khandakar MR. Prediction of clinical outcome in acute hemorrhagic stroke from a single CT scan on admission. N Am J Med Sci 2012;4:463-7.
7. Triamvisit S, Chongruksut W, Watcharasaksilp W, Rattanasathien R, Saisuwan S, Chaiwang S, et al. Predicting factors of poor outcome of hemorrhagic stroke patients. J Med Assoc Thai 2019;102:279-85.
8. González-Pérez A, Gaist D, Wallander MA, McFeat G, García-Rodríguez LA. Mortality after hemorrhagic stroke: data from general practice (The Health Improvement Network). Neurology 2013;81:559-65.
9. Chongruksut W, Limpastan K, Jetjumnong C, Watcharasaksilp W, Vaniyapong T, Norasetthada T, et al. Age as a prognostic factor of 30-day mortality in hemorrhagic stroke patients: A Thai large tertiary care referral center. Asian J Surg 2020;43:991-5.
10. Fahlström A, Nittby Redebrandt H, Zeberg H, Bartek J, Bartley A, Tobieson L, et al. A grading scale for surgically treated patients with spontaneous supratentorial intracerebral hemorrhage: the Surgical Swedish ICH Score. J Neurosurg 2020;133:800-7.
11. Muengtaweepongsa S, Seamhan B. Predicting mortality rate with ICH score in Thai intracerebral hemorrhage patients. Neurol Asia 2013;18:131-5.
12. Nilsson OG, Lindgren A, Brandt L, Säveland H. Prediction of death in patients with primary intracerebral hemorrhage: a prospective study of a defined population. J Neurosurg 2002;97:531-6.
13. Tetri S, Juvela S, Saloheimo P, Pyhtinen J, Hillbom M. Hypertension and diabetes as predictors of early death after spontaneous intracerebral hemorrhage. J Neurosurg 2009;110:411-7.
14. Togha M, Bakhtavar K. Factors associated with in-hospital mortality following intracerebral hemorrhage: a three-year study in Tehran, Iran. BMC Neurol 2004;4:9. doi: 10.1186/471-2377-4-9.
15. Park C, Charalambous LT, Yang Z, Adil SM, Hodges SE, Lee HJ, et al. Inpatient mortality and healthcare resource utilization of nontraumatic intracerebral hemorrhage complications in the US. J Neurosurg 2021;135:1081-90.