Original research

Factors of postoperative mortality in stroke-related intracerebral hematoma located in supratentorial region

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Abstract

Objective: Acute cerebrovascular accidents remain a leading cause of mortality and disability. Supratentorial intracerebral hematomas are the most severe form of hemorrhagic stroke, and the effectiveness and optimal timing of their surgical treatment remain a subject of debate.

The aim of the study was to identify independent factors influencing postoperative mortality in the surgical treatment of supratentorial intracerebral hematomas.

Methods: A single-center retrospective cohort study was conducted. Data from 217 patients undergoing surgery for ICH at the National Hospital (2019–2024) were analyzed. Demographic, clinical (time to surgery, level of consciousness according to the Glasgow Coma Scale (GCS)), and neuroimaging (volume, location, midline displacement, and severity of intraventricular hemorrhage (IVH) according to the Graeb scale) parameters, surgery type, and recurrence were assessed. The primary endpoint was in-hospital mortality. Binary logistic regression analysis (LRA) was used to identify independent predictors of mortality.

Results: Overall mortality was 21.7% (n=47). Multiple LRA revealed the following independent risk factors for postoperative mortality: age over 70 years (OR=4.1, 95%CI 1.8–9.4; p<0.001), GCS score ≤8 at admission (OR=5.6, 95%CI 2.5–12.5; p<0.001), midline displacement >7 mm (OR=3.8, 95%CI 1.7–8.5; p=0.001), and IVH with Graeb score ≥5 (OR=3.2, 95%CI 1.4–7.3; p=0.006). Surgery performed within 1-3 days from hemorrhage onset was also associated with an increased mortality risk (OR=2.9, 95%CI 1.2-7.0; p=0.018) compared with surgery performed after 10 days. Hematoma recurrence was an extremely unfavorable prognostic factor.

Conclusion: Postoperative mortality after supratentorial intracerebral hematomas is determined by a combination of independent factors: advanced age, profound depression of consciousness, significant brain herniation, and severe intraventricular hemorrhage. Optimization of patient selection for surgical treatment should take these prognostic markers into account. The identified association between higher mortality and surgery performed within 1-3 days requires further study, taking into account the initial severity of the patient's condition.

Key words: Intracerebral hematoma, hemorrhagic stroke, supratentorial location, postoperative mortality, prognostic factors

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Highlights

1. Key independent predictors of postoperative mortality in supratentorial intracerebral hematomas: advanced age (>70 years), impaired consciousness (GCS ≤8), severe midline dislocation (>7 mm), and severe intraventricular hemorrhage (Graeb score ≥5).
2. Intracerebral hematoma recurrence is an extremely unfavorable prognostic factor that maximally increases the risk of mortality (highest OR), necessitating reliable hemostasis during surgery and postoperative monitoring.
3. Increased mortality in interventions performed within 1–3 days is most likely due to a more severe baseline condition of patients rather than the harmfulness of early surgery per se, indicating the need to consider selection bias and conduct prospective studies.

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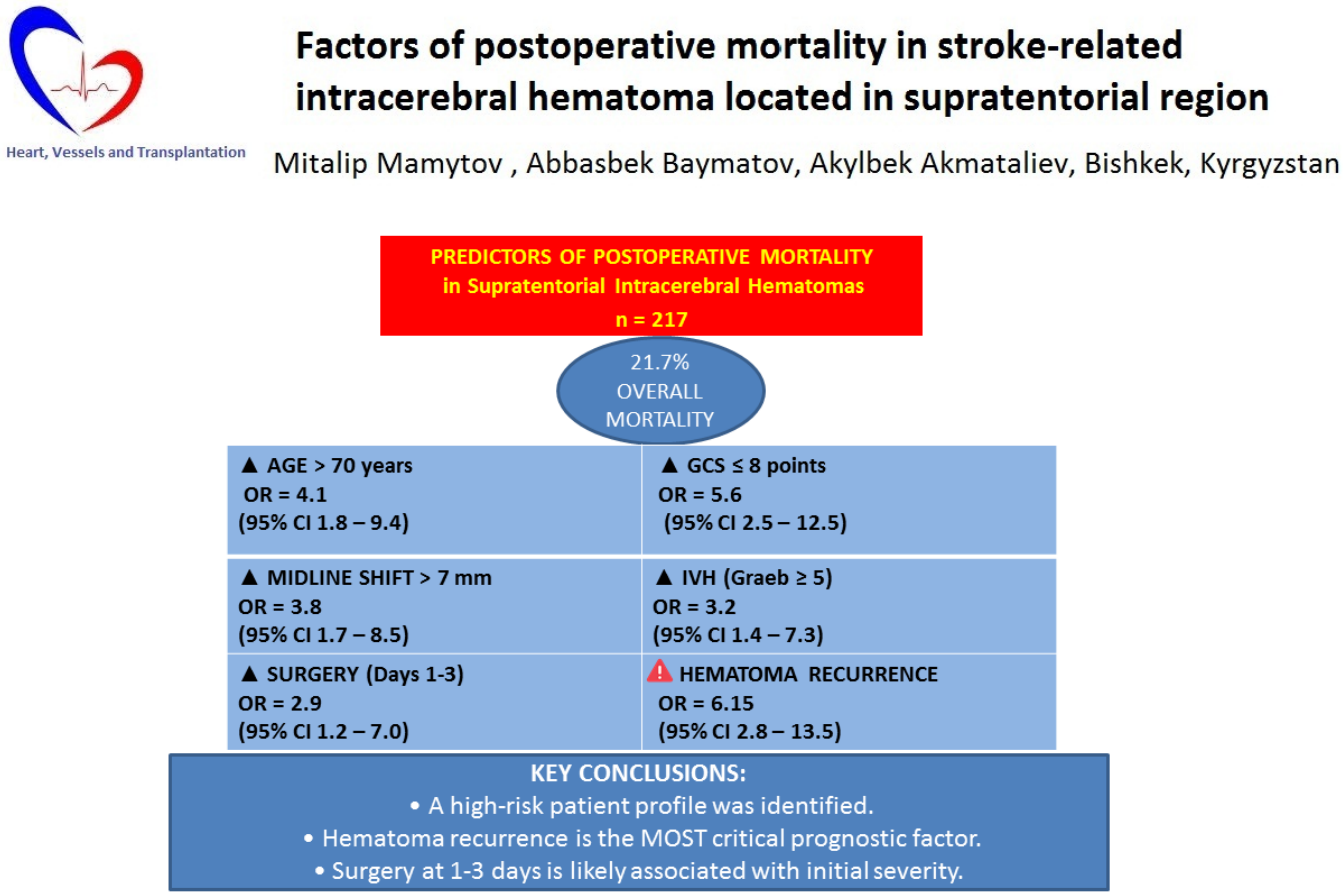
Graphical abstract



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Introduction

Timely detection and treatment of stroke-related intracerebral hematomas is a pressing medical and social challenge due to their high mortality and disability rates. Despite its smaller share (approximately 15%) in the structure of acute cerebrovascular accidents, hemorrhagic stroke is characterized by the most severe course and the worst prognosis (1). In Kyrgyzstan, the mortality rate from cerebrovascular diseases remains one of the highest among the CIS countries (2- 4).

The development of neurosurgical technologies, including minimally invasive techniques and neuroimaging guidance, has contributed to improved treatment outcomes (7, 8). However, the optimal timing, methods, and criteria for patient selection for surgical intervention for stroke-related supratentorial intracerebral hematomas (SICH) remains controversial, as evidenced by the wide range of postoperative mortality rates (from 0 to 63%) in various studies (9-12).

The aim of the study was to identify independent prognostic factors influencing postoperative mortality in patients with supratentorial intracerebral hemorrhage.

Methods

Study design and population

A single-center retrospective cohort study was conducted. The analysis included 217 consecutive patients with SICH who underwent surgery in the neurosurgical departments of the National Hospital of the Ministry of Health of the Kyrgyz Republic between January 2019 and January 2024.

Exclusion criteria: patients with intracerebral hemorrhages due to ruptured arterial aneurysms or arteriovenous malformations; patients with isolated intraventricular hemorrhages without a parenchymal hematoma component.

Patients were divided into 2 groups: survivors (n=170) and died (n=47).

Due to the retrospective nature of the study, the requirement for Ethical approval was waived. Informed consent was obtained from all patients or guardian for all procedures and treatment.

Baseline and clinical characteristics

The following data were collected for each patient: demographic variables: age, sex; clinical: time from onset of hemorrhage symptoms to surgery (categorized as <12 hours, 12-24 hours, 1-3 days, 4-10 days, >10 days), level of consciousness on admission, assessed using the Glasgow Coma Scale (GCS) (13). For analysis, patients were divided into groups: clear consciousness (15 points), obtundation (11-14), stupor (8-10), and coma I (6-7).

Neuroimaging - computed tomography and/or magnetic resonance imaging

We assessed the following neuroimaging data: hematoma volume, calculated using the formula (A × B × C)/2, hematomas were classified as small (<20 cm^3), medium (20-50 cm^3), and large (>50 cm^3); location - subcortical (lobar), putamenal (lateral), thalamic (medial), mixed; magnitude of midline structure displacement (in mm); and presence and severity of concomitant intraventricular hemorrhage (IVH), assessed using the modified Graeb scale (14).

Surgical intervention

Indications for surgery included progressive decline in consciousness, worsening neurological deficits, and signs of dislocation syndrome. The choice of a specific method (open removal, puncture, fibrinolysis) was determined by a multidisciplinary team, taking into account the location and volume of the hematoma, the patient's age, and comorbidities. The following surgical variables were included in analysis: type of surgical intervention performed (osteoplasty craniotomy, decompressive craniotomy, puncture removal, local fibrinolysis).

Follow-up and outcomes

We included in analysis in hospital during postoperative period follow-up data. The following outcomes were recorded: in-hospital mortality and development of hematoma recurrence in the postoperative period.

Statistical analysis

Statistical processing of the data was performed using IBM SPSS Statistics version 26.0. Quantitative data not normally distributed (tested with the Shapiro-Wilk test) are presented as medians and interquartile ranges (M (Q25-Q75)) and compared using the Mann-Whitney U test. Categorical variables are presented as absolute and relative frequencies (n, %) and compared using the Chi-square test or Fisher's exact test. To identify independent factors associated with postoperative mortality, we used binary logistic regression (the enter-method). Variables that demonstrated a statistically significant association ($p < 0.1$) with mortality in univariate analysis were included in the model. Multiple logistic regression analysis results are presented as odds ratios (OR) with 95% confidence intervals (95% CI). Statistical significance was set at $p < 0.05$.

Results

Clinical characteristics

Of the 217 patients included in the study, 47 (21.7%) died. The mean patient age was 56.9 (47.0; 68.0) years. There were 129 men (59.4%). The distribution of patients by clinical and neuroimaging characteristics by outcome is presented in Table 1.

The patients who died were of older age (p<0.001), they had markedly lower Glasgow coma grade score on admission (p<0.001), more patients who underwent surgery with 1-3 days died (p=0.003), they had tendency to higher hematoma volume, and significantly higher number of patients with mixed type by hematoma location (p=0.017) and larger midline displacement died (p<0.001) and they had higher Graeb score, i.e. severe IVH and hematoma recurrence (p<0.001 for both) as compared to survivors (Table 1).

Table 1. Comparison of clinical and neuroimaging characteristics between the groups of surviving and deceased patients

Variables	All patients (n=217)	Survived (n=170)	Died (n=47)	p
Age, years, Me (Q25–Q75)	56.9 (47.0; 68.0)	54.5 (45.0; 65.0)	68.0 (60.0; 75.0)	<0.001
Age >70 years, n (%)	52 (24.0)	32 (18.8)	20 (42.6)	0.001
GCS at admission, n (%)				
- Fully conscious (GCS 15)	18 (8.3)	17 (10.0)	1 (2.1)	
- Drowsy / obtunded (GCS 11–14)	89 (41.0)	82 (48.2)	7 (14.9)	<0.001
- Stuporous (GCS 8–10)	59 (27.2)	39 (22.9)	20 (42.6)	
- Coma (grade I) (GCS 6–7)	51 (23.5)	32 (18.8)	19 (40.4)	
GCS ≤8, n (%)	110 (50.7)	71 (41.8)	39 (83.0)	<0.001

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Table 1. Comparison of clinical and neuroimaging characteristics between the groups of surviving and deceased patients Continued from page XXX

Variables	All patients (n=217)	Survived (n=170)	Died (n=47)	p
Time to surgery, n (%)				
– <12 hours	8 (3.7)	6 (3.5)	2 (4.3)	0.003
– 12–24 hours	9 (4.1)	7 (4.1)	2 (4.3)	
– 1–3 days	76 (35.0)	53 (31.2)	23 (48.9)	
– 4–10 days	77 (35.5)	59 (34.7)	18 (38.3)	
– >10 days	47 (21.7)	45 (26.5)	2 (4.3)	
Hematoma volume, n (%)				
– Small (<20 cm^3)	20 (9.2)	14 (8.2)	6 (12.8)	0.052
– Medium (20–50 cm^3)	96 (44.2)	80 (47.1)	16 (34.0)	
– Large (>50 cm^3)	101 (46.5)	76 (44.7)	25 (53.2)	
Location, n (%)				
– Subcortical	62 (28.6)	55 (32.4)	7 (14.9)	0.017
– Putamenal	74 (34.1)	55 (32.4)	19 (40.4)	
– Thalamic	37 (17.1)	31 (18.2)	6 (12.8)	
– Mixed	44 (20.3)	29 (17.1)	15 (31.9)	
Midline structure displacement, n (%)				
– Absent	29 (13.4)	26 (15.3)	3 (6.4)	<0.001
– 1–3 mm	62 (28.6)	51 (30.0)	11 (23.4)	
– 4–7 mm	71 (32.7)	56 (32.9)	15 (31.9)	
– >7 mm	55 (25.3)	37 (21.8)	18 (38.3)	
IVH (Graeb scale), n (%)				
– None / 1–2 points	146 (67.3)	126 (74.1)	20 (42.6)	<0.001
– 3–6 points	65 (30.0)	41 (24.1)	24 (51.1)	
– ≥7 points	6 (2.8)	3 (1.8)	3 (6.4)	
IVH (Graeb) ≥5, n (%)	31 (14.3)	17 (10.0)	14 (29.8)	<0.001
Hematoma recurrence, n (%)	18 (8.3)	8 (4.7)	10 (21.3)	<0.001

Data are presented as median (Q25-Q75) and number percentage
Mann-Whitney U test, Chi-square or Fischer exact tests
GCS - Glasgow Coma Scale, IVH – intraventricular hemorrhage

Predictors of mortality

The results of binary logistic regression to identify independent predictors of postoperative mortality are presented in Table 2.

The analysis showed that advanced age (p<0.001), severe impairment of consciousness (p<0.001), marked brain displacement (p<0.001), severe IVH (p=0.006), and the development of hematoma recurrence (p<0.001) were independent factors significantly increasing the risk of mortality. Surgical intervention performed within 1–3 days from the onset of hemorrhage was also associated with a higher risk of mortality compared with interventions performed after 10 days (p=0.018).

Table 2. Independent factors associated with postoperative mortality (multiple logistic regression analysis)

Predictor	OR	95% CI	p
Age >70 years	4.10	1.81 – 9.39	<0.001
GCS on admission ≤8 points	5.62	2.52 – 12.54	<0.001
Surgery within 1–3 days (ref.: >10 days)	2.90	1.20 – 7.03	0.018
Displacement of midline structures >7 mm	3.81	1.71 – 8.51	0.001
IVF (Graeb scale) ≥5 points	3.21	1.40 – 7.34	0.006
Hematoma recurrence	6.15	2.15 – 17.60	<0.001

CI – confidence interval, GCS - Glasgow Coma Scale, IVH – intraventricular hemorrhage, OR - odds ratio

Discussion

The results of our study allowed us to identify a set of independent factors determining the risk of postoperative mortality in patients with SICH. These factors include age over 70 years, a GCS score ≤8, midline shift greater than 7 mm, and severe IVH (Graeb score ≥5).

Our findings are consistent with previously published studies demonstrating the negative impact of advanced age, decreased level of consciousness, and mass effect on surgical outcomes (11). Severe IVH is well known to significantly worsen prognosis due to the development of obstructive hydrocephalus and toxic injury to brain tissue caused by blood breakdown products (5, 6).

Of particular interest is the observed association between surgery performed within 1–3 days and increased mortality. This finding likely reflects not the detrimental effect of early intervention itself, but rather the initial severity of patients' conditions at the time of surgery. In our cohort, the majority of patients (62.7%) were admitted to the neurosurgical department from other hospitals after neuroimaging had been performed, which introduced a selection bias: patients operated on early were those in the most severe condition, with rapid neurological deterioration and brain displacement, whereas more stable patients could undergo delayed surgery. This observation highlights the importance of accounting for baseline disease severity when comparing surgical timing and underscores the need for prospective randomized studies to determine the optimal timing of intervention (9).

Hematoma recurrence proved to be an extremely unfavorable prognostic factor, demonstrating the highest odds ratio (OR 6.15), which is consistent with literature data reporting high mortality rates in cases of recurrent hemorrhage. This finding emphasizes the critical importance of meticulous intraoperative hemostasis and strict postoperative blood pressure control.

Study limitations

This study has several limitations, including its retrospective design and single-center nature, which may limit the generalizability of the results. The presence of selection bias related to the timing of hospitalization and surgery may have influenced the analysis of the time-to-surgery factor. Long-term functional outcomes (e.g., modified Rankin Scale scores) were not assessed, which limits the evaluation of quality of survival.

Strengths

The strengths of this study include a relatively large and homogeneous patient cohort, a detailed analysis of clinical and neuroimaging parameters, and the use of multivariate statistical analysis to identify independent predictors of mortality.

Conclusions

Postoperative mortality following surgical treatment of supratentorial intracerebral hematomas is determined by a set of independent factors, including advanced age (>70 years), severe impairment of consciousness (GCS ≤8), pronounced midline shift (>7 mm), and severe concomitant intraventricular hemorrhage (Graeb score ≥5). Hematoma recurrence is an extremely unfavorable prognostic factor that markedly increases the risk of death.

The association between surgery performed within 1–3 days and increased mortality is likely mediated by the initial severity of patients' conditions and requires further investigation in prospective studies.

Consideration of the identified prognostic factors may help optimize patient selection for surgical treatment and improve clinical outcomes.

Ethics: Due to the retrospective nature of the study, the requirement for Ethical approval was waived. Informed consent was obtained from all patients or guardian for all procedures and treatment

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