Irregular Shape as An Independent Predictor of Prognosis in Patients with Primary Intracerebral Hemorrhage

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Abstract

BACKGROUND AND PURPOSE

The utility of non-contrast computed tomography (NCCT) markers in the prognosis of spontaneous intracerebral hemorrhage (ICH) has been concerned. This study aimed to investigate the predictive value of the computed tomography irregularity shape for poor functional outcomes in patients with spontaneous intracerebral hemorrhage.

PATIENTS AND Methods:

We retrospectively reviewed all 782 patients with intracranial hemorrhage in our stroke emergency center from January 2018 to September 2019. Laboratory examination and CT examination were measured within 24 hours of admission. After three months, the patient's functional outcome was assessed using the modified Rankin Scale (mRS). Multinomial logistic regression analyses were applied to identify independent predictors of functional outcome in patients with intracerebral hemorrhage.

RESULTS

Out of the 627 patients included in this study, those with irregular shapes on CT imaging had a higher proportion of poor outcome and mortality 90 days after discharge ($P<0.001$). Irregular shapes were found to be significant independent predictors of poor outcome and mortality on multiple logistic regression analysis. Besides, the increase of plasma D-dimer was associated with the occurrence of irregular shape ($P=0.0387$).

CONCLUSIONS

Patients with irregular shape showed worse functional outcomes after intracerebral hemorrhage. The elevated expression level of plasma D-dimer may be directly related to the formation of irregular shapes.

Introduction

Spontaneous intracranial hemorrhage (ICH), a subtype of stroke with a severe high mortality and disability rate, accounts for approximately 10-15% of all stroke patients[1–3]. Early hematoma expansion(HE), frequently accompanied by the occurrence of neurological deterioration, is associated with poor functional outcomes in patients with intracerebral hemorrhage[4]. Heterogeneity of hematoma has been verified to be associated with hematoma expansion.[5,6] Although the CT angiography (CTA) spot sign is accepted as the gold standard for judging the risk of hematoma expansion[7], its complicated examination process can cause unnecessary risks to patients. Therefore, the prompt and accurate identification of patients who are most likely to benefit from antihematoma therapy will improve functional outcomes of patients with intracerebral hemorrhage.

Compared with CTA, non-contrast computed tomography (NCCT) is an inexpensive and widely used examination tool and more suitable for early diagnostic applications in patients with intracerebral hemorrhage[8]. Some non-contrast CT biomarkers of intracerebral hemorrhage have been paid more and more attention by researchers for their good performance in predicting the poor prognosis of patients. Morotti et al, showed good predictive performance when the irregular shape was used as a noncontrast computed tomography marker for judging early intracerebral hemorrhage expansion [9]. But its study was based on unadjusted pooled estimates, there was no independent collection of real patient medical records for analysis, and the factors associated with the appearance of irregular shapes have not been explored.

Therefore, in this study, we comprehensively collected the clinical data of patients with intracerebral hemorrhage and explored whether the irregular shape could serve as an independent predictor for judging the prognosis of patients. In our previous studies, it has been confirmed that plasma D-dimer expression level can predict the poor prognosis of patients with intracerebral hemorrhage[10]. On this basis, we further investigated whether there is a specific correlation between the appearance of the irregular shape of hematoma and the elevated expression level of plasma D-dimer.

Patients And Methods

1. Patients

The clinical data of 782 patients with ICH admitted to the emergency neurosurgery ward of the First Affiliated Hospital of Harbin Medical University from January 2018 to September 2019 were retrospectively analyzed. Inclusion and exclusion criteria were: aged ≥ 18 years; CT scan was performed within 24 hours of admission, and standard techniques were used (CA-7000 Sysmex; Dade Behring) to analyze the concentration of D-dimer. Patients without CT images or follow-up CT scans within 24 hours after the initial CT examination were excluded, as were patients with intracranial hemorrhage due to trauma or aneurysm.

To assess the clinical status, Glasgow Coma Scale (GCS) score was measured by a neurosurgeon at the time of patient admission. To determine the functional outcome, patients were followed up at least three months after symptom onset, and their clinical outcomes were assessed by using the modified Rankin scale (mRS). (poor functional outcome: mRS score 4 – 6; favorable functional outcome: mRS score 0 – 3). The study protocol was approved by the Institutional Review Board of The First Affiliated Hospital of Harbin Medical University. Simultaneously, all methods were carried out in accordance with the relevant regulations and guidelines of Harbin Medical University.

2. Image features

The imaging data of the patients were evaluated independently by two experienced neurologists. Hematoma volumes were measured on industry-standard DICOM images using 3D slicer 4.10.2, an open-source software (SPL, Harvard Medical School, Boston, USA). For patients with severe symptoms, continuous deterioration, and suspected intracerebral hemorrhage expansion, the non-contrast CT scans will be examined within 24 hours after admission, and the presence of hematoma expansion and irregular shapes will be judged. Hematoma expansion was defined as an absolute growth>6 ml or a relative growth>33 in hematoma size on follow-up non-enhanced CT scan compared with the initial CT examination after admission[11]. Irregular shapes were defined as the presence of two or more connected or separated irregular hematomas at the edge of the hematoma on the axial section with the largest hematoma cross-sectional area [12](Supplemental Figure 1).

3. Statistical analysis

Statistical analysis and calculations were carried out using dedicated software (IBM SPSS Statistics 21.0; SPSS Inc, Armonk, NY, USA) or the GraphPad Prism 8 software (version 8.0.3; GraphPad Software Inc, San Diego, CA). Baseline characteristics were compared between patients with and without hematoma expansion. Categorized variables were expressed as counts (percentages) and compared using the chi-square test or Fisher's exact test while continuous variables were expressed as mean ± SD or median (interquartile range [IQR]) values were compared using independent sample Student's t-test.

Variables associated with mortality at 90 days after discharge, poor prognosis, and hematoma enlargement were included in the univariate analysis. Variables with P values <0.05 in the univariate analysis were included in multivariate logistic models to adjust for confounders. The scatter plot represents the relationship between irregular shape and plasma D dimer expression levels. Statistical significance for all tests was defined as $P < 0.05$.

Results

According to the inclusion and exclusion criteria, among the 782 patients included in our study. Figure 1 shows the study flow chart of patient inclusion for the analysis. There were 627 eligible patients, including 428 males and 199 females. The mean age of the patients was 57.95 years (range, 18-91 years). The mean hematoma volume of all patients was 25.56 ±27.91 mL, the mean plasma D-dimer level on admission was 1.36 ±4.69mg/ L, and a total of 220 patients had an elevated expression level of D-dimer on admission (35.0%). Hematoma expansion was observed in 43 patients, 28 of whom presented with irregular shapes. Among the 627 patients included in this study, 248 cases were diagnosed with irregular shapes. And in the patients with irregular shapes there was a significantly higher rate of poor outcomes and mortality at 90 days after discharge (mRS = 4 – 6 at 3 months: positive 131 / 248 [52.8%] vs negative 94 / 379 [24.8%], P <.001; mortality at 3 months: positive 52 / 248 [20.9%] vs negative 19 / 379 [5.0%], *P* <.001; Figure 2). Table 1 shows the comparison of clinical characteristics between patients with irregular shapes and the control group. And the results showed that initial blood pressure, initial hematoma volume, hematoma expansion, presence of IVH, the degree of midline shift and elevated plasm D-dimer levels was significantly related to the occurrence of irregular shapes.

Table 1
Clinical characteristics related to Irregular Sign in patients with ICH

Characteristics	Patients, No. (%)		P Value
	Patients with Irregular sign (n=248)	Patients without Irregular sign (n=379)	
Age, y	57.82±11.57	58.04 ± 11.48	0.812
Sex (male)	165 (66.5)	263 (69.4)	0.452
History of Hypertension	230 (92.7)	342 (90.5)	0.323
History of Diabetes	29 (11.7)	40 (10.6)	0.664
First systolic BP, mm Hg	176.88 ± 29.73	168.33 ±26.55	<0.001
Heart Rate	79.54±19.71	80.25 ±16.58	0.643
Temperature, °C	36.60 ± 0.33	36.57 ± 0.24	0.198
Initial hematoma volume, ml	38.56 (34.43-42.68)	17.23 (15.13-19.32)	<0.001
Hematoma expansion	28 (17.5)	15 (5.3)	<0.001
IVH	107 (43.1)	115 (30.3)	0.001
Location of ICH			0.733
Lobar	25 (10.1)	35 (9.3)	
Deep	223 (89.9)	343 (90.7)	
Midline shift, mm	5.14 (4.57-5.70)	2.19 (1.87-2.50)	<0.001
Admission INR	1.01 (0.99-1.03)	1.01 (0.99-1.03)	0.965
Admission PT, s	11.42 (11.21-11.63)	11.41 (11.19-11.62)	0.896
Admission APTT, s	25.89 (25.47-26.31)	25.99(25.62-26.36)	0.683
Admission Fibrinogen, g/l	2.85 (2.73-2.97)	2.96 (2.76-3.16)	0.417
Admission D-Dimer, > 0.55mg/l FEU	103(41.7)	117(31.5)	0.009
GCS score on admission	11.01±2.74	11.41±2.57	0.063
Surgery	103 (41.5)	77 (20.3)	<0.001

Abbreviations: APTT = activated partial thromboplastin time, BP = blood pressure; GCS = Glasgow Coma Scale; ICH = intracerebral hemorrhage; INR = international normalized ratio; IVH = intraventricular hemorrhage on presentation; mRS = modified Rankin Scale; NIHSS = NIH Stroke Scale; PT = prothrombin time. Values are n (%), mean ± SD, or median (interquartile range).

Univariate logistic regression analysis was performed for poor outcome and mortality after 90 days of discharge in patients with ICH, and the factors associated with the development of hematoma expansion within 24 hours of admission were explored (Table 2). The analysis results indicated a significantly higher rate of early hematoma expansion in patients with irregular shapes (OR OR 3.776, [95% CI: 1.950-7.312], *P* <.001) and had a poor prognosis at 90 days (OR 4.380 [95% CI: 3.003-6.389], P <.001) and an expressively higher mortality rate (OR 5.233 [95% CI: 2.991-9.155], P <.001). The results also indicated that patients with elevated plasm D-dimer levels had a higher risk of mortality (OR 3.518 [95%CI: 2.096-5.905], P<0.001) and poorer prognosis (OR 2.809 [95%CI: 1.928-4.092], P<0.001),this is in full accordance with our previous study[10]. Multivariate logistic regression analyses were performed for significative variables in the univariate logistic analysis. Multivariate regression analysis showed that age (OR 1.052,95%CI 1.031-1.074, P<0.001), First systolic Blood pressure (OR 1.008, 95%CI 1.001-1.017, P =0.049), irregular shapes (OR 3.190, 95%CI 2.007-5.070, P<0.001), initial hematoma volume (OR 1.024, 95%CI 1.009-1.039, P = 0.001) and intraventricular hemorrhage on presentation (OR 1.967, 95%CI 1.237-3.128, P = 0.004) independently predicted poor outcome of ICH. Meanwhile, the irregular shape had equally good performance in independently predicting mortality (OR 2.744, 95%CI 1.415-5.321, P = 0.003) and early hematoma expansion (OR 2.607 95%CI 1.711-3.974, P<0.001) in patients with spontaneous intracerebral hemorrhage(Table 3). Overall survival of all patients included in this study was investigated based on Kaplan Meier curve analysis (Figure 3), which showed that irregular shape at hematoma presentation was significantly associated with shorter survival of patients with intracerebral hemorrhage (P < 0.001). From the above analysis, we found that irregular shape, as one of the markers on non-contrast CT imaging, can be used as a reliable indicator for the development of the disease and prognosis of patients with ICH. In addition, in the data analysis, we also found that the appearance of irregular shapes tended to be accompanied by altered plasma D-dimer expression levels, so we speculated whether the generation of irregular shapes resulted from the increased plasma D-dimer expression. In the scatter plot, plasma D-dimer expression levels were significantly correlated with the appearance of irregular shapes (P = 0.039, Figure 4).

Table 2
Univariate Associations with Poor Functional Outcome (mRS 3-6) and Mortality and Hematoma expansion

Variable	90-day poor outcome			90-day mortality			HE		
	OR	95%-CI	P Value	OR	95%-CI	P Value	OR	95%-CI	P Value
Age, y	1.037	1.020-1.054	<0.001	1.032	1.009-1.055	0.006	0.984	0.957-1.012	0.261
Sex (male)	0.988	0.678-1.438	0.948	0.975	0.568-1.673	0.926	0.352	0.153-0.811	0.014
History of Hypertension	1.608	0.843-3.067	0.150	1.675	0.582-4.823	0.339	1.322	0.390-4.489	0.654
History of Diabetes	1.229	0.698-2.161	0.475	1.196	0.560-2.553	0.643	0.940	0.353-2.502	0.901
First systolic BP, mm Hg	1.016	1.009-1.022	<0.001	1.025	1.015-1.034	<0.001	1.009	0.998-1.021	0.100
Heart Rate	1.012	1.002-1.023	0.021	1.024	1.011-1.038	<0.001	0.991	0.971-1.011	0.373
Temperature	1.769	0.915-3.421	0.090	2.120	0.906-4.962	0.083	0.657	0.179-2.412	0.527
Initial hematoma volume, ml	1.043	1.033-1.054	<0.001	1.039	1.029-1.048	<0.001	1.025	1.012-1.038	<0.001
IVH	3.283	2.258-4.772	<0.001	3.576	2.125-6.018	<0.001	1.071	0.547-2.097	0.842
Location of ICH	1.355	0.757-2.425	0.307	0.577	0.283-1.178	0.131	0.800	0.297-2.154	0.659
Midline shift	1.258	1.189-1.332	<0.001	1.260	1.186-1.339	<0.001	1.140	1.046-1.243	0.003
Admission INR	1.365	0.567-3.290	0.488	1.646	0.640-4.234	0.301	1.109	0.271-4.531	0.886
Admission PT, s	1.036	0.950-1.131	0.423	1.059	0.966-1.160	0.221	0.999	0.858-1.162	0.985
Admission APTT, s	0.912	0.863-0.965	0.001	0.972	0.901-1.048	0.461	1.016	0.927-1.114	0.731
Admission D-Dimer, > 0.55mg/l FEU	2.809	1.928-4.092	<0.001	3.518	2.096-5.905	<0.001	1.032	0.533-1.998	0.926
Admission Fibrinogen, g/l	1.062	0.949-1.188	0.294	0.969	0.721-1.154	0.721	0.626	0.413-0.949	0.027
Irregular Sign	4.380	3.003-6.389	<0.001	5.233	2.991-9.155	<0.001	3.776	1.950-7.312	<0.001

Abbreviations: APTT = activated partial thromboplastin time, BP = blood pressure; CI = confidence interval; GCS = Glasgow Coma Scale; ICH = intracerebral hemorrhage; INR = international normalized ratio; IVH = intraventricular hemorrhage on presentation; mRS = modified Rankin Scale; NIHSS = NIH Stroke Scale; PT = prothrombin time. Values are n (%), mean ± SD, or median (interquartile range).

Variable	90-day poor outcome			90-day mortality			HE		
	OR	95%-CI	P Value	OR	95%-CI	P Value	OR	95%-CI	P Value
GCS score on admission	0.900	0.842-0.962	0.002	0.862	0.790-0.940	0.001	0.958	0.851-1.078	0.474
Surgery	3.054	2.060-4.527	<0.001	0.668	0396-1.129	0.132	7.674	3.941-14.942	<0.001

Abbreviations: APTT = activated partial thromboplastin time, BP = blood pressure; CI = confidence interval; GCS = Glasgow Coma Scale; ICH = intracerebral hemorrhage; INR = international normalized ratio; IVH = intraventricular hemorrhage on presentation; mRS = modified Rankin Scale; NIHSS = NIH Stroke Scale; PT = prothrombin time. Values are n (%), mean ± SD, or median (interquartile range).

Table 3
Multiple associations with Poor Functional Outcome (mRS 3–6) and Mortality and Hematoma expansion

Variable	90-day poor outcome			90-day mortality			HE		
	Adjusted OR	95%-CI	P Value	Adjusted OR	95%-CI	P Value	Adjusted OR	95%-CI	P Value
Age, y	1.052	1.031-1.074	<0.001	1.034	1.004-1.065	0.026	0.978	0.947-1.011	0.188
First systolic BP, mm Hg	1.009	1.000-1.017	0.045	1.014	1.002-1.025	0.019	1.008	0.996-1.020	0.211
Heart Rate	1.012	0.998-1.027	0.095	1.021	1.004-1.037	0.014	0.990	0.969-1.012	0.375
Irregular Sign	3.216	2.023-5.112	<0.001	2.689	1.376-5.255	0.004	2.527	1.211-5.275	0.014
Midline shift	1.070	0.982-1.165	0.121	1.041	0.944-1.147	0.421	1.007	0.878-1.155	0.923
Initial hematoma volume, ml	1.040	1.010-1.040	0.001	1.023	1.009-1.038	0.002	1.020	1.000-1.041	0.048
D-dimer, > 0.55mg/l FEU	1.367	0.830-2.252	0.219	1.548	0.767-3.124	0.223	1.209	0.540-2.706	0.644
Admission APTT, s	0.975	0.911-1.044	0.467	1.098	1.007-1.199	0.035	1.048	0.946-1.160	0.370
Admission Fibrinogen, g/l	1.056	0.939-1.188	0.363	0.791	0.563-1.110	0.175	0.612	0.391-0.957	0.031
GCS score on admission	0.935	0.862-1.014	0.103	0.869	0.781-0.967	0.010	0.989	0.871-1.122	0.860
IVH	2.002	1.257-3.189	0.003	1.874	0.961-3.653	0.065	0.806	0.372-1.744	0.583

Abbreviations: BP = blood pressure; CI = confidence interval; GCS = Glasgow Coma Scale; ICH = intracerebral hemorrhage; IVH = intraventricular hemorrhage on presentation; mRS = modified Rankin Scale. Values are n (%), mean ± SD, or median (interquartile range)

Discussion

Our study demonstrated that early hematoma enlargement in patients with intracerebral hemorrhage was significantly associated with poor outcomes and mortality in the short and medium-term after discharge from the hospital. Irregular shape, as a marker of NCCT, can not only well predict the risk of early hematoma enlargement, but also serve as an independent predictor of patients' functional prognosis. The present study explored the factors related to the formation of the irregular shape, indicating for the first time that the elevated plasma D-dimer expression level on admission was significantly correlated with the appearance of the irregular shape of the hematoma, and was probably the cause of its formation.

As a serious disability of the nervous system disease, spontaneous intracerebral hemorrhage (ICH) is attracting more and more researchers' attention on how to predict the occurrence of its adverse outcomes quickly and accurately, and then help clinicians to carry out graded management of patients. Hematoma growth is an independent predictor of poor outcomes and mortality after intracerebral hemorrhage[4], and about 1/3 of patients will have sustained bleeding after ICH[13]. In recently performed clinical experiments, significant progress has been made in predicting hematoma expansion. For example, in patients with intracerebral hemorrhage, serum calcium and magnesium levels at the time of hospital admission were associated with hematoma expansion independently and inversely[14,15];Patients with hyperglycemia will mediate the development of hematoma expansion through the inhibition of platelet aggregation by plasma kallikrein [16]. In the aspect of imaging, the computed tomography angiography (CTA) spot sign is a well-established imaging marker that can independently predict hematoma expansion in patients with ICH [7]. However, due to the complex operation of CTA, it is not routinely performed in the emergency setting, and the patient's condition cannot be judged in time. In cases where CTA was not available, researchers have gradually explored the predictive value of NCCT markers, including blend sign, irregular shape, island sign, for intracerebral hemorrhage expansion, and the results showed equally good predictive performance[9,17]. Qi et al., in a retrospective analysis of 252 patients with intracerebral hemorrhage, showed that the island sign was an independent predictor of hematoma enlargement and poor outcomes in patients with ICH [18]. In the study conducted by Zhang et al,1111 patients with spontaneous intracerebral hemorrhage(ICH)were recruited, and it was found that blend sign could help doctors to grade the management of patients with intracerebral hemorrhage in admission[19]. In a previous study, Moratti et al established a scoring system to predict instability of the hematoma based on three indicators: presence or absence of the mixed sign, time to the appearance of the mixed sign, and reduction in the density of the hematoma at presentation[20]. But these studies did not directly use the irregular shape of hematoma to evaluate the prognosis of patients and did not explore the cause of NCCT imaging hallmarks.

The reason for the formation of this imaging hallmark of irregular shape was not investigated intensively in numerous previous studies. The cause of the irregular shape is not clear. Thrombin activation and coagulation disorders are the main influencing factors of hematoma expansion[21,22]. The massive release of thrombin, which induces inflammatory reactions in the perivascular tissues and then damages the blood-brain barrier(BBB), may lead to early hematoma expansion[23,24]. However, the association between plasma D-dimer and early hematoma enlargement is not clear. Plasma D-dimer is a fibrin degradation product released from the plasmin degradation of fibrin monomers[25], and its expression reflects the level of activation of the systemic coagulation response. Acute brain injury caused by hematoma formation is closely related to coagulation activation, whereas an increase in D-dimer, the end product of coagulation, reflects the activation level of systemic coagulation response[26]. Plasma D-dimer has been shown to have a good performance in the prediction of poor outcome and mortality in patients with spontaneous ICH [10,27,28]. In the retrospective analysis, we demonstrated the predictive efficacy of irregular shapes for hematoma expansion in intracerebral hemorrhage and can be used as an independent predictor to predict the functional outcome of patients. In addition, this study also pioneered the independent inclusion of plasma D-dimer in the prediction of irregularity signs and showed a significant statistical difference. However, in this study, there was no significant statistical association between the level of plasma D-dimer on admission and hematoma expansion, which might be related to the sample size and systematic error. We also analyzed the predictive value of plasma D-dimer in the functional outcome and mortality of patients in this sample, and the results showed that plasma D-dimer was significantly correlated with the prognosis of patients. In our present, the irregular shape is a strong predictor of the outcome situation judgment in intracerebral hemorrhage patients. In survival analysis, patients with irregular shapes had a significantly shorter overall survival (OS) than patients without irregular shapes.

Our study also has certain limitations. First of all, the formation mechanism of irregular shape is not precise, and no study has shown whether D-dimer plays an essential role in hematoma expansion, and the specific mechanism of action has not been explored. Second, all the patients included in this study were admitted to our center's emergency department, and the sample size was small. Patients were generally more severe at the time of admission, which may produce biases regarding patient selection, data collection, and analysis. Third, some patients were admitted to the hospital after a long period of referral, and the disease will develop further during this period of referral, which has a particular influence on the results of various examinations. Fourth, other non-contrast CT markers also have excellent performance in predicting hematoma expansion and poor outcomes. Different markers should be included in predictive studies to enhance functional outcomes' prediction efficiency in patients with ICH

Conclusion

CT irregular shape has an excellent performance in predicting functional outcomes in patients with spontaneous intracerebral hemorrhage. As an imaging marker of NCCT, the irregular shape can help doctors identify patients with rapid disease progression, poor prognosis, and high mortality, then give a more precise therapy option during treatment. Moreover, this is the first study to confirm D-dimer's statistical significance in predicting irregular shapes and has excellent potential to further explore D-dimer's pathophysiological mechanism in hematoma enlargement. In order to improve prediction accuracy and sensitivity, plasma D-dimer level increases can be combined with other cerebral hemorrhage-related factors in the subsequent studies.

Abbreviations

NCCT

Non-contrast computed tomography

ICH

Intracerebral hemorrhage

CTA

computed tomography angiography

HE

hematoma expansion

mRS

modified Rankin Scale

GCSs

Glasgow Coma Scale score

OR

Odds Ratio

CI

confidence interval

Declarations

Data availability statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Code availability (software application or custom code) Not applicable.

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Consent to participate The need for informed consent was waived due to the retrospective nature of the study.

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Ethical approval The study protocol was approved by the Institutional Review Board of The First Affiliated Hospital of Harbin Medical University. Simultaneously, all methods were carried out in accordance with the relevant regulations and guidelines of Harbin Medical University. And has therefore been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments. The need for informed consent was waived by the Institutional Review Board of The First Affiliated Hospital of Harbin Medical University due to the retrospective nature of the study.

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Figures

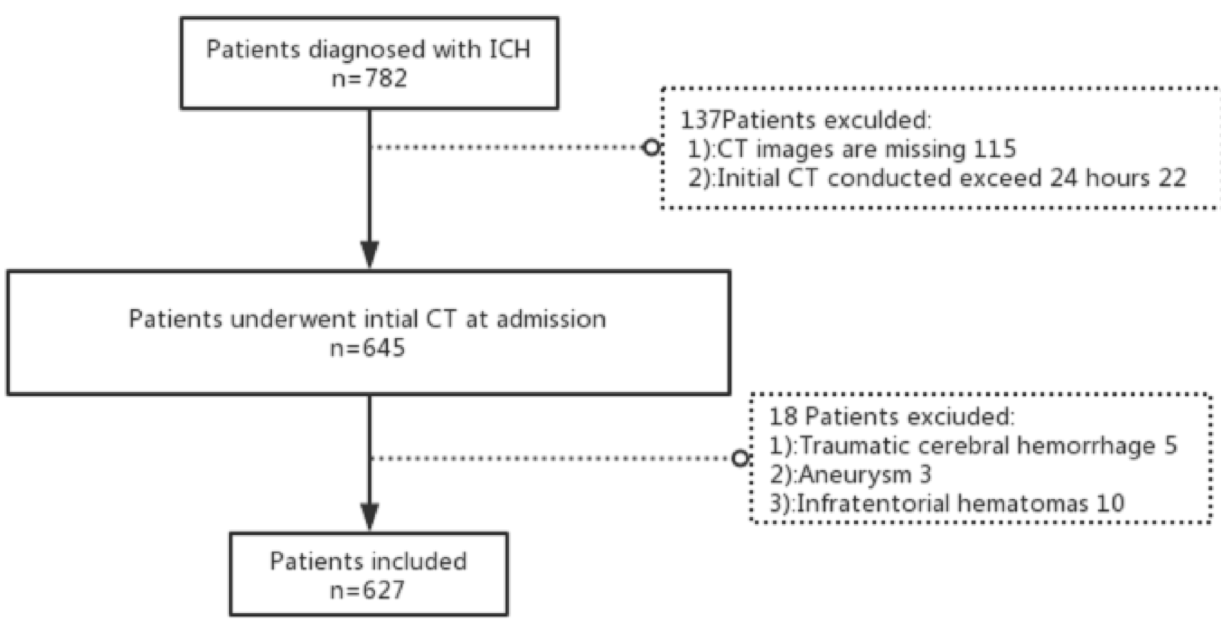

Figure 1

Flowchart of patient enrollment

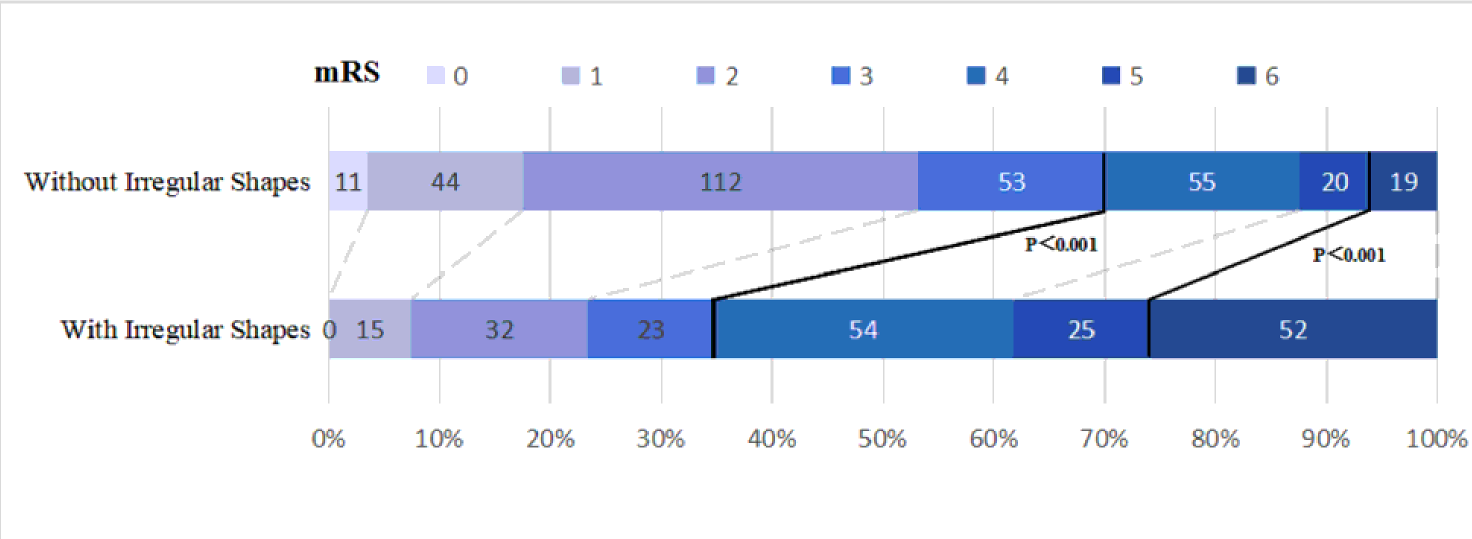

Figure 2

Distribution of modified Rankin Scale (mRS) according to the presence or absence of irregular shape. The bold line separates favorable (mRS, 0–3) and poor outcome (mRS, 4–6), or survival and death

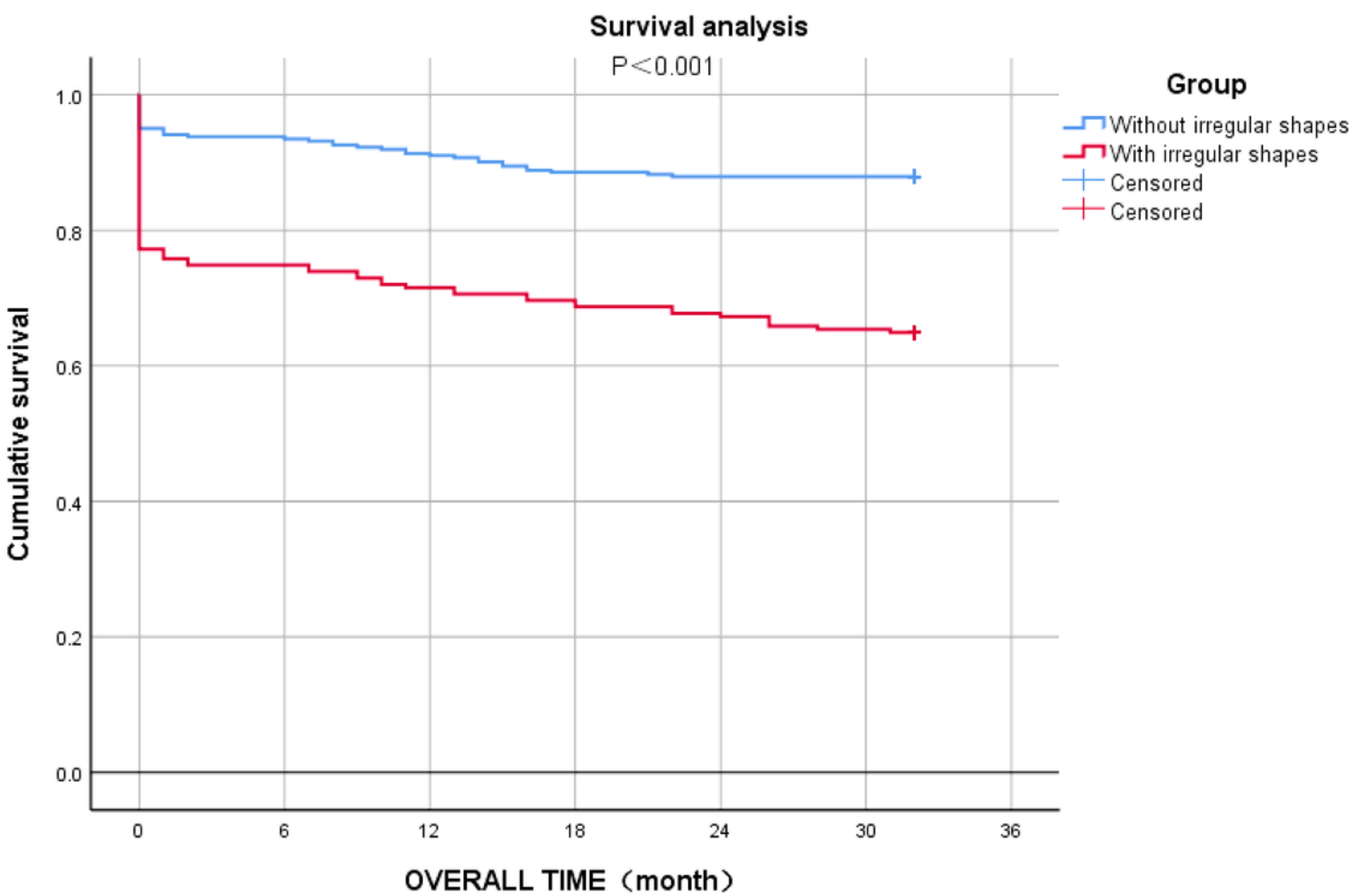

Figure 3

Kaplan Meier Curve Analysis showed that the overall survival of patients with spontaneous intracerebral hemorrhage with irregular shape in intracranial hematoma was worse than that with stable hematom

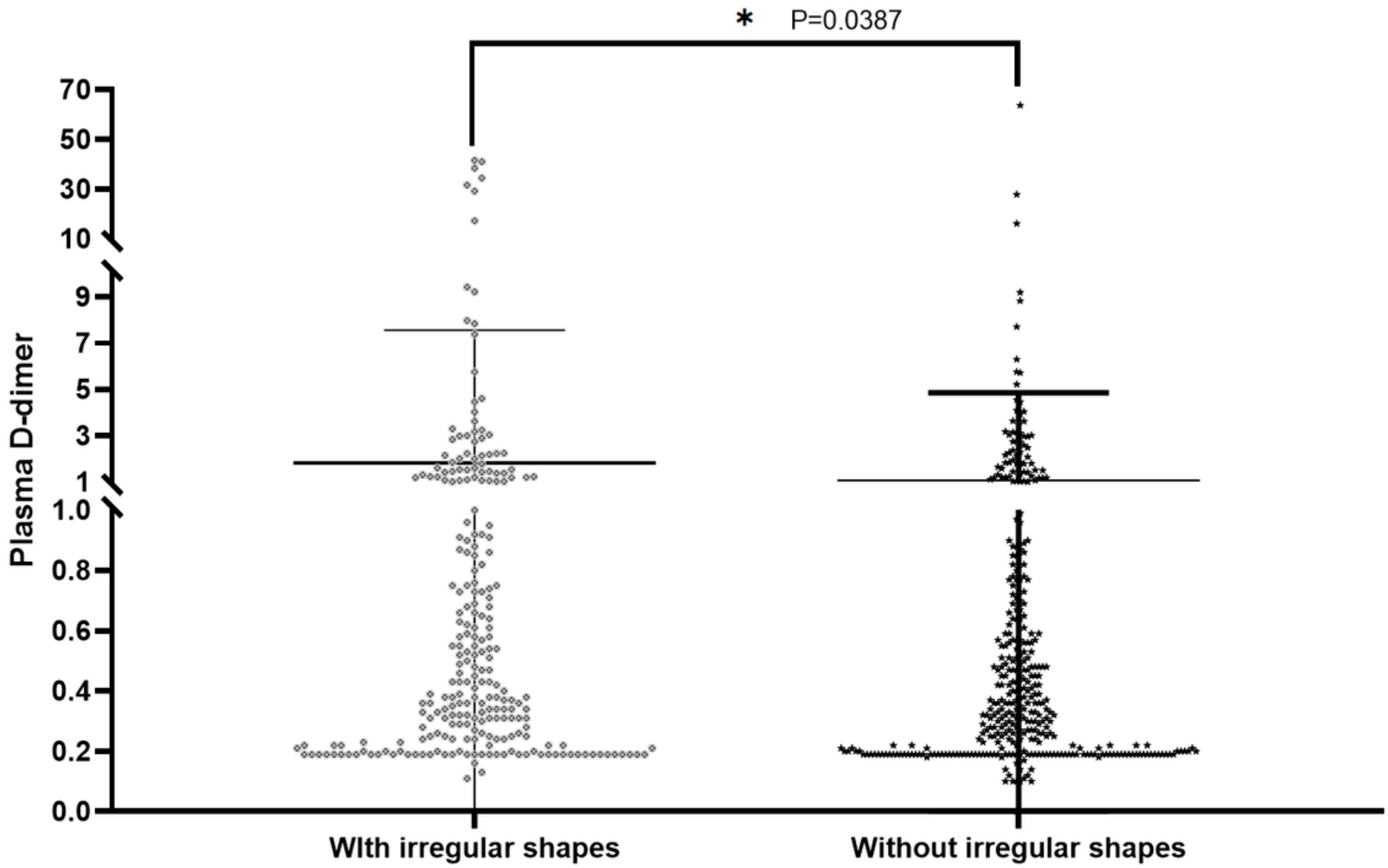

Figure 4

Scatter plot showing that the relationship between the irregular shape and plasma D-dimer expression level. The appearance of irregular shape in patients is often accompanied by an increase in plasma D-dimer expression on admission

Supplementary Files

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