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Prognosis Assessment in Spontaneous (non-traumatic) Intracerebral Hemorrhage with Artificial Intelligence-Assisted Hemorrhage Volume Analysis

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Abstract

Objective: Spontaneous (non-traumatic) intracerebral hemorrhage (sICH) is associated with high mortality and morbidity rates. With the increasing incidence of sICH, hemorrhage volume and hemorrhage location on brain computed tomography (CT) are important in determining prognosis. CT scans obtained from patients with sICH are reported using artificial intelligence (AI)-assisted programs. These programs provide data on the type, volume, and location of bleeding. In this study, we aimed to investigate the reliability of AI-assisted hemorrhage volume measurement, the effect of measured volume on QTc, and the contribution of these parameters to predicting mortality in patients with sICH.

Materials and Methods: The study was designed as a retrospective, single-center cohort study. Hemorrhage volumes on CT images were calculated using AI algorithms from Hevi AI. QTc values were calculated using the Bazett formula, and statistical analyses were conducted by grouping patients according to 1-week and 1-month mortality.

Results: Eighty-five patients diagnosed with sICH were included in the study. The mean age of the patients was 62.9±14.6 years. No significant association was observed between age and 1-month mortality (p=0.890). Large hemorrhage volume, low Glasgow Coma Scale (GCS) score, and prolonged QTc duration were significantly associated with 1-week mortality (p<0.001). Hemorrhage volume showed a moderate-to-high significant negative correlation with GCS (r=-0.755, p<0.001) and a moderately significant positive correlation with QTc (r=0.477, p<0.001). In the Cox regression analysis performed to determine the effect of risk factors on mortality, large hemorrhage volume and low GCS level increased the probability of 1-week mortality (p=0.001, hazard ratio=1.018, confidence interval [CI]=1.008–1.029; and p=0.020, HR=0.852, CI=0.745–0.975, respectively).

Conclusion: AI-assisted measurement of large hemorrhage volume and low GCS appear to be important prognostic indicators, particularly regarding 1-week mortality.

Keywords: Artificial intelligence; hemorrhage volume; mortality; QTc interval; spontaneous (non-traumatic) intracerebral hemorrhage

Introduction

Spontaneous (non-traumatic) intracerebral hemorrhage (sICH) is defined as non-traumatic intracranial hemorrhage and is associated with high mortality and morbidity rates [1]. ICH is the second most common subtype of stroke and is associated with high mortality and morbidity worldwide [1,2]. Risk factors for sICH include advanced age, smoking, alcohol use, chronic hypertension, diabetes mellitus, medication use (anticoagulation, narcotics, stimulants), and etiological factors such as amyloid angiopathy, primary or metastatic tumors, and vascular malformations [3]. The primary parameters affecting the clinical course of sICH include hemorrhage volume, location, and low GCS. Furthermore, QTc prolongation due to sICH not only exacerbates the clinical picture but also stands out as a prognostic indicator [4].

Due to sICH, there is a direct interaction between the central nervous system and the cardiac system. This interaction is associated with an imbalance in the autonomic nervous system and can cause various ECG changes. One of these changes is

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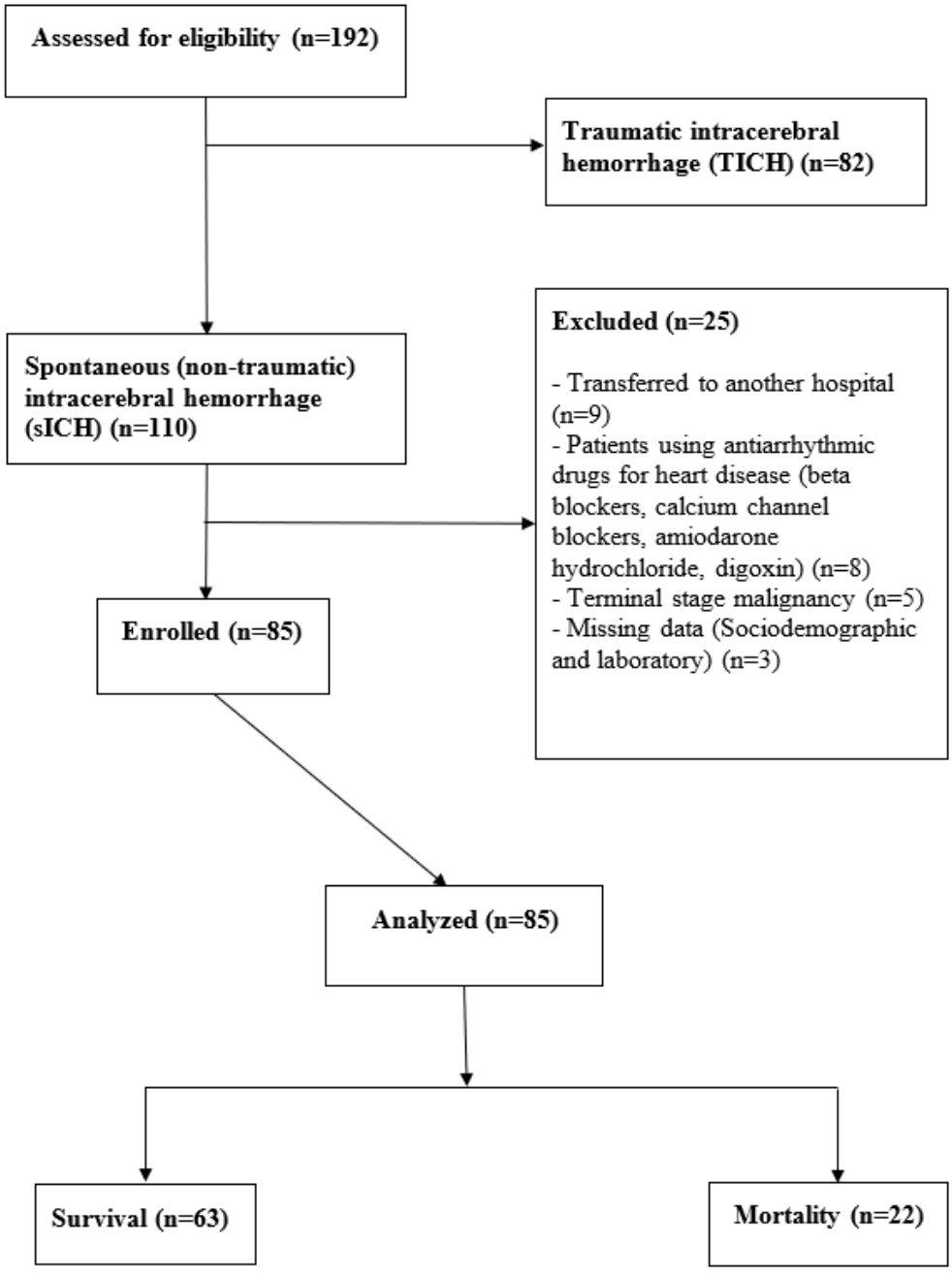
the QTc interval. As a parameter that affects heart rhythm and reflects ventricular repolarization on ECG, the QTc interval plays an important role in determining clinical prognosis. All these parameters are critical determinants of mortality risk and are particularly crucial for predicting prognosis in the early stages [5].

The 2022 American Heart Association/American Stroke Association guidelines for the management of patients with sICH recommend that CT evaluation within the first hours after onset is reasonable to identify patients at risk for subsequent hemorrhage expansion [6]. The volume, shape, location, and density of the hemorrhage detected on CT are clinically relevant. Manual volume assessment on CT can typically be accomplished by measuring the hemorrhage area on consecutive images using area measurement tools and multiplying the total area by the slice thickness. However, such manual segmentation is time-consuming and therefore impractical for use in emergency departments [4]. In recent years, artificial intelligence (AI) technologies have gained significant ground in medical imaging and clinical data analysis.

Study Flow Diagram



AI-assisted hemorrhage volume analysis provides clinicians with rapid and reliable data in the management of patients with sICH, enabling early intervention. With AI-assisted programs that have diagnostic accuracy, sensitivity, and specificity close to those of gold standard methods, these segmentation times can be calculated in seconds. This allows emergency department clinicians to obtain quantitative data about hemorrhage volume quickly and practically, enabling them to be proactive in patient management.

The pathophysiology underlying QTc prolongation in sICH is complex, with many factors implicated. In sICH, excessive sympathetic activation, particularly affecting the right insula or thalamus, leads to catecholamine-mediated myocardial damage, myocardial stunning, and repolarization abnormalities. Factors such as hemorrhage location, medications used, and fluid and electrolyte balance contribute to QTc prolongation. However, studies investigating the relationship between hemorrhage volume and QTc prolongation are limited [7].

In this study, the primary objective was to examine the effects of AI-assisted hemorrhage volume detection on early mortality in sICH. Second, we aimed to investigate the relationship between hemorrhage volume and QTc prolongation, as well as the predictive power of QTc.

Materials and Methods

The study was a retrospective, single-center cohort study. The study was approved by the University of Health Sciences Sisli Hamidiye Etfal Training and Research Hospital Health Application and Research Center Clinical Research Ethics Committee, dated June 17, 2025, and numbered 4922. Patients were selected from those over the age of 18 who presented to Department of Emergency Medicine, Şişli Hamidiye Etfal Training and Research Hospital between May 1, 2024, and May 1, 2025.

Study Inclusion Criteria

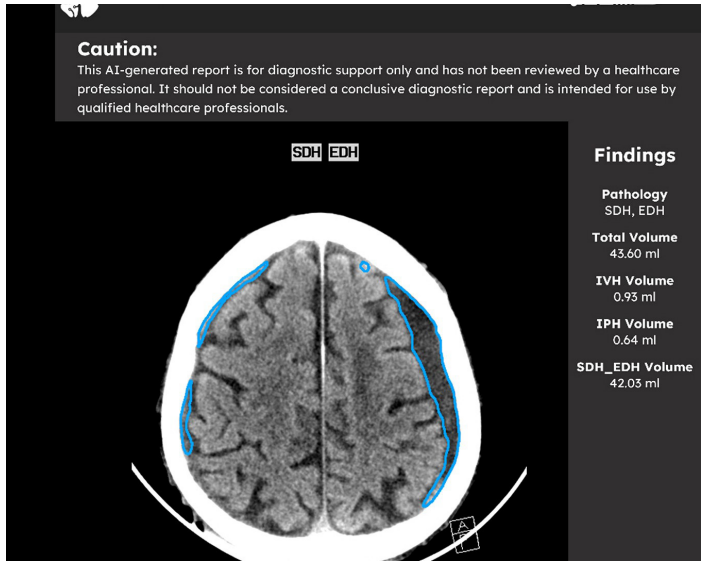
Patients who presented to the emergency department with non-traumatic neurological symptoms, had intracranial hemorrhage detected by cranial CT, and had hemorrhage volume determined by artificial intelligence were included in the study.

Data Collection

Patient demographics, clinical features, and cranial CT images were retrieved from the hospital automation system. Non-contrast cranial CT scans were obtained using a SOMATOM Definition Edge 128-slice multidetector computed tomography device (Siemens Healthineers, Forchheim, Germany), and the images were reconstructed with a 5-mm slice thickness. For manual measurement of hemorrhage volume, a simplified version of the formula used for the volume of an ellipsoid (4/3π×[A/2]×[B/2]×[C/2]) was used. Here, A, B, and C are the three diameters of the ellipsoid, as previously defined. Since π (pi) was taken as approximately 3, the formula was simplified to ABC/2 [8].

Hevi AI [9] is a program that uses a novel deep learning (DL) architecture consisting of convolutional neural networks (CNNs) and recurrent neural networks (RNNs), a common type of DL method with an attention mechanism, to detect and subcategorize ICH in non-contrast head CT scans. It utilizes state-of-the-art deep learning technology. It distinguishes between various intracranial hemorrhage subtypes and provides automatic hemorrhage volume measurements for rapid assessment. Accuracy, sensitivity, and specificity on the validation set were 99.41%, 99.70%, and 98.91%, respectively, with an average prediction time of 45±8 seconds for head CT scans. It is an artificial intelligence program integrated into the hospital PACS system (Figure 1. Hemorrhage volume detected with Hevi AI). No bias or statistically significant differences were found between the two methods (manual measurement and Hevi AI) (p=0.296, confidence interval=-2.52 to 2.25, Bland–Altman analysis).

At the time of admission to the emergency department, the first available and technically satisfactory routine 12-lead ECG (25 mm/s paper speed, 10 mm/mV amplitude, and 500 Hz sampling rate; Nihon Kohden, Tokyo, Japan) was obtained from our digital ECG system. The duration of the QRS complex was defined as the time to the end of the T wave, and this time was used to measure QTc. After evaluating the QT interval in multiple leads, the highest reported QT interval in any given lead was used. Five consecutive



Picture 1. Hemorrhage volume detected with Hevi AI

heartbeats in lead II were used to evaluate QTc duration and RR intervals by two clinicians specializing in arrhythmias, who were blinded to other independent variables. The measurement was performed using a combination of automated technology and manual procedures. Interobserver agreement was assessed. Data were included if two observers agreed manually and the other observer agreed automatically on all measurements. When there was a discrepancy, the average of the two values was calculated. To ensure that the QTc interval remained constant regardless of heart rate, heart rates ranging from 60 to 100 beats/minute were used. After adjusting for heart rate, the QTc interval was determined. QT correction: QTc (ms) was calculated as follows using RR (s) and HR (bpm) values [10]. The most commonly used formula for determining the QTc interval is the Bazett formula.

Bazett formula: $QTcB=QT/RR^{1}/^{2}$

The normal duration of a QTc interval is 360 ms or longer; a duration longer than 450 ms in men and 460 ms in women is considered prolonged [11,12].

Statistical Analysis

We performed the power analysis of our study using G*Power software (version 3.1.9.7). The calculations were made using the following parameters: Cox regression for time-dependent mortality was calculated using hazard ratio (HR)=2, power (1–β)=0.80, alpha level=0.05, confidence interval=95%, and 30% mortality criteria, and it was determined that at least 80 patients should be included in the study. Mean, standard deviation, median (25–75), highest frequency, and ratio values were used in the descriptive statistics of the data. The distribution of variables was assessed using the Kolmogorov–Smirnov test. The independent samples t-test was used to analyze normally distributed continuous independent variables. The Mann–Whitney U test was used in the analysis of quantitative independent data. The chi-square test was used to analyze qualitative independent data. Cox regression analysis was used to assess the probability of risk factors for 1-week and 1-month mortality. Correlations between continuous variables were examined using the Pearson correlation test for normally distributed data. Receiver operating characteristic (ROC) analysis was performed to determine the predictive value of independent variables for 1-week and 1-month mortality. A value of $p<0.05$ was considered statistically significant. All statistical analyses were conducted using SPSS software (version 28.0, IBM Corp., Armonk, NY, USA).

Results

A total of 85 patients with sICH were included in the study. The number of male patients (n=51) was higher than the number of female patients (n=34). The mean age of all patients was 62.9±14.6 years. The mean age of female patients (67.5±15.3 years) was significantly higher than that of male patients (59.9±13.5 years) (p=0.018) (not shown in the table). During the 1-month follow-up of all patients, we found that 22 (25.9%) patients died. There were no differences between the survival and mortality groups in terms of sociodemographic characteristics, laboratory findings, and chronic diseases during the 1-month period. The three most frequently diagnosed chronic diseases among the groups were hypertension (HT), diabetes mellitus (DM), and coronary artery disease (CAD). Although the rate of surgical treatment after hemorrhage was higher in the survival group, there was no difference between the groups (Table 1).

However, no significant association was observed between age and 1-week or 1-month mortality (p=0.665, p=0.890). A significant association was found between mortality and hemorrhage volume. A larger hemorrhage volume (119.29±51.9) was significantly associated with higher mortality ($p<0.001$), and hemorrhage size appeared to be associated with a poorer prognosis. Low GCS and prolonged QTc duration were significantly associated with increased mortality ($p<0.001$). Low GCS is a strong indicator of poor prognosis, while prolonged QTc duration increases the risk of mortality (Table 2).

The most common hemorrhage type was intraparenchymal hemorrhage (IPH) (68.2%), concentrated in the parietal and frontal lobes. Overall mortality was increased in right hemisphere hemorrhages, but these findings did not reach statistical significance. In 28 (32.9%) patients, hemorrhage occurred within the ventricle (Table 3).

Hemorrhage volume showed a moderately to highly significant negative correlation with GCS ($r=-0.755$, $p<0.001$) and a moderately significant positive correlation with QTc ($r=0.477$, $p<0.001$). No significant relationship was found between age and hemorrhage volume (Table 4).

ROC analysis of the predictive value of hemorrhage volume and QTc for 1-week mortality revealed that both parameters were predictive and highly sensitive and specific (AUC=0.975, $p<0.001$ and AUC=0.857, $p<0.001$, respectively; Figure 1. ROC analysis of hemorrhage volume and QTc for 1-week mortality) (Table 5).

ROC analysis of the predictive value of hemorrhage volume and QTc for 1-month mortality revealed that both parameters were predictive and moderately sensitive and specific (AUC=0.886, $p<0.001$ and AUC=0.729, p=0.001, respectively; Figure 2. ROC analysis of hemorrhage volume and QTc for 1-month mortality) (Table 6).

In a Cox regression analysis performed to determine the probability

Table 1. Analysis of sociodemographic, laboratory, and chronic diseases among survival and mortality groups in all patients during a 1-month follow-up

		Survival (n=63)	Mortality (n=22)	
		mean±SD median (25-75)	mean±SD median (25-75)	p
Age	year	62.6±12.6	63.1±15.4	0.890[t]
Gender	male	35 (55.6%)	16 (72.7%)	0.245[x2]
	female	28 (44.5%)	6 (27.3%)	
Chronic diseases:				
HT (n%)	+	33 (52.4%)	16 (72.7%)	0.096[x2]
DM (n%)	+	33 (52.4%)	12 (54.5%)	0.861[x2]
CAD (n%)	+	22 (34.9%)	9 (40.9%)	0.615[x2]
Hematological parameters:				
Hemoglobin	g/dl	12.5±2.1	12.9±1.5	0.257[t]
Platelet	10^9/L	258±87	237±96	0.343[t]
aPTT	second	25 (24-28)	28 (24-30)	0.272[m]
PT	second	12.5±1.7	12.1±1.5	0.342[t]
INR	-	1.06 (0.98-1.14)	1.13 (1.05-1.95)	0.057[m]
Glucose	mg/dL	148 (116-201)	198 (138-224)	0.055[m]
Sodium	mEq/L	138 (136-140)	139 (136-140)	0.468[m]
Potassium	mEq/L	4.5±0.6	4.4±0.6	0.675[t]
Calcium	mg/dL	8.7±0.4	8.8±0.5	0.792[t]
Using antiaggregant (n%)	+	13 (20.6%)	7 (31.8%)	0.287[x2]
Using anticoagulant (n%)	+	9 (14.3%)	6 (27.3%)	0.169[x2]
Surgical treatment after hemorrhage (n%)	+	42 (66.7%)	14 (63.6%)	0.796[x2]

HT: Hypertension; DM: Diabetes mellitus; CAD: Coronary artery disease; aPTT: Activated partial thromboplastin time; PT: Prothrombin time; [m]Mann Whitney U; [x2]Chi-Square test; [t]T-test; SD: Standard deviation

of independent variables on 1-week and 1-month mortality, the probability of mortality increased with large hemorrhage volume and low GCS level. Advanced age and QTc duration were not found to be significant. These results suggest that hemorrhage

Table 2. Baseline characteristics of patients with intracerebral hemorrhage according to gender and mortality status

	Mortality (1-week)			Mortality (1-month)		
	Yes (n=15)	No (n=70)	p	Yes (n=22)	No (n=63)	p
	mean±SD median (25-75)	mean±SD median (25-75)		mean±SD median (25-75)	mean±SD median (25-75)	
Age, year	61.46±13.4	63.28±14.9	0.665[t]	62.6±12.6	63.1±15.4	0.890[t]
Volume, mL	119.29±51.9	28.04±24.9	<0.001[t]	94.1±57.8	26.7±25.1	<0.001[t]
GCS	6 (4-7)	15 (12-15)	<0.001[m]	7 (5-10)	15 (13-15)	<0.001[m]
QTc, ms	491.6±33.5	446.3±26.4	<0.001[t]	475.5±40.5	446.9±25.6	0.005[t]
Gender male n%	10 (66.7%)	41 (58.6%)	0.772[x2]	16 (72.7%)	35 (55.6%)	0.245[x2]

SD: Standard deviation; GCS: Glasgow Coma score; QTc: Corrected QT interval, p: Statistical significance (<0.05), [m]Mann Whitney U, [x2]Chi-Square test, [t]T-test

Table 3. Hemispheres and areas where bleeding occurs

Area and frequency of the lesion n (%)		Right hemisphere n (%)		Left hemisphere n (%)
Intraparenchymal hemorrhage (IPH)	58 (68.2)	19 (22.4)	Frontal	19 (22.4)
Subdural hemorrhage (SDH)	23 (27.1)	28 (32.9)	Parietal	24 (28.2)
Epidural hemorrhage (EDH)	10 (11.8)	14 (16.5)	Temporal	15 (17.6)
Subarachnoid hemorrhage (SAH)	37 (43.5)	1 (1.2)	Occipital	4 (4.7)
Intraventricular hemorrhage (IVH)	28 (32.9)	7 (8.2)	Lateral Ventricle	4 (4.7)
		8 (9.4)	Third-Ventricle	4 (4.9)
		5 (5.9)	Fourth-Ventricle	4 (4.9)
		6 (7.1)	Thalamus	3 (3.5)
		0	Pons	(1.2)

* A patient may experience hemorrhage in more than one area

Table 4. Correlation analysis of hematoma volume with age, QTc and GCS

Pearson correlation		Age, year	GCS	QTc, ms
Volume, mL	r	-0.008	-0.755	0.477
	p	0.939	<0.001	<0.001
	n	85	85	85

GCS: Glasgow Coma score; QTc: Corrected QT interval; r: correlation coefficient

volume and GCS are predictive factors for 1-week and 1-month mortality (Table 7).

Discussion

In our study, we found that large hemorrhage volume, low GCS score, and prolonged QTc were variables that showed significant differences in 1-week and 1-month mortality. We found a moderate-to-high inverse relationship between large hemorrhage volume and GCS level and a positive, weak-to-moderate correlation between hemorrhage volume and QTc. In the analysis conducted to determine the probability of risk factors for mortality, it was found that large hemorrhage volume and low GCS level increased the probability of 1-week mortality. The probability of 1-month mortality was found to increase only with large hemorrhage volume.

Hemorrhage volume in patients with sICH shows a strong correlation with mortality, and this correlation is a frequently emphasized prognostic factor in the literature. Our study demonstrates that AI-assisted hemorrhage volume analysis provides rapid and reliable results in sICH management, making an important contribution to guiding clinical decisions. The importance of parameters such as hemorrhage volume, GCS, and QTc interval in prognostic assessments has been supported by previous studies. Broderick et al. [13] reported that mortality was significantly increased when hemorrhage volume exceeded 30 mL. This finding supports the conclusion in our study that large hemorrhage volume is associated with mortality. The GCS score

Table 5. Receiver Operating Characteristic (ROC) Curve analysis with variables for mortality (1-week)

Mortality	Sensitivity (%)	Specificity (%)	AUC	95% CI	Cut off	p
Volume, mL	100	87.1	0.975	0.947-1.000	62.2	<0.001
QTc, ms	80.0	98.6	0.857	0.709-1.000	486	<0.001

AUC: Area Under the Curve; %95 CI: Confidence Interval; p: Statistical significance (<0.05); QTc: Corrected QT interval

Table 6. Receiver Operating Characteristic (ROC) Curve analysis with variables for mortality (1-month)

Mortality	Sensitivity (%)	Specificity (%)	AUC	95% CI	Cut off	p
Volume, mL	77.3	87.3	0.886	0.808-0.964	56.6	<0.001
QTc, ms	54.5	98.4	0.729	0.583-0.876	486	0.001

AUC: Area Under the Curve; %95 CI: Confidence Interval; p: Statistical significance (<0.05); QTc: Corrected QT interval

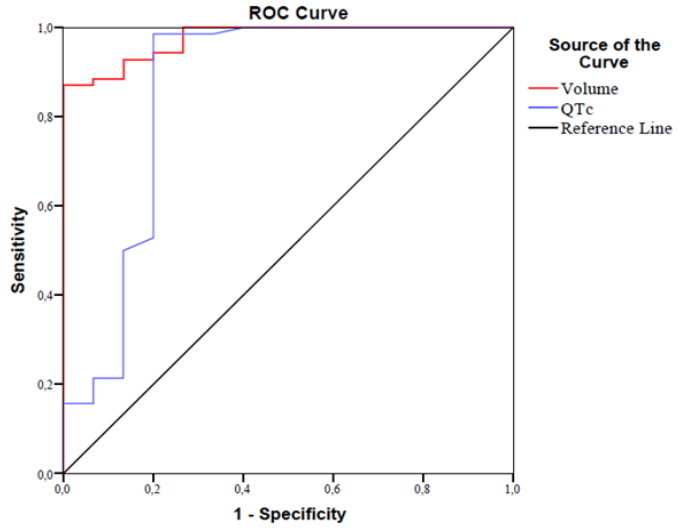


Figure 1. ROC analysis of hemorrhage volume and QTc for 1-week mortality

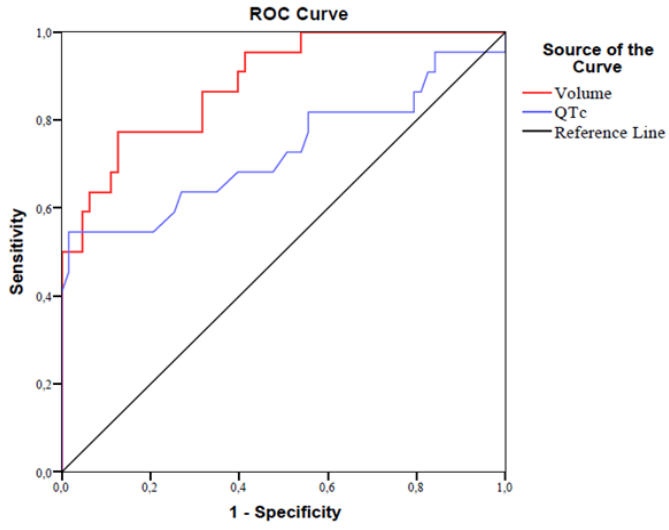


Figure 2. ROC analysis of hemorrhage volume and QTc for 1-month mortality

is widely used as an indicator of neurological status in patients with sICH, and a low GCS score is considered a strong predictor of mortality. A study by Jungin Han et al. [14] in patients with stroke emphasized the strong relationship between low GCS scores and increased mortality rates. Similarly, in our study, it was determined that a low GCS score showed a negative correlation with mortality and was one of the important indicators in predicting short-term mortality risk. This finding indicates that the GCS score should continue to be used as an important determinant of clinical prognosis.

In the literature, QTc prolongation in sICH has been accepted as an electrocardiographic finding associated with intracranial hemorrhage and has been identified as a predictive parameter that may contribute to mortality. In a study on sICH cases by Osama Amin et al., [5] it was reported that QTc prolongation increased complications and mortality after intracranial hemorrhage. Our study concluded that QTc interval prolongation is associated with mortality. However, the absence of a risk factor increasing the probability of mortality in the sample group and its weak-to-moderate correlation with hemorrhage volume can be explained by the location of the hemorrhage. Another reason is that the QTc interval included in the study was measured at the time of admission; indeed, studies have shown that other ECG changes, such as QTc prolongation, appear hours later in sICH. These findings indicate that the QTc interval should be evaluated

Table 7. Cox regression analysis of one-week and one-month in-hospital mortality of cases with variables

Mortality	1-week			1-month		
	HR	95% CI	*p*	HR	95% CI	*p*
Age, year	0.984	0.941-1.028	0.467	0.990	0.958-1.023	0.546
Volume, mL	1.018	1.004-1.031	0.009	1.018	1.007-1.029	0.001
GCS, point	0.726	0.556-0.948	0.019	0.862	0.740-0.1003	0.054
QTc, ms	1.020	0.993-1.047	0.141	1.013	0.994-1.032	0.183
IPH	3.229	0.129-80.736	0.475	0.535	0.053-5.415	0.596
SDH	0.321	0.018-5.587	0.436	1.143	0.125-10.442	0.906
EDH	6.034	0.136-268.165	0.353	0.445	0.017-11.316	0.624
SAH	2.274	0.394-13.129	0.358	1.242	0.319-4.838	0.755
IVH	0.367	0.055-2.41	0.300	0.672	0.176-2.570	0.561

HR: Hazard Ratio; %95 CI: Confidence Interval; GCS: Glasgow Coma Score; QTc: Corrected QT interval; IPH: Intraparenchymal hemorrhage; SDH: Subdural hemorrhage; EDH: Epidural hemorrhage; SAH: Subarachnoid hemorrhage; IVH: Intraventricular hemorrhage, p: Statistical significance (<0.05), (1-week and 1-month Cox regression Omnibus Tests of Model Coefficients p<0.001, No significant multicollinearity was detected among variables included in the Cox regression model (VIF range: 1.116–2.601)

more carefully as a risk factor in intracranial hemorrhages. The QTc interval should be examined in more detail in future studies as a parameter that may reflect the interaction between the cardiac and neurological systems.

AI-based analyses are increasingly used in sICH prognosis. In recent years, numerous studies have reported that AI algorithms successfully predict mortality risk by accurately determining hemorrhage volume in cerebral hemorrhage cases. The study by Kai Gong et al. [15] reported that AI algorithms improved clinical decisions by rapidly and accurately detecting hemorrhage volume. Our study supports this finding and shows that AI-assisted analyses provide clinically significant benefits in rapidly classifying patients, creating treatment plans, and predicting prognosis. In our study, the prognostic value of hemorrhage volume detected by the AI-assisted program was investigated, as the diagnostic values of the AI-assisted program were similar to those of the manual method. Previous studies have shown the importance of this diagnostic method in terms of high accuracy, sensitivity, and specificity, as well as its ability to provide quantitative data within seconds and demonstrate prognosis for mortality. This result strengthens the applicability of AI-based systems in emergency medicine practice and neurology.

Our study found that certain demographic factors, such as age and gender, did not have a significant effect on mortality. This finding is consistent with the study by Justin T. Hsieh et al. [16] and suggests that demographic factors such as age may be of secondary importance in sICH prognosis. The limited effect of age on mortality indicates that more specific neurological and cardiac parameters should be prioritized, particularly in clinical practice. However, advanced studies suggest that artificial intelligence could further refine prognosis predictions by integrating other demographic and clinical data more comprehensively. However, the small number of patients in the study and the advanced average age of the groups are parameters that may explain these nonsignificant results for age, which is a nonmodifiable risk factor for mortality.

The strongest predictors of 30-day mortality and functional outcome in patients with sICH are baseline hemorrhage volume and subsequent hemorrhage expansion [17]. However, precise hemorrhage measurement is rare in routine clinical practice, primarily due to the lack of available tools that are fast, effective, and reliable for volumetric assessment. The hemorrhage volume determined using our AI-assisted algorithm, which provides a rapid and highly sensitive diagnostic method, was found to be associated with early (1-week) and 1-month mortality risk. Large hemorrhage volume measured at presentation is a prognostic factor consistent with the literature, and awareness of the need for aggressive treatment is warranted.

Questions regarding the optimal medical and surgical management of sICH remain [18]. However, the primary procedures to be performed in emergency departments include initial medical stabilization; rapid and accurate neuroimaging to establish the diagnosis and explain the etiology; standardized neurological assessment to determine baseline severity; prevention of hemorrhage expansion through blood pressure management and reversal of coagulopathy; and prevention of secondary brain injury. In the acute phase, timely and aggressive management can mitigate secondary brain injury. In this regard, the rapid and easy detection of prognostic factors, such as bleeding volume, using AI-assisted programs may readily guide patient management.

Limitations of Our Study and Future Research

Our study has some limitations. The small number of cases is a significant limitation. In particular, the retrospective design may have led to the omission of some potential variables. Future studies using prospective designs will be important to validate these findings and compare the effectiveness of different AI algorithms. Furthermore, large-scale studies conducted in different hospitals and centers could improve the generalizability of AI-assisted prognostic models. The relationship between hemorrhage localization and QTc interval was not investigated. Additionally, the fact that QTc was calculated from the initial ECG and that 24–48-hour ECG monitoring with Holter or a monitor was not performed may have obscured the prognostic value of this risk factor. Another limitation is that only patients whose measurements could be obtained by the AI system were included in the study.

Conclusion

In conclusion, large bleeding volume and low GCS score emerge as critical factors in determining short-term (1-week) mortality risk in patients with sICH. It was concluded that AI-assisted hemorrhage volume analysis can be used as a powerful tool in predicting the prognosis of sICH and has the potential to improve clinical management. Future research should focus on the combined assessment of these parameters and the investigation of the integration of AI-based systems into broader clinical practice.

Ethics

Ethics Committee Approval: This study was approved by the University of Health Sciences Şişli Hamidiye Etfal Training and Research Hospital Clinical Research Ethics Committee (Date: June 17, 2025; Approval No: 4922).

Informed Consent: The requirement for informed consent was waived due to the retrospective design.

Conflict of Interest: The author declare that there is no conflict of interest.

Use of AI for Writing Assistance: Not declared.

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Authorship Contributions: Concept: D.O., B.E., E.A.; Design: A.M., S.C.; Data Collection and/or Processing: S.C., A.A.; Analysis and/or Interpretation: A.M., B.E., E.A.; Literature Search: D.O., A.M., B.E., E.A.; Writing: D.O., A.M., E.A.

Peer-review: Externally peer-reviewed.

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