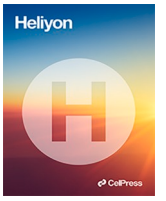
Heliyon 10 (2024) e34644

Contents lists available at ScienceDirect

Heliyon

journal homepage: www.cell.com/heliyon



Research article

Relationship between coagulopathy score and ICU mortality: Analysis of the MIMIC-IV database

Zhijie Xie [a,*], Suijun Zhu [b], Jun Wang [a], Min Zhang [c], Xuan Lv [a], Yijun Ma [a], Hua Shan [a], Yinjun Zhong [b]

[a] *Master of Medicine, The First People's Hospital of Linping District, Department of Neurosurgery, China*
[b] *Bachelor of Medicine, The First People's Hospital of Linping District, Department of Neurosurgery, China*
[c] *Bachelor of Nursing, The First People's Hospital of Linping District, Department of Neurosurgery, China*

ARTICLE INFO

Keywords:
Coagulopathy score
ICU mortality
SAPSII
MIMIC-IV database

ABSTRACT

Objective: Coagulopathy score has been applied as a new prognostic indicator for sepsis, heart failure and acute respiratory failure. However, its ability to forecast intensive care unit (ICU) mortality in patients with an acute cerebral hemorrhage (ICH) has not been assessed. The purpose of this study was to clarify the relationship between ICU mortality and early coagulation problem score.

Methods: Data from the Medical Information Mart for Intensive Care (MIMIC-IV) (v2.0) database were used in this retrospective cohort analysis. The association between the coagulation disorder score and ICU mortality was examined using multivariate logistic regression. Furthermore, the impact of additional variables on the results was investigated by a subgroup analysis.

Results: 3174 patients (57.3 % male) were enrolled in total. The ICU mortality reached 18.2 %. After adjusting for potential confounders, the ICU mortality of patients rose with the increase of coagulation disorder score. The ROC curve revealed the predictive accuracy of coagulation dysfunction score to mortality in patients with ICU. The coagulation disorder score had a lower AUC value (0.601, $P < 0.001$) than the SAPSII(AUCs of 0.745[95 % CI, 0.730–0.761]) and the combined indicators(AUCs of 0.752[95 % CI, 0.737–0.767]), but larger than single indicators platelet, INR and APTT. In the subgroup analysis, most subgroups showed no significant interaction, but only age showed significant interaction in the adjusted model.

Conclusion: The coagulopathy score and ICU mortality were found to be strongly positively correlated in this study, and its ability to predict ICU mortality was better than that of a single measure (platelet, INR, or APTT), but worse than that of the SAPSII score, GCS system.

1. Introduction

Acute cerebral hemorrhage(ICH) is a severe type of stroke worldwide. Although it accounts for only 10–30 % of strokes, it has an extremely high death and disability rate [1]. The neuronal damage involved in the process of brain injury caused by intracerebral

* Corresponding author. The First People's Hospital of Linping District; Address: No. 369, Yingbin Road, Nanyuan Street, Linping District, Hangzhou City, Zhejiang Province, China.

E-mail addresses: 1046589573@qq.com (Z. Xie), 1061996170@qq.com (S. Zhu), wangjun266@126.com (J. Wang), 8714697@qq.com (M. Zhang), abc_237385512@163.com (X. Lv), 49982196@qq.com (Y. Ma), 1571768575@qq.com (H. Shan), zxy283061767@163.com (Y. Zhong).

https://doi.org/10.1016/j.heliyon.2024.e34644
Received 15 April 2024; Received in revised form 16 June 2024; Accepted 12 July 2024
Available online 14 July 2024

Abbreviations

MIMIC-IV	Medical Information Mart for Intensive Care
ICU	intensive care unit
ICH	acute cerebral hemorrhage
GOS	Glasgow Outcome Score
GCS	Glasgow Coma Scale
BBB	blood-brain barrier
BMI	body mass index
ROC	receiver operating characteristic
AUC	area under the curve
PLT	platelet count
WBC	white blood cell count
HGB	hemoglobin
NEUT	neutrophil count
Lym	lymphocyte count
OR	odds ratio
CI	confidence interval
SIC	sepsis induced coagulation function
SQL	Structured Query Language
BNU	blood urea nitrogen
SBP	systolic blood pressure
DBP	diastolic blood pressure
MBP	mean blood pressure
SpO2	saturation of peripheral oxygen
INR	international normalized ratio
PT	prothrombin time
APTT	activated partial thromboplastin time
COPD	chronic obstructive pulmonary disease
SOFA	sequential organ failure assessment score
SAPS II	simplifed acute physiology score II
RR	respiratory rate
HR	heart rate

hemorrhage includes primary damage caused by the space occupying effect and secondary harm brought on by blood degradation products [2–4]. In addition, as a regulator of pathological brain inflammation, thrombin dysfunction can not only induce the destruction of the blood-brain barrier(BBB) and the degeneration of neural cells by accelerating oxidative stress and inflammatory response, but also lead to further expansion of hematoma [5,6]. Systemic coagulation dysfunction usually occurs within a few minutes after brain injury, indicating that it is induced by brain-derived substances, which can be quickly released into the whole body due to the mechanical destruction of the BBB, and increase the permeability of the BBB outside of the damaged region through secondary ischemia and inflammatory injury, resulting in uncontrolled passage of macromolecules through endothelial cells [7–11]. These pathophysiological mechanisms often lead to adverse outcomes of cerebral hemorrhage.

A recent retrospective study reported that the scoring system used to evaluate early coagulation disorders, consisting of PLT,APTT, INR parameters, was found to be a valuable factor for hospital mortality [12]. Therefore, new biomarkers are still required to predict the development and severity of coagulopathy caused by brain injury in a timely, accurate and reliable manner in order to develop preventive measures and targeted therapies. We speculate that the coagulopathy score may serve as an effective biomarker for prognosis in patients with ICH. Our research aimed to describe the relationship between the coagulopathy score and the outcomes of individuals with ICH. We also sought to evaluate the coagulopathy score's capacity to forecast ICU death in patients with ICH in comparison to other markers.

2. Methods

2.1. Population

Who were diagnosed as intracranial hemorrhage or cerebral hemorrhage according to ICD-9/ICD10 criteria were included. At the same time, the following patients were excluded: (1) patients under 18 years old at the time of first admission; (2) 1685 patients were not admitted to ICU; (3) only the first admission data were extracted from patients with intracranial hemorrhage or cerebral hemorrhage admitted to ICU for several times; (4) 180 patients with missing clinical data such as platelet, INR and APTT within 24H of ICU were excluded, (5) 892 patients with ICU hospitalization time $<$ 24 h were excluded. Finally, this study comprised 3174 patients (see

Fig. 1).

2.2. Data extraction

All data were selected from the MIMIC-IV database, a large publicly available critical care database that includes inpatient information from 2008 to 2019 at Beth Israel Deacon Medical Center, which was approved by the Massachusetts Institute of Technology (Cambridge, MA) and Beth Israel Deaconess Medical Center (Boston, MA). NavitePremium(version 16.1.7) software and Structured Query Language (SQL) was used to collecte data for this investigation. The following information were collected:Demographic characteristics, vital signs, diagnosis, comorbidities including lung disease, heart failure, liver and kidney disease, laboratory

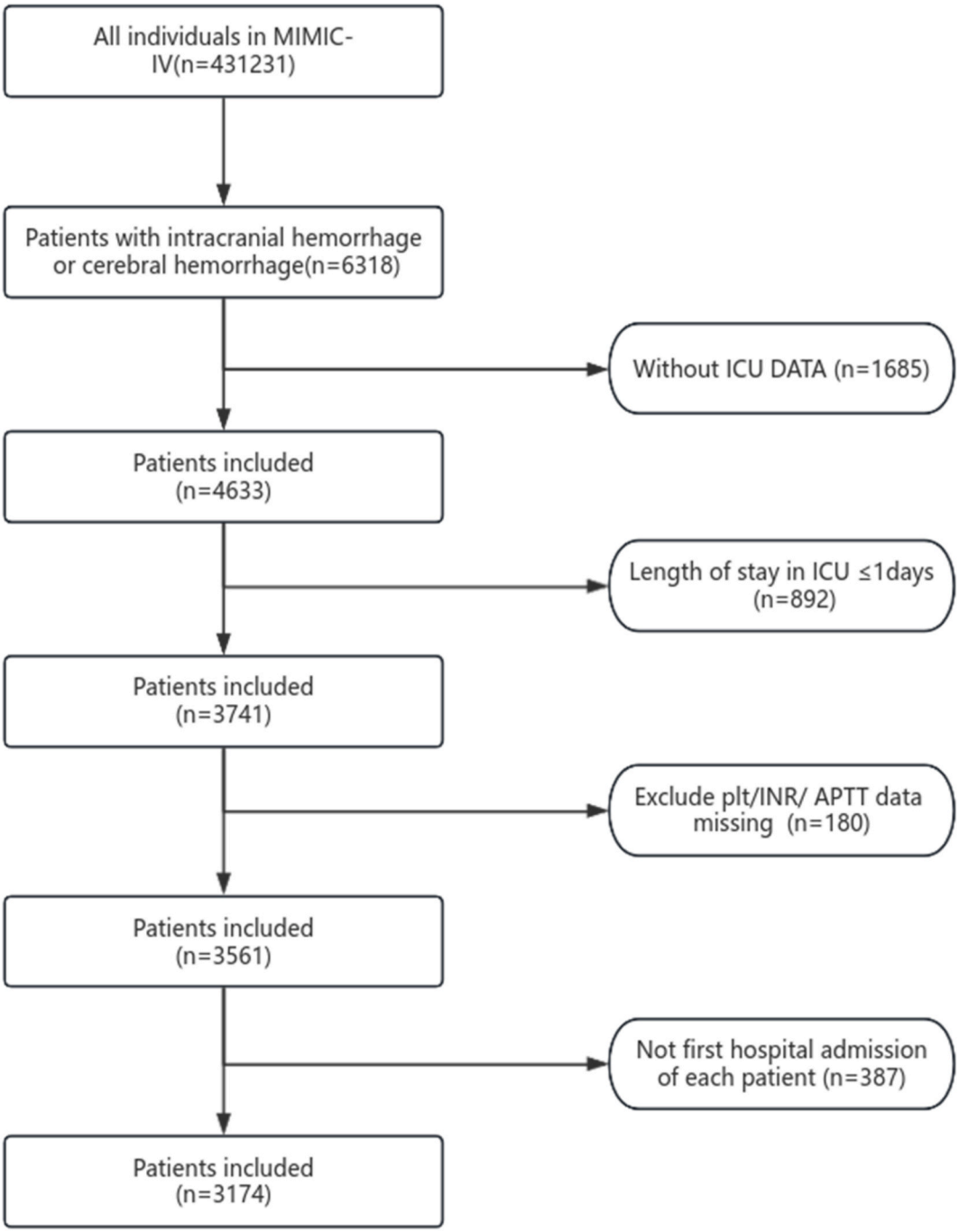


Fig. 1. The criteria of inclusion and exclusion.

indicators, treatment, SAPSII, etc. Our agency's Institutional Review Board (IRB) approval is exempt since this study involves an analysis of anonymized publicly accessible third-party databases and has been approved by the local IRB. The actual identity data in the database of the patient is hidden. Therefore, there is no need to obtain the patient's informed consent.

2.3. Definition of the coagulopathy score, Sepsis3.0,SOFA, SAPSII

According to relevant research reports [12–14], the coagulopathy score was based on sepsis induced coagulation function (SIC), which was determined by summing the scores from the following three sections: the APTT score (0 point: APTT <29 s, 1 point: 29 s ~ 34 s, 2 point: APTT >34 s), the INR score (0 point: INR <1.4, 1 point: 1.4 ~ 2.6, 2 point: INR >2.6) and the platelet score (0 point:plt >150*10^9/L, 1 point: 100 ~ 150*10^9/L, 2 point: plt <100*10^9/L). Sepsis3.0 is defined as life-threatening organ dysfunction caused by dysregulated body response to infection (Sepsis = infection + sequential organ failure score SOFA≥2) [15]. SOFA(Sequential Organ Failure Assessment) is a scoring system used to evaluate the degree of major organ function damage in patients in intensive care unit (ICU). SAPSII(simplifed acute physiology score II) is a scoring system used to assess the severity of a patient's condition and predict the

Table 1
Baseline characteristics of the patients.

Clinical variables	All(n = 3174)	Survivor(n = 2711)	Non-survivor(n = 463)	P
Age,years	68.2(54.8,80.4)	67.3(53.7,79.7)	73.4(61.5,82.9)	< 0.001
Gender, n(%)				0.002
Male	1831(57.3)	1594(58.8)	237(51.2)	
Female	1343(42.3)	1117(41.2)	226(48.8)	
Race, n (%)				< 0.001
White	1907(60.1)	1689(62.3)	218(47.1)	
Black	243(7.7)	212(7.8)	31(6.7)	
Latino	99(3.1)	83(3.1)	16(3.5)	
Asian	109(3.4)	89(3.3)	20(4.3)	
Others	816(25.7)	638(23.5)	178(38.4)	
Vital signs				
Systolic blood pressure (mmHg)	127.0(117.2136.3)	127.0(117.2136.2)	127.5(117.5136.5)	0.576
Diastolic blood pressure (mmHg)	66.1(58.9,73.7)	66.5(59.4,74.2)	62.9(55.8,70.2)	< 0.001
Mean blood pressure(mmHg)	82.8(75.8,90.4)	83.2(76.2,90.6)	81.0(74.3,88.6)	< 0.001
Heart rate (beats/min)	79.9(70.7,90.3)	79.3(70.2,89.4)	83.4(74.8,94.8)	< 0.001
Respiratory rate (beats/min)	18.2(16.4,20.3)	18.0(16.3,20.0)	19.4(17.2,22.0)	< 0.001
Temperature (∘C)	37.0(36.7,37.3)	37.0(36.7,37.2)	37.1(36.7,37.6)	< 0.001
Diagnoses and comorbidities, n (%)				
Congestive heart failure	383(12.1)	301(11.1)	82(17.7)	< 0.001
Myocardial infarct	260(8.2)	204(7.5)	56(12.1)	0.001
COPD	416(13.1)	361(13.3)	55(11.9)	0.397
Pneumonia	433(13.6)	372(13.7)	61(13.2)	0.751
Diabetes	687(21.6)	559(20.6)	128(27.6)	0.001
Chronic kidney disease	336(10.6)	265(9.8)	71(15.3)	< 0.001
Sepsis	1352(42.6)	1103(40.7)	249(53.8)	< 0.001
Laboratory parameters				
White blood cell (10^9/L)	10.7(8.2,14.0)	10.5(8.0,13.0)	12.7(9.6,16.0)	< 0.001
Hemoglobin (g/dL)	12.1(10.6,13.4)	12.1(10.7,13.4)	11.6(10.1,13.0)	< 0.001
Hematocrit	(32.0,39.9)	36.3(32.3,40.1)	35.3(30.7,39.3)	< 0.001
Glucose (mg/dL)	129(109,154)	126(107,148)	150(128,183)	< 0.001
Creatinine (mg/dL)	0.90(0.70,1.10)	0.85(0.70.1.10)	1.00(0.75,1.40)	< 0.001
Blood nitrogen urea (mg/dL)	16.0(12.0,22.0)	15.5(12.0,21.0)	19.0(14.0,28.5)	< 0.001
Sodium (mmol/L)	139.5(137.0,142.0)	139.5(137.0,142.0)	140.0(138.0,143.0)	< 0.001
Potassium (mmol/L)	4.05(3.75,4.35)	4.00(3.75,4.35)	4.05(3.75,4.40)	0.109
Platelet (109/L)	201(159,251)	216(173,271)	201(153,259)	< 0.001
INR	1.10(1.05,1.30)	1.10(1.10,1.30)	1.20(1.10,1.50)	< 0.001
APTT (sec)	27.9(25.5,31.2)	28.5(26.1,32.1)	29.9(26.1,35.1)	0.014
PT (sec)	12.5(11.6,14.0)	12.6(11.7,14.2)	13.5(12.3,16.6)	< 0.001
Treatment, n (%)				
Heparin	1631(51.4)	1515(55.9)	116(25.1)	< 0.001
Vasoactive agent	699(22.0)	474(17.5)	225(48.6)	< 0.001
Antibiotics	1698(53.5)	1421(52.4)	277(59.8)	0.003
Mechanical ventilation	1736(54.7)	1295(47.8)	441(95.2)	< 0.001
GCS	13(8,14)	13(9,14)	7(3,15)	< 0.001
SOFA	2(1,4)	2(1,4)	4(2,7)	< 0.001
SAPS II	33(25,41)	31(24,39)	41(35,51)	< 0.001

Data were mean ± SD or median (IQR) for skewed variables or numbers (in percentage)) for categorical variables. WBC white blood cells; BNU blood urea nitrogen; SBP systolic blood pressure; DBP diastolic blood pressure; MBP mean blood pressure; SpO2 saturation of peripheral oxygen; INR, international normalized ratio; PT, prothrombin time; APTT, activated partial thromboplastin time; COPD, chronic obstructive pulmonary disease; SOFA sequential organ failure assessment score; SAPS II simplifed acute physiology score II; RR, respiratory rate; HR, heart rate; GCS, Glasgow Coma Score.

risk of death.

2.4. Statistical analysis

The baseline characteristics are expressed as the mean ± standard deviation (SD) of normal distribution quantitative data. Skewed data is expressed as median [quartile range (IQR)], and classified data is a number (percentage). The normality of the variables was assessed using the Kolmogorov-Smirnov test. Independent-sample T-test, chi-square test and Mann-Whitney *U* test were used to compare the characteristics of patients and ICU survival status. The risk factors of ICU death were analyzed by Logistic regression. The results were displayed as a 95 % confidence interval (CI) and odds ratio (OR). The related confounding variables were adjusted and multi-factor Logistic analysis was carried out. Model II was adjusted for Age, Gender, Race, GCS, SAPSII, White blood cell, Hemoglobin, Hematocrit, Blood nitrogen urea, Creatinine, Sodium, Glucose, Diabetes, Mean blood pressure, Heart rate, Respiratory rate, temperature, Congestive heart failure, Sepsis3.0, Mechanical ventilation, Myocardial infarct, Antibiotics, Vasoactive agent, Chronic kidney disease. The ROC curves were drawn, and the AUCs of SAPSII and coagulopathy score were compared. Logistic regression was used for the subgroup analysis to investigate the relationship between the coagulopathy score and ICU mortality; Models I and II were represented on a forest map, and the P for interaction was computed, which vividly shows the results of subclass analysis. $P < 0.05$ was considered to be statistically significant. The software SPSS, GraphPad Prism, and MedCalc were used for all data analyses and computations.

3. Results

3.1. Patient characteristics

This retrospective analysis comprised 3174 participants in total according to the final survival status of ICU. The baseline characteristics are presented in Table 1. There were 1343 women and 1831 males among the patients, with a high median age(68.2years). And 72.3 % of the patients in the study were white. Compared to the survival group, the patients in non-survival were older and had higher heart rate, body temperature and respiration, and more complications, such as Myocardial infarct, congestive heart failure, diabetes and kidney disease, sepsis, and received more treatment, including vasoactive agent such as milrinone and dopamine, mechanical ventilation, antibiotics and so on. The survivor group had lower white blood cells, creatinine, neutrophils, blood nitrogen urea, INR, APTT and PT, and higher hemoglobin, hematocrit and platelet count. And patients were less likely to receive heparin anticoagulation therapy. Patients in the survivor group scored higher on the GCS and lower on the SOFA and SAPSII.

3.2. Association between coagulopathy score and coagulopathy endpoints

Overall, the ICU mortality rate was 18.2 %. Higher Plt, INR, and APTT values were strongly correlated with ICU mortality in the survival group. Moreover, the results demonstrated that the ICU mortality rose as their coagulopathy score increased, with a maximum death rate of 46.2 observed for those with a coagulopathy score of 6 (see Table 2).

Table 3 shows an adjusted analysis of ICU mortality in patients using a binary logistic model. Model I(unadjusted), and the model II (adjusted). When used as a classification variable, the risk of final ICU mortality rose with the increase of the coagulopathy score in

Table 2
Association of the coagulopathy score with ICU mortality.

Characteristics	All (n = 3174)	Survivor (n = 2711)	Non-survivor(n = 463)	*P*-value
Platelet score				< 0.001
0 (≥150*10^9/L)	2675	2322(86.8)	353(13.2)	
1 (100–150*10^9/L)	371	297(80.1)	74(19.9)	
2 (<100*10^9/L)	128	92(71.9)	36(28.1)	
INR score				< 0.001
0 (≤1.4)	2635	2307(87.6)	328(13.0)	
1 (1.4–2.6)	428	321(75.0)	107(25.0)	
2 (>2.6)	111	83(74.8)	28(25.2)	
APTT score				< 0.001
0 (≤29 s)	1686	1492(88.5)	194(11.5)	
1 (29–34 s)	870	730(83.9)	140(16.1)	
2 (>34 s)	618	489(79.1)	129(20.9)	
Total score				< 0.001
Coagulopathy score = 0	1420	1267(89.2)	153(10.8)	
Coagulopathy score = 1	839	726(86.5)	113(13.5)	
Coagulopathy score = 2	468	385(82.3)	83(17.7)	
Coagulopathy score = 3	245	191(78.0)	54(22.0)	
Coagulopathy score = 4	150	110(73.3)	40(16.7)	
Coagulopathy score = 5	39	25(64.1)	14(35.9)	
Coagulopathy score = 6	13	7(53.8)	6(46.2)	

INR, international normalized ratio; APTT, activated partial thromboplastin time.

model I and model II. When the coagulopathy score = 6, the OR values of the two groups were 7.098(95%CI, 2.355–21.393) and 4.394 (1.130,17.084), respectively. When used as continuous variables, both groups of models showed a higher risk of ICU death, and the unadjusted and adjusted OR values were 1.339(95%CI, 1.249–1.435) and 1.252(1.140,1.375), respectively.

According to ROC curve, the predictive accuracy of coagulopathy score to ICU mortality of patients was displayed in Fig. 2, and the AUC value of coagulopathy score was 0.601(P < 0.001), which was less than SAPSII(AUCs of 0.745[95 % CI, 0.730–0.761]), GCS(AUCs of 0.678[95 % CI, 0.661–0.694]) and the combined indicators(AUCs of 0.752[95 % CI, 0.737–0.767]), but larger than that of the indicators of platelet, INR and APTT.

3.3. Subgroup analysis

Subgroup analysis was utilized to evaluate modelI(unadjusted) and II (adjusted). Adjustment factors included Age, Gender, race, GCS, SAPSII, White blood cell, Hemoglobin, Hematocrit, Blood nitrogen urea, Creatinine, Sodium, Glucose, Diabetes, Mean blood pressure, Heart rate, Respiratory rate, temperature, Congestive heart failure, Sepsis3.0, Mechanical ventilation, Myocardial infarct, Antibiotics, Vasoactive agent, Chronic kidney disease. Subgroup analysis were performed to test whether the relationship between coagulation score and ICU mortality was affected by baseline characteristics. Fig. 3 shows the risk ratio OR values and Pforinteraction of coagulation score and ICU mortality in each subgroup. The results showed that the OR values of all subgroups were more than 1, which meant that the mortality in ICU increased significantly with the increase of blood coagulation score. Overall, there was no significant interaction between most groups. In addition, we noticed that age showed a significant interaction in the model II (adjusted).(P for interaction = 0.007), which may affect the relationship between coagulation score and ICU mortality. Therefore, we re-analyzed the relationship between coagulation function score and ICU mortality in different age groups, as shown in Table 4. The results showed that coagulation scores in both groups of patients could increase ICU mortality.

4. Discussion

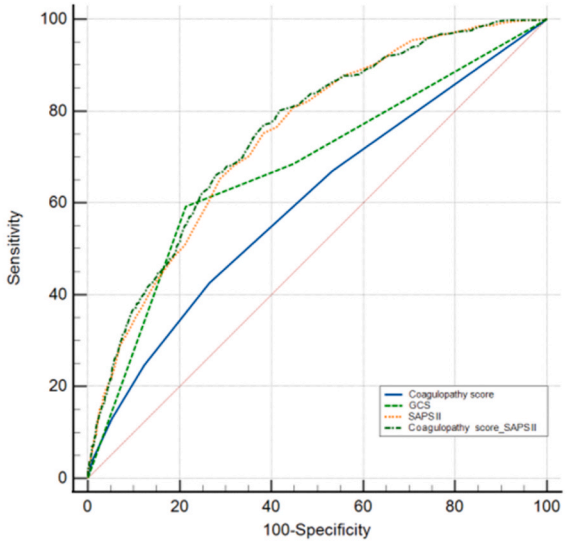
This retrospective study assessed the relationship between coagulation disorder and ICU mortality in patients with ICH. The results of this study indicated that a higher coagulopathy score had associations with an increased risk of ICU mortality in ICH patients. The predictive ability of coagulopathy score to ICU mortality in patients with ICH was better than that of single index platelet, INR and APTT, but inferior to SAPSII. Even after adjusting for mixed risk factors, coagulation disorder scores were still closely related to ICU mortality. In the subgroup analysis, we discovered that in most subgroups, ICU mortality in patients with ICH increased significantly with the increase of coagulopathy score. Therefore, for clinical doctors, the coagulopathy score may be a promising decision-making tool and may be an independent risk factor for critically severe patients with ICH.

As a new indicator in recent years, coagulopathy score was initially utilized to forecast the prognosis of patients with cardiopulmonary dysfunction [12]. With the deepening of scientific research, the clinical value of coagulation dysfunction has been gradually excavated. Li et al. found that coagulopathy score was associated with poor prognosis in critically ill CHF patients, include higher rates of adverse cardiac events, longer hospital stays in the intensive care unit, and shorter-term death [14,16]. Our results suggest that although the predictive power of ICH patients is inferior to that of SAPSII and GCS, the AUC of coagulation disorder score is larger than that of a single coagulation indicator, which has a certain predictive potential for ICU mortality in ICH patients.

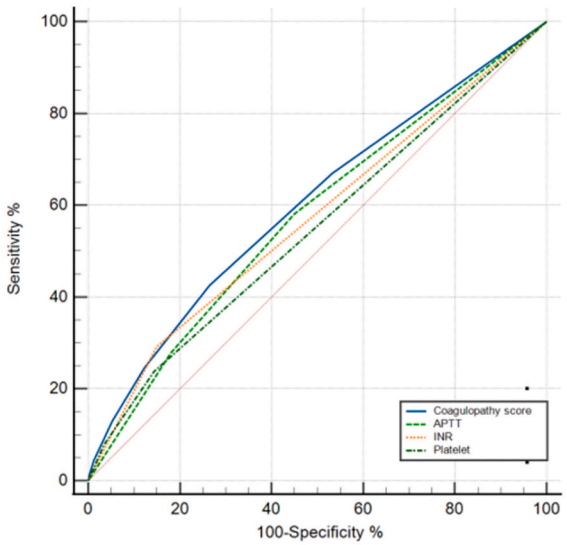
Compared with the complex SAPSII scoring system, this scoring system can quickly judge the patient's blood coagulation system only through the blood parameters obtained by routine admission, and the effect is also better than that of a single coagulation index. SAPSII is composed of up to 17 variables and takes the worst value within 24 h as the judgment index. Compared with ICH score, SAPSII has a partial timeliness, and comprehensive consideration of multiple systems such as vital signs, serum test indicators, GCS

Table 3
Association between the coagulopathy score and ICU mortality.

	OR	*P*-value
Model1		
Coagulopathy score = 0	Reference	
Coagulopathy score = 1	1.289(0.997,1.671)	0.055
Coagulopathy score = 2	1.785(1.335,2.387)	< 0.001
Coagulopathy score = 3	2.341(1.657,3.308)	< 0.001
Coagulopathy score = 4	3.011(2.021,4.487)	< 0.001
Coagulopathy score = 5	4.637(2.360,9.112)	< 0.001
Coagulopathy score = 6	7.098(2.355,21.393)	< 0.001
Continuous	1.339(1.249,1.435)	< 0.001
Model2		
Coagulopathy score = 0	Reference	
Coagulopathy score = 1	1.392(1.016,1.908)	0.040
Coagulopathy score = 2	1.546(1.074,2.227)	0.019
Coagulopathy score = 3	2.026(1.295,3.169)	0.002
Coagulopathy score = 4	2.212(1.309,3.738)	0.003
Coagulopathy score = 5	3.901(1.664,9.145)	0.002
Coagulopathy score = 6	4.394(1.130,17.084)	0.033
Continuous	1.252(1.140,1.375)	< 0.001



	AUC	95%CI	P
Coagulopathy score	0.601	0.584-0.619	<0.001
SAPSII	0.745	0.730-0.761	<0.001
GCS	0.678	0.661-0.694	<0.001



	AUC	95%CI	P
Coagulopathy score	0.601	0.584-0.619	<0.001
APTT	0.576	0.558-0.593	<0.001
INR	0.571	0.554-0.589	<0.001
Platelet	0.549	0.531-0.566	0.001

Fig. 2. (A) The ROC curves for the prediction of ICU mortality of coagulopathy score and SAPA II and combined indicator. (B) The ROC curves for the prediction of ICU mortality of coagulopathy score, platelet, INR, and APTT.

score, surgical selection, etc., so it has higher sensitivity and specificity. However, its scoring process is complicated, which is not conducive to rapid clinical evaluation. The GCS score has been widely used to assess the consciousness of patients with cerebral hemorrhage. Although it has the advantages of being fast and convenient, its score is highly subjective. Furthermore, in the intensive care unit, it is difficult to use GCS to accurately assess the consciousness of intubated and sedated patients. The coagulation function score is obtained by rapid serum index test. A large number of studies have confirmed the correlation between coagulation dysfunction and increased cerebral hemorrhage and poor prognosis [17–20]. In addition, an increasing number of patients are taking long-term oral anticoagulants and antiplatelet drugs for cardiovascular and cerebrovascular diseases. Such patients often suffer rapid deterioration of their condition due to coagulation dysfunction [21,22]. As we all know, the lethal triad includes hypothermia, acidosis, and coagulopathy. Therefore, clinicians cannot ignore the correction of coagulation disorders in patients with cerebral hemorrhage. This study also confirmed the correlation between coagulation function score and poor prognosis, aiming to comprehensively evaluate the coagulation function of ICH patients so that clinicians can take intervention measures as early as possible, such as fresh frozen plasma transfusion, reversal of anticoagulant drugs, Vitamin K, prothrombin complex, etc.

Notably, the subgroup analysis results are shown in Fig. 3, and Model II (adjusted) shows a significant interaction between age and coagulopathy score and ICU mortality. Older age is closely related to changes in coagulation status, as confirmed in the study by Ochi et al. [23–25] Therefore, age may affect the relationship between coagulation score and mortality. In addition, the risk of ICU death increased with the rise of coagulopathy score in both groups.

Furthermore, our study also found that the baseline white blood cell level and the incidence of sepsis were significantly higher in death group. Coagulation activation is almost a common event in the initial stage of sepsis and deteriorates rapidly with the progression of the disease. Once DIC occurs, the mortality rate of sepsis increases significantly because DIC is a systemic hypercoagulable reaction that hinders normal tissue circulation and leads to multiple organ failure [26]. The release of inflammatory mediators, endothelial injury and platelet disorders also promote the progression of thrombosis [27]. Hemostatic imbalance is one of its main manifestations. In sepsis, even if the fibrinolysis is hyperactive, it is still far from excessive hypercoagulable [28]. This may also be one of the reasons for the increase in ICU mortality in patients with ICH. Therefore, blood coagulation needs to be monitored frequently during sepsis. Many studies have shown that coagulation disorder in patients with ICH is closely related to vascular endothelial cell injury, tissue factor release, platelet dysfunction, Microvascular failure and other factors [29,30]. It is usually characterized by the over-activation and consumption of coagulation factors, the interaction between coagulopathy and inflammatory system, the formation of microthrombus, and then reduce the blood perfusion of brain tissue, and finally reduce the survival rate of patients [31–35].

Sepsis-related DIC has a high mortality rate, which is a dynamic process that starts with coagulation dysfunction and can develop into sepsis-induced coagulation dysfunction (SIC). Therefore, to provide an early and valuable prediction of coagulopathy, PLT, INR, and APTT were selected as the main coagulation indices for evaluating early coagulopathy with reference to the definition of SIC and coagulopathy. And the results of this study showed that the ability of coagulation score to predict ICU mortality is better than a single indicator (platelet, INR or APTT).

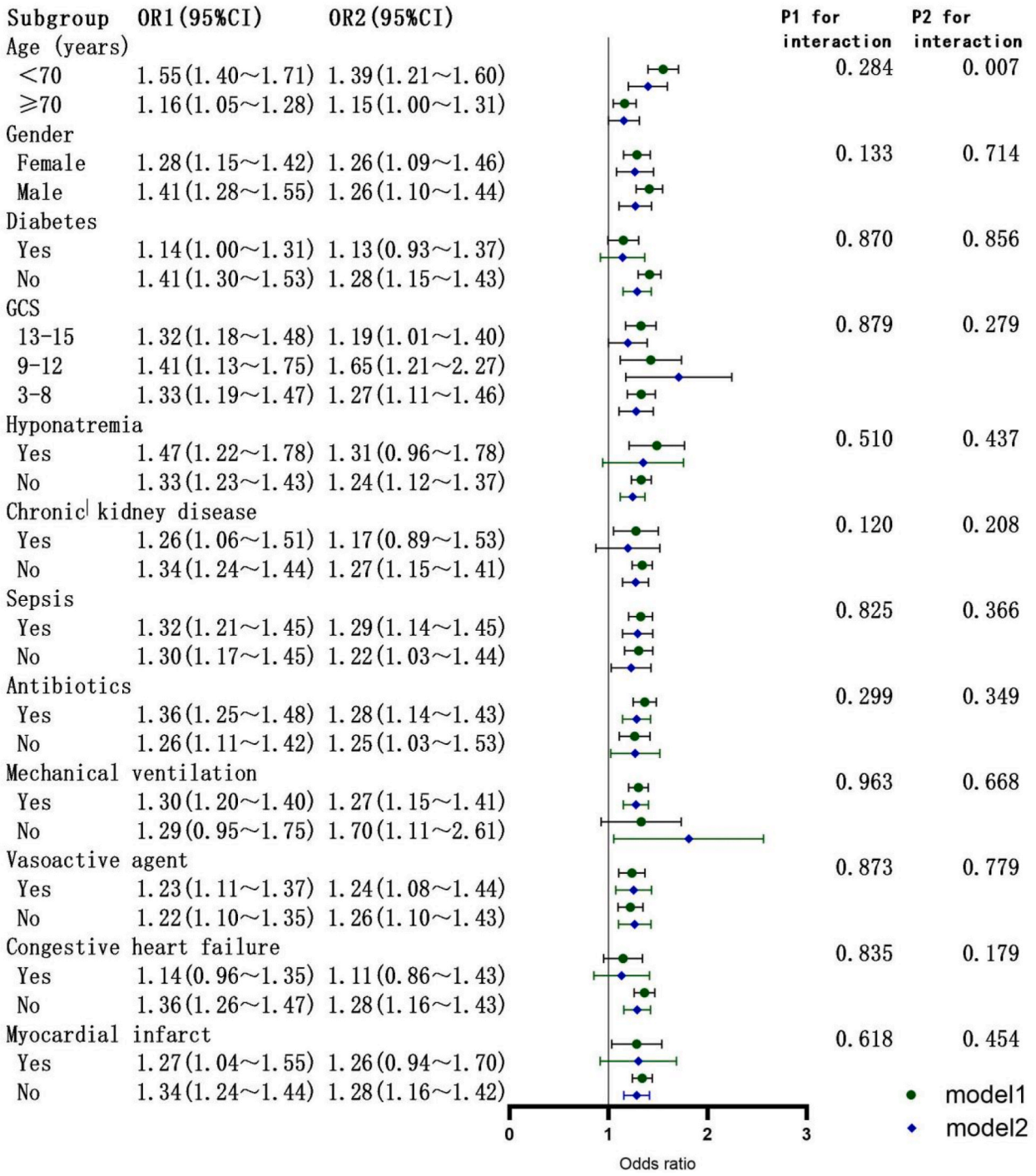


Fig. 3. Subgroup analysis of the association between coagulopathy score and ICU mortality.

The main advantage of this research is to confirm that the increased coagulopathy score is an independent risk factor for the higher death rate of severe patients with ICH in the United States. Coagulopathy score has convenience and potential clinical predictive value in the process of clinical decision-making. However, our study also had several limitations. In light of this retrospective investigation. There may be other potential residual confounders. Consequently, its necessary to conduct further high-quality prospective studies and dynamically monitor the changes of blood coagulation. This endeavor may improve the prompt identification of patients with severe ICH in a clinical setting by leveraging convenient biomarkers, thereby making it possible to use specialized treatment strategies meant to increase patient survival.

Table 4
The relationship between coagulation disorder score and ICU mortality in different age groups.

	Standard Error	OR	95%CI	*P*-value
Age < 70				
Coagulation score model1	0.051	1.55	1.40–1.71	< 0.001
Coagulation score model2	0.067	1.36	1.19–1.54	< 0.001
Age≥70				
Coagulation score model1	0.051	1.16	1.05–1.28	0.004
Coagulation score model2	0.067	1.22	1.07–1.39	0.044

5. Conclusion

In summary, we found that the coagulopathy score was significantly positively associated with ICU mortality, and its ability to predict ICU mortality was better than that of a single measure (platelet, INR, or APTT), but worse than that of the SAPSII score system and GCS. It is important for clinicians to conduct personalized management of severely ICH patients according to their early coagulation conditions.

Ethics declarations

Review and/or approval by an ethics committee was not needed for this study because the MIMIC database is a public, anonymized database that has been approved by the Institutional Review Boards of the Massachusetts Institute of Technology and Beth Israel Deaconess Medical Center and therefore did not require approval from our agency's ethics committee. The actual identity data in the database of the patient is hidden. Therefore, there is no need to obtain the patient's informed consent.

Data availability

Data will be made available on request.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

CRediT authorship contribution statement

Zhijie Xie: Writing – review & editing, Writing – original draft. **Suijun Zhu:** Writing – review & editing. **Jun Wang:** Investigation. **Min Zhang:** Investigation. **Xuan Lv:** Writing – review & editing. **Yijun Ma:** Investigation. **Hua Shan:** Investigation. **Yinjun Zhong:** Investigation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

We thank the Department of Neurosurgery of the first people's Hospital of Linping District for providing technical assistance.

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