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Derivation and validation of a novel risk score for safe discharge after acute upper gastrointestinal bleeding in elderly patients in China

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Keywords: Upper gastrointestinal bleeding (UGIB); elderly patients; Risk score; safe discharge

Abstract **Objectives:** Acute upper gastrointestinal bleeding (UGIB) is a common reason for emergency hospital admission, and distinguishing low-risk patients which are suitable for outpatient management, is a clinical and research priority. We aimed to develop a simple risk score to

identify patients with UGIB in elderly patients in which hospital admission is not required.

Design: This was a single-center retrospective study.

Setting: Patients from January 2015 to December 2020 for the derivation cohort and from January 2021 to June 2022 for the validation cohort in Zhongda Hospital Southeast University were enrolled in this study.

Participants: A total of 822 patients (derivation cohort; 606 and validation cohorts; 216) were included in this study. Patients aged ⩾ 65 years with coffee-ground vomiting, melena, or/and hematemesis were included in the analysis. Patients who had been admitted but had UGIB or who were transferred between hospitals were excluded.

Methods: Baseline demographic characteristics and clinical parameters were recorded at the first visit. Multivariable logistic regression modelling was performed to identify predictors of safe discharge.

Results: 304/606 (50.2%) and 132/216 (61.1%) patients were not safely discharged in the derivation and validation cohorts, respectively. A clinical risk score of 5 variables was entered into UGIB risk stratification: Charlson Comorbidity (CCM) > 2 , SBP < 100 mmHg, Hb < 10 g/dL, BUN≥6.5mmol/L, albumin <30 g/L. The optimal cut-off value was ⩾ 1, and the sensitivity was 97.37 %, and the specificity was 19.21%, respectively, for predicting not safely discharged (NSD). The area under the curve (AUC) was 0.806.

Conclusions: A novel clinical risk score was developed with good discriminative performance to identify elderly patients with UGIB who were suitable for safe outpatient management. This not only avoids patients to an unneeded, hospital admission with its associated risks, but also reduces the financial burden on the patient, hospital system, and society.

Strengths and limitations of this study

This was the first study on the construction of a risk score for upper gastrointestinal bleeding in elderly patients.

This risk score utilized simple and easily available parameters that can be implemented in almost every hospital.

This study applied other group of data to verify the validity of the risk score.

This was a single-center retrospective study.

The patients who were directly discharged from the ED were not included in the analysis, It might lead to a selection bias.

Background

Upper gastrointestinal bleeding (UGIB), defined as bleeding within the gastrointestinal tract proximal to the ligament of Treitz, is a common medical emergency. In recent years, the reported incidence of UGIB were 67/100 000 adults per year in the USA and 134/ 100 000 in the United Kingdom [1,2], with mortality rates ranging from 2 to 8.6%[1,2]. UGIB was a major cause of morbidity and mortality in elderly patients, with more than $ 1 billion in direct medical costs annually in the United States

[1,3]. The incidence increased with increasing age, meaning elderly patients had a higher incidence of UGIB (197/100,000 in those aged 65–75 and 425/100,000 in those over 75 years)[4]. By 2030, approximately 0.3 billion people will be over 65 years old in China. It is necessary to emphasize the necessity of evidence-based clinical methods. The Asia-Pacific working group consensus suggested that UGIB can be managed using "early risk stratification" with influential prognostic factors [5]. Several risk scoring systems such as the Rockall score (RS), Glasgow Blatchford score (GBS), and AIMS65 had been developed to predict outcomes including mortality, need for hospital based intervention, and need for blood transfusion [6-10]. However, the latest UGIB guidelines for elderly patients were released in 2013 by the American Society for Gastrointestinal Endoscopy (ASGE) [11].

A systematic review including16 studies showed that the Glasgow Blatchford score (GBS) was more sensitive and specific than the Full Rockall score (RS) and AIMS65 in predicting hospital intervention and 30-day mortality requirements[12]. Implementation of GBS prognostic assessment was associated with a 15% to 20% reduction in hospitalizations due to UGIB[13]. It was therefore recommended to identify patients who are at very low risk and managed as outpatients. However, to date, there have been few studies on these scoring systems for upper gastrointestinal bleeding in elderly patients. CY Wang et al. reported that the RS is

accurate in predicting rebleeding and mortality outcomes in order adults with AUGIB. Still, the area under the ROC curve was lower than 0.8 [14]. Kalkan Ç et al. also documented the RS is more beneficial for predicting mortality and rebleeding than the GBS and AIMS65 [15]. The sample of both studies above was small (341 and 335).

The international consensus Group guidelines recommended using risk scores to assess UGIB patients; however, their precise role in practice geriatric patients remains uncertain, so the guidelines did not fully address specific issues important to the management of UGIB in the geriatric population. Therefore, the guidelines did not completely solve the particular problems important for UGIB management in elderly patients [5,16].

When dealing with UGIB patients, the challenge faced by emergency department (ED) physicians was to determine the cause and prognosis and decide whether to be hospitalized for investigation or intervention. However, for elderly patients, there was no internationally recognized effective scoring system to stratify the disease.

We aimed to derive and validate a simple risk score system that can be used to distinguish between elderly patients who can be safely managed as outpatients and those who will benefit from inpatient care. In addition, we also compared the discriminative ability of the new score system with the previously published risk scoring systems to evaluate its effectiveness.

Methods

Design: This was a single-center retrospective study of Zhongda Hospital Affiliated to Southeast University.

Setting: We conducted two groups of retrospective study: one was from January 2015 to December 2020 for the derivation cohort, and the other was from January 2021 to June 2022 for the validation cohort.

Operational definition

UGIB: Bleeding that developed in the gastrointestinal tract proximal to the ligament of Treitz, presenting with coffee-ground vomiting, melena, or/and hematemesis [5,16].

Safe discharge: No following symptoms after presentation [17]: rebleeding, blood transfusion; therapeutic intervention to control bleeding; all causes of death.

Rebleeding: The presentation of melena or/and fresh hematemesis associated with the development of shock (systolic blood pressure < 100 mmHg or/and pulse > 100 beats/minute or hemoglobin decreased by more than 2 g/dL after successful initial treatment) [5].

Blood transfusion: The indication for blood transfusion was that the average patient's hemoglobin level decreased to < 7 g/dL or the hemoglobin level of patients at high risk of heart disease decreased to 8 g / dL [18].

Therapeutic intervention: Endoscopic, radiological, or surgical

hemostasis.

Endoscopic management: The indication for endoscopic treatment was Forrest Ia-IIb ulcer bleeding [19].

elderly patients: Aged⩾65 years old [20].

Patient and Public Involvement

No patient was involved.

Data collection

Patients with coffee-ground vomiting, melena, or/and hematemesis were included in the analysis. Inclusion criteria: ① Patients presented in the emergency department with black stool and/or hematemesis; ② Aged ⩾65 years old; ③ Fecal occult blood was positive. Exclusion criteria: ① Patients with upper gastrointestinal bleeding during hospitalization; ② Patients with incomplete information; (3) Patients transferred from other hospitals; ④ Patients with lower gastrointestinal bleeding manifested by blood stool. Finally, 606 and 216 patients were enrolled in the derivation and validation cohorts, respectively.

Through the electronic medical record system， demographic data (sex and age), clinical presentation, comorbidities, medications history (including antiplatelet drugs, oral anticoagulants, and/or nonsteroidal anti-inflammatory drugs), hemodynamic parameters, hemoglobin, biochemical

parameters (coagulation panel, albumin, creatinine, and urea nitrogen) were recorded. The need for endoscopic treatment, blood transfusion, radiologic intervention, or surgery was also analyzed.

Data analysis

Eleven candidate predictors were selected from both biological and clinical perspectives: age, sex, Charlson comorbidities, systolic blood pressure (SBP), heart rate, use of oral anticoagulants or oral antiplatelet, hemoglobin (g/dL), international normalized ratio (INR), albumin (g/L), serum urea nitrogen (mmol/L), and creatinine (μmol/L). Charlson comorbidity index [21] was used to define comorbidities.

We use SPSS version 22.0 and MedCalc version 19 for statistical calculations. Count data were expressed as the number of cases (*n, %*), and the $\chi 2$ test was used for comparison. Measurement data with normal distribution were expressed as mean ± standard deviation ($x \pm s$), and independent sample t-test or univariate analysis was used to compare between groups. The measurement data with non-normal distribution were expressed as median (quartile) [M (Q1, Q3)], and the Mann-Whitney U test was used for comparison. Regression models were constructed. Statistically significant variables in univariate analysis were included in multivariate regression analysis. Regression models were constructed using backward elimination. The variables in the final regression model

were classified according to the thresholds most closely related to safe discharge, resulting in easy-to-calculate scores. Results were expressed as ORs with 95% CIs. The Hosmer--Lemeshow test was used to evaluate the goodness of fit.

Based on the established logistic regression model, a new risk score was generated. ROC curves with 95% CIs were used for predicting the identified ability of outcomes. Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were also calculated [22]. The Delong test was used to compare different AUCs in the scoring system.

Results

A total of 822 patients (derivation cohort; 606 and validation cohorts; 216) were included in this study. The incidence of not safely discharged (NSD) was 50.2% (304/606) and 61.1% (132/216) in the derivation and validation cohorts, respectively.

Most patients (404/606, 66.7%, and 158/216, 73.1%) were men (Table 1). The median age was 74 (68,79) and 77.5 (71, 84). Almost one-fifth of patients had a Charlson Comorbidity (CCM) [21] score of greater than 2, which had higher morbidity in the NSD cohort (27.6% vs. 9.3%, P <0.01) (Table 2).

Table 1 Demographics and Mean clinical parameters of the study population in the two cohort

Variable	Derivation cohort	Validation cohort	P
	Total（n =606）	Total（n =216）	
Male,n (%)	404 (66.7）	158 (73.1)	0.079
Median age, year (IQR)	74 (68,79)	77.5 (71, 84)	**<0.01**
Findings at endoscopy			
peptic ulcer	302 (49.8)	91(42.1)	
Variceal bleeding	44 (7.3)	20 (9.3)	
Upper GI cancer	75 (12.3)	27(12.5)	
Erosions	86 (14.2)	26 (12.0)	
others	99 (16.4)	52 (24.1)	
Comorbidities,n (%)			
Any malignancy	110 (18.2)	30 (13.9)	0.180
Hypertention	346 (57.1)	124 (57.4)	0.937
Diabetes	145 (23.9)	48 (22.2)	0.855
CHD	130 (21.5)	54 (25)	0.158
Heart failure	16 (2.6）	2 (0.1)	0.139
Stroke	174 (28.7)	66 (30.1)	0.609
Renal failure	72 (11.9)	22 (10.2)	0.641
Liver disease	65 (10.7)	16 (7.4)	0.160
CCM >2	112 (18.5)	62 (28.7)	0.518
≥2 Comorbidities	395 (65.0)	144 (66.7)	0.693
Antiplatelet/ anticoagulant use	220 (36.3)	70 (32.1)	0.304
HR (SD)	82 (15)	82 (16)	0.752
SBP, mmHg (SD)	122 (20)	126 (23)	0.261
Hb, g/dL (SD)	91 (29)	84 (24)	0.147
Coagulopathy, INR ≥ 1.5	19 (3.1)	14 (6.5)	0.032
BUN,mmol/L (SD)	12.5 (8.7)	11.4 (6.5)	0.221
Creatinine,μmol/L (SD)	107 (86)	109 (97)	0.820
Albumin,g/L(SD)	33.7 (6.0)	35.6 (6.0)	0.820

CCM Charlson comorbidity, HR heart rate, SBP systolic blood pressure, Hb hemoglobin,INR international normalized ratio.

Table 2 Demographics and Mean clinical parameters of the study population in the derivation cohort

Variable	Total （n =606）	Not safely discharged, NSD （n=304）	safely discharged,SD （n=302）	P
Male,n(%)	404 (66.7）	196 (64.5)	208 (68.9)	0.075
Median age, year(IQR)	74 (68,79)	73（67-78）	75（69-79）	0.417
CCM SCORE >2	112 (18.5)	84 (27.6）	28 (9.3)	<0.01

Antiplatelet/anticoagulant use	220 (36.3)	102 (33.6)	118 (39.1)	0.318
HR ≥ 100	76 (12.5)	52 (17.2)	24 (7.9)	0.019
SBP < 100 mmHg	60 (10.0)	50 (16.4)	10 (3.3）	<0.01
Hb < 10 g/dL	390 (64.4)	260 (85.5)	130 (43.0)	<0.01
INR ≥ 1.5	19 (3.1)	17 (5.6)	2 (0.7）	<0.01
BUN ≥ 6.5 mmol/L	436 (71.9)	244 (80.3)	192 (63.6)	<0.01
Creatinine >100μmol/L	182 (30.0)	114(37.5)	68 (22.5)	0.954
Albumin <30 g/L	160 (26.4)	128 (42.1)	32 (10.6)	<0.01

CCM Charlson comorbidity, HR heart rate, SBP systolic blood pressure, Hb hemoglobin, INR international normalized ratio.

Patients in the NSD cohort were more likely to have tachycardia (HR ≥ 100, 17.2% vs 7.9%, P =0.019), hypotension (SBP < 100 mmHg, 16.4% vs 3.3%, P < 0.01) and their hemoglobin (Hb) and albumin level were lower (Hb < 10 g/dL, 85.5% vs 43.0%, P < 0.01 and albumin<30g/L, 42.1% vs 10.6%, P < 0.01), Urea nitrogen was higher (BUN≥ 6.5mmol/L, 80.3% vs 63.6%, P < 0.01). Coagulopathy was more frequent (INR≥1.5 5.6% vs 0.7%, P < 0.01).

Table 3 Severity outcome and therapeutic interventions of the study population in the derivation cohort

Variable	N(%)
Rebleeding	124 (20.5%)
Required blood transfusion	268 (44.2%)
therapeutic intervention (total)	108(17.8%)
Endoscopic treatment	80 (13.2)
Radiologic intervention	6 (1.0)
surgery	15 (2.8)
Endoscopy+radiology	4 (0.7)
Endoscopy+surgery	2 (0.3)
radiology+surgery	1 (0.2)
mortality	52 (8.6%)
ICU admission	50 (8.4%)

Table 3 outlines the clinical outcomes and therapeutic interventions

in the study population. More than a third of patients required blood transfusion (n = 268/606, 44.2%), and 124 (20.5%) patients suffer rebleeding. Overall, 108 patients (17.8%) underwent therapeutic intervention during admission. 50 patients (8.4%) required admission to the Intensive Care Unit (ICU). The mortality rate was 8.6% (52 patients).

Logistic regression

Based on calculations from the derivative cohort, significant predictors ($P < 0.05$) included: CCM > 2, HR ≥ 100, SBP < 100 mmHg, BUN≥6.5mmol/L, Hb < 10 g/dL, albumin <30g/L, Coagulopathy (INR≥ 1.5), and Creatinine >100μmol/L (Table 4).

Table 4 Univariable analysis for predictive factors of NSD in the derivation cohort

Variable	Univariate analysis	
	Odds ratio (95% CI)	P value
Age ≥65	1.51 (0.96-2.38)	0.075
Gender, male	0.82 (0.51-1.32)	0.417
CCM > 2	3.74 (1.94-7.20)	<0.001
Antiplatelet/anticoagulant use	0.79 (0.49-1.26）	0.318
HR ≥ 100	2.39 (1.16-4.94)	0.019
SBP< 100mmHg	5.75 (2.14-15.46)	<0.001
BUN ≥6.5mmol/L	2.33 (1.39-3.92)	<0.001
Hb< 10g/dL	7.82 (4.49-13.62)	<0.001
Albumin<30g/L	6.14 (3.33-11.30)	<0.001
INR ≥1.5	9.38 (2.13-41.36)	0.003
Creatinine >100μmol/L	1.93(1.17-3.19)	0.010

CCM Charlson comorbidity, HR heart rate, SBP systolic blood pressure, Hb hemoglobin,INR international normalized ratio.

Table 5 Multivariable logistic regression analysis for predictive factors of NSD in the derivation cohort

Variable	*β*	*Ward*	*OR*	*P*	95%*CI*
CCM > 2	0.455	5.616	1.576	0.018	1.082-2.295
SBP< 100mmHg	1.479	6.735	4.726	0.009	0.955-23.377
BUN ≥6.5mmol/L	0.636	3.969	1.890	0.046	1.010-3.534
Hb< 10g/dL	1.616	27.883	5.033	<0.001	2.763-9.169
Albumin<30g/L	1.065	9.339	2.901	0.002	1.465-5.743
	-2.193	38.259	-	<0.001	-

These variables were included in a multivariate logistic regression model— CCM > 2, SBP < 100 mmHg, BUN≥6.5mmol/L, Hb < 10 g/dL, and albumin <30g/L were statistically significant in predicting NSD (Table 5). The final logistic regression function was: log (odds of NSD)= 0.636 (BUN) + 1.616 (Hb) +1.065 (albumin) + 0.455 (CCM) +1.479 (SBP)-2.193. These 5 variables were used to develop a prognostic scoring model (Table 6).

Table 6 Prognostic factors for NSD for inclusion in our clinical risk score

Clinical predictive risk factor	Score
S: SBP< 100mmHg	3
A: Albumin<30g/L	2
H: Hb< 10g/dL	3
C: CCM > 2	1
N: BUN ≥6.5mmol/L	1

The optimum cut-off was ≥ 1 point(s), the sensitivity was 97.37%, the specificity 19.21%, the positive predictive value (PPV) was 54.8%, and the negative predictive value (NPV) was 87.9% in predicting NSD (Table 7). When the thresholds used for defining NSD were <1， the false negative rate was 2.0%.

Table 7 Clinical risk score for NSD with sensitivity, specificity, PPV and NPV

Score	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
≥1	97.37	19.21	54.8	87.9
≥2	84.21	62.91	69.6	79.8
≥3	51.32	90.73	84.8	64.9
≥4	16.45	97.35	86.2	53.6
≥5	2.63	100	100	50.5

The AUCs of our risk score, GBS, MAP(ASH), and AIMS65 were shown in Table 8 and Figure 1. For both cohorts, our risk score had the largest AUCs of 0.806 and 0.807, which were significantly higher than that of GBS, MAP(ASH), and AIMS65 ($p<0.05$).

Table 8 Values of the three scoring systems in the prediction of NSD

Derivation cohort	AUC (95%*CI*)	P				Validation cohort	P			
		CSHAN	GBS	AIMS65	MAP(ASH)	AUC(95%*CI*)	CSHAN	GBS	AIMS65	MAP(ASH)
CSHAN	0.806 (0.756-0.849)	*	0.019	0.025	0.031	0.807 (0.722-0.892)	*	0.046	0.053	0.034
GBS	0.762 (0.708-0.815)	0.019	*	0.034	0.035	0.788 (0.698-0.878)	0.046	*	0.060	0.049
AIMS65	0.711 (0.661-0.781)	0.025	0.034	*	0.030	0.689 (0.587-0.792)	0.053	0.060	*	0.062
MAP(ASH)	0.669 (0.612-0.721)	0.031	0.035	0.030	*	0.767 (0.720-0.877)	0.034	0.034	0.062	*

Discussion

As reported by the several studies, around 29 million people take daily aspirin without the physician's recommendation in the United States [23]. Antithrombotic therapy might increase the risk of UGIB from ulcers or

erosions [24]. Our cohort's mean age was over 70, and almost two-thirds of the patients had 2 or more comorbidities. The higher use of antiplatelet/ anticoagulant medications (36.3% and 32.1%) in this cohort might be related to the higher incidence rate in elderly patients. Management of antiplatelet/ anticoagulant medications should be the first step treatment in UGIB.

The mortality rate for non-variceal UGIB decreased from 4.5% in 1989 to 2.1% in 2009, and the incidence decreased from 108 to 78 cases per 100,000 population in 1994 and 2009. However, the economic burden of immediate hospitalization for UGIB increased from $3.3 billion to $7.6 billion[25]. A similar trend was observed for variceal UGIB [25]. Using a prognostic score system and early discharge with low risk could reduce the associated costs without increasing harm [16]. The primary aim of the initial assessment was to determine whether the admission was required or whether endoscopic intervention was required urgently or even managed in the outpatient setting [26].

Several risk-scoring systems have been used for UGIB patients, but most of them were used to predict mortality and intervention [6-10]. Few predictive models were used for patients being safely discharged or not. Furthermore, heterogeneous available resources and insufficient clinicians' experience worldwide led to the lack of standardized international standards for UGIB management in elderly patients.

Previous studies had attempted to risk-stratify patients with UGIB using intervention, rebleeding, and mortality as endpoints. The full Rockall score (RS), which was composed of age, shock, comorbidity and the diagnosis and presence of stigmata of recent hemorrhage at endoscopy, was derived in 1996 from 4185 cases of AUGIB in the United Kingdom (UK) and designed to predict mortality [6]. As the full RS relied on endoscopic findings, its use in initial ED assessment was limited. Blatchford O et al. Cited hemoglobin, blood urea, pulse, systolic blood pressure, a presentation with syncope or melaena, and evidence of hepatic disease or cardiac failure as predictive factors to predict the need for intervention[27]. Stanley AJ et al. reported that the GBS has high accuracy at predicting the need for hospital-based intervention with the area under the receiver operating characteristic curve (AUROC) of 0.86. A GBS of ≤1 was the optimum threshold to predict survival without intervention (sensitivity 98.6%, specificity 34.6%) [28]. The 2019 guidelines from the International Consensus Group (ICG) [16] suggested using a GBS of 1 or less to identify patients who are at very low risk for rebleeding or mortality and thus may not require hospitalization or inpatient endoscopy for patients with acute UGIB. Whereas GBS was considered too complex for practical use in ED. Saltzman JR et al. constructed a prediction model named AIMS65 comprising albumin, international normalized ratio, altered mental status, blood pressure, and age to predict death; they reported an

AUROC of 0.77 for the prediction of death [7]. AIMS65 provided a more age-appropriate score and might be a beneficial supplement to a risk stratification model for distinguishing high-risk patients. Recent studies found that AIMS65 may provide more accurate in-hospital mortality prediction and the necessity of admission to the ICU. Robertson M et al. identified AIMS65 > 3 as a high-risk group, with a mortality rate of 12.1%, while the mortality rate of the low-risk group was only 3.6% [29]. While the ICG suggested against using the AIMS65 prognostic score to identify patients at very low risk for rebleeding or mortality and thus might not require hospitalization or inpatient endoscopy [16]. Furthermore, there were few studies on those score systems on geriatric patients to validate whether they are suitable for elderly patients. MAP (ASH) score was established in 2020 [10]. MAP (ASH) has good predictive accuracy for intervention and mortality [10]. However, it was a new risk score, and further research is needed to confirm its predictive effect in elderly patients.

In our previous research [30], we found MAP, GBS, AIMS65, and pRS only performed fairly in predicting mortality with the AUROCS of 0.781, 0.755, 0.754, and 0.692, indicating they might not be very suitable for elderly patients.

We derived a simple risk score system with five variables that can be used to distinguish between patients who can be safely managed as outpatients and those who will benefit from inpatient care. The system was

designed to ensure the absence of rebleeding, blood transfusion, and hospital-based intervention to control bleeding and death to capture adverse events. Previous studies had reported that unstable vital signs, anemia, hypoproteinemia, azotemia, and existing comorbidities were predictive of adverse outcomes [27,31]. In our research, we identified CCM > 2, SBP < 100 mmHg, Hb < 10 g/dL, BUN≥6.5mmol/L, and albumin <30g/L as risk factors. We included the use of antiplatelet/ anticoagulant medications, INR≥ 1.5, age, sex, heart rate, and creatinine in the model but these were not statistical predictors and therefore were not included in the score. Previous research suggested that the use of antiplatelet/ anticoagulant medications and coagulopathy might be related to the increased severity of bleeding [7,24,32]. Several studies also indicated that advancing age and creatinine were risk factors for predicting adverse outcomes [27,31]. This is inconsistent with our results, probably because the target population is different.

In the current cohort, we found that our CSHAN score accurately predicted NSD in UGIB, and the AUROC was statistically higher than that of GBS, AIMS65, and MAP, suggesting that CSHAN was more suitable for predicting NSD in geriatric patients.

A patient with a score of fewer than 1 point at presentation has an 87.9% chance of safe discharge from ED. We recommend using this threshold for patients with no other hospitalization indications. Overall, the risk factors

in the existing literature were partially consistent with our findings [27,31]. In our research cohort, almost 30-50% of patients presenting with UGIB were safely discharged. A large micro cost study in UGIB indicated the average cost per patient at £2,458 in the UK. 60% of the cost was attributed to the cost of the inpatient bed [33]. A 30-50% reduction in hospital admissions would equate to a saving of £10.4 million per year. However, patients will need outpatient resources.

This study has several limitations. This was a single-center retrospective study, patients discharged directly from ED were not included, which might have led to selection bias. However, the patients who were suitable for discharge directly from ED were likely at "safely discharged" with UGIB, which might not have a significant impact on our risk score. An integral part of the safe discharge outcome depends on the absence of blood transfusion, which might be inaccurate because many transfusions might be considered unneeded when layered according to life signs and anemia. [34,35]. It might lead to an underestimation of the ratio of patients who can be discharged safely

Our study was based on clinically accessible risk stratification for elderly patients with UGIB. To the best of our knowledge, this is the first analysis of this nature in the world. The ROC curve showed higher predictive accuracy and sensitivity for patients with a threshold ≥1 point, which could direct the possible discharge of low-risk patients. The model

was easy to implement and could be used to assist clinical decision-making and early identification of patients with severe UGIB requiring aggressive blood cell transfusion, entering monitoring units, and requiring intervention.

In conclusion, our risk score used five easily quantifiable basic predictors and was easy to calculate. Compared with the previously available two risk scores, the forecasting of safe discharge was the best. The score could be routinely included in the acute medical triage route to determine UGIB patients who can be safely discharged without requiring hospital admission. Further research is required to be externally verified in the results presented in this study.

Abbreviations

UGIB: Upper gastrointestinal bleeding; GBS: Glasgow Blatchford score; RS: the full Rockall score; AUCs: area under the receiver operator characteristics curves;

Acknowledgments

Not applicable.

Authors' contributions

YJ: study concept and design, data collection, data analysis, and writing of the draft manuscript; LQ: measurement of the samples and study co-design; MY: data collection; KX: data collection; XL: data collection and review of the manuscript. All authors have read and approved the manuscript.

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Availability of data and materials

The datasets generated and/or analyzed during the current study are not publicly available due [Belong to Zhongda Hospital] but are available from the corresponding author upon reasonable request.

Ethics approval and consent to participate

This study was approved by the Ethics Committee for Clinical Research of Zhongda Hospital, affiliated to Southeast University. This study used the medical records obtained from the past clinical diagnosis and treatment. Upon application, the Ethics committee agreed that informed consent was not required. All methods were carried out in accordance with relevant guidelines and regulations. The ethics reference number: 2021ZDSYLL333-P01.

Consent for publication

Not available.

Competing interests

All the authors declare that they have no conflicts of interest.

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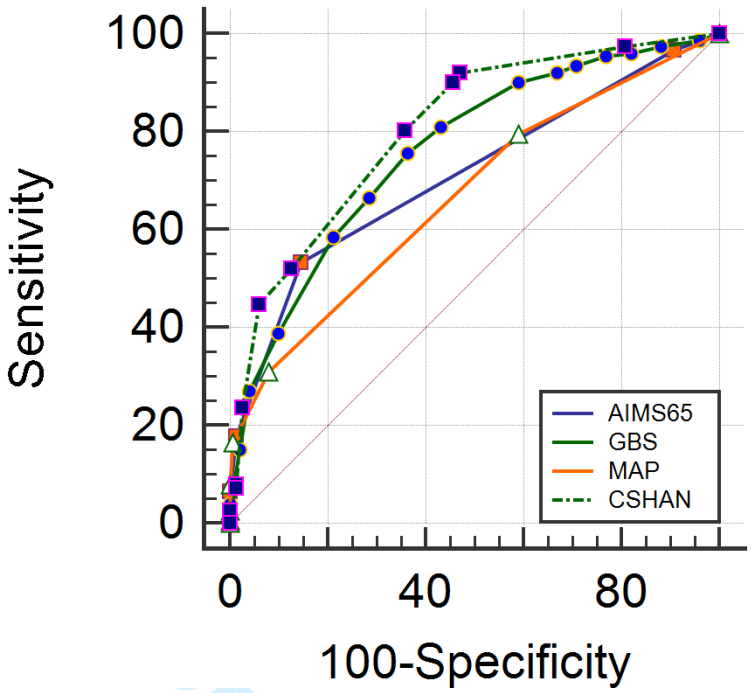
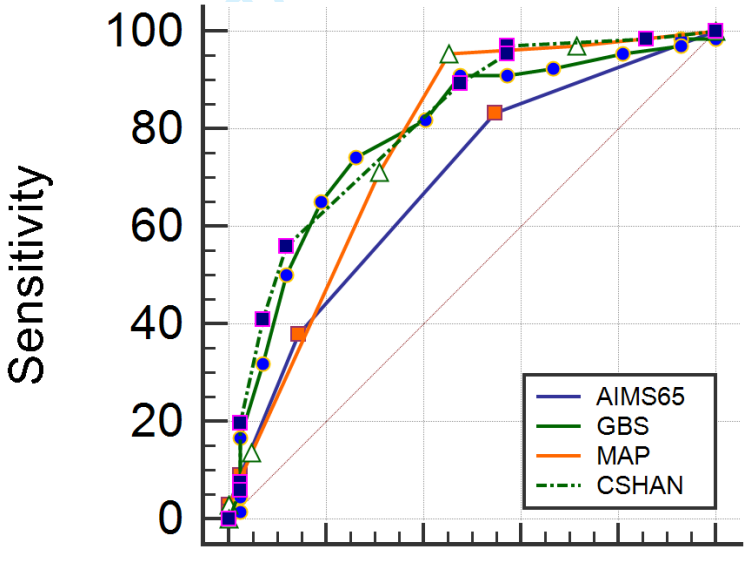


1(a) Derivation cohort



1(b) Validation cohort

Fig 1 curves for three scoring systems in evaluation of NSD

TRIPOD Checklist: Prediction Model Development and Validation

Section/Topic	Item		Checklist Item	Page
Title and abstract				
Title	1	D;V	Identify the study as developing and/or validating a multivariable prediction model, the target population, and the outcome to be predicted.	1
Abstract	2	D;V	Provide a summary of objectives, study design, setting, participants, sample size, predictors, outcome, statistical analysis, results, and conclusions.	1-2
Introduction				
Background and objectives	3a	D;V	Explain the medical context (including whether diagnostic or prognostic) and rationale for developing or validating the multivariable prediction model, including references to existing models.	3-4
	3b	D;V	Specify the objectives, including whether the study describes the development or validation of the model or both.	4
Methods				
Source of data	4a	D;V	Describe the study design or source of data (e.g., randomized trial, cohort, or registry data), separately for the development and validation data sets, if applicable.	5
	4b	D;V	Specify the key study dates, including start of accrual; end of accrual; and, if applicable, end of follow-up.	5
Participants	5a	D;V	Specify key elements of the study setting (e.g., primary care, secondary care, general population) including number and location of centres.	
	5b	D;V	Describe eligibility criteria for participants.	
	5c	D;V	Give details of treatments received, if relevant.	
Outcome	6a	D;V	Clearly define the outcome that is predicted by the prediction model, including how and when assessed.	5
	6b	D;V	Report any actions to blind assessment of the outcome to be predicted.	
Predictors	7a	D;V	Clearly define all predictors used in developing or validating the multivariable prediction model, including how and when they were measured.	6
	7b	D;V	Report any actions to blind assessment of predictors for the outcome and other predictors.	
Sample size	8	D;V	Explain how the study size was arrived at.	
Missing data	9	D;V	Describe how missing data were handled (e.g., complete-case analysis, single imputation, multiple imputation) with details of any imputation method.	7
Statistical analysis methods	10a	D	Describe how predictors were handled in the analyses.	6-7
	10b	D	Specify type of model, all model-building procedures (including any predictor selection), and method for internal validation.	6-7
	10c	V	For validation, describe how the predictions were calculated.	7
	10d	D;V	Specify all measures used to assess model performance and, if relevant, to compare multiple models.	10
	10e	V	Describe any model updating (e.g., recalibration) arising from the validation, if done.	
Risk groups	11	D;V	Provide details on how risk groups were created, if done.	5
Development vs. validation	12	V	For validation, identify any differences from the development data in setting, eligibility criteria, outcome, and predictors.	8
Results				
Participants	13a	D;V	Describe the flow of participants through the study, including the number of participants with and without the outcome and, if applicable, a summary of the follow-up time. A diagram may be helpful.	
	13b	D;V	Describe the characteristics of the participants (basic demographics, clinical features, available predictors), including the number of participants with missing data for predictors and outcome.	8
	13c	V	For validation, show a comparison with the development data of the distribution of important variables (demographics, predictors and outcome).	8
Model development	14a	D	Specify the number of participants and outcome events in each analysis.	
	14b	D	If done, report the unadjusted association between each candidate predictor and outcome.	
Model specification	15a	D	Present the full prediction model to allow predictions for individuals (i.e., all regression coefficients, and model intercept or baseline survival at a given time point).	10
	15b	D	Explain how to the use the prediction model.	11
Model performance	16	D;V	Report performance measures (with CIs) for the prediction model.	12
Model-updating	17	V	If done, report the results from any model updating (i.e., model specification, model performance).	
Discussion				
Limitations	18	D;V	Discuss any limitations of the study (such as nonrepresentative sample, few events per predictor, missing data).	17-18
Interpretation	19a	V	For validation, discuss the results with reference to performance in the development data, and any other validation data.	16
	19b	D;V	Give an overall interpretation of the results, considering objectives, limitations, results from similar studies, and other relevant evidence.	13-15
Implications	20	D;V	Discuss the potential clinical use of the model and implications for future research.	13-17
Other information				
Supplementary information	21	D;V	Provide information about the availability of supplementary resources, such as study protocol, Web calculator, and data sets.	
Funding	22	D;V	Give the source of funding and the role of the funders for the present study.	

*Items relevant only to the development of a prediction model are denoted by D, items relating solely to a validation of a prediction model are denoted by V, and items relating to both are denoted D;V. We recommend using the TRIPOD Checklist in conjunction with the TRIPOD Explanation and Elaboration document.

BMJ Open

A novel risk score for acute upper gastrointestinal bleeding in elderly patients: a single-center retrospective study

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A novel risk score for acute upper gastrointestinal bleeding in elderly patients: a single-center retrospective study

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Abstract **Objectives:** Acute upper gastrointestinal bleeding (UGIB) is a common reason for emergency hospital admission, and distinguishing low-risk patients which are suitable for outpatient management, is a clinical and research priority. This study aimed to develop a simple risk score to identify patients with UGIB in elderly patients, for whom hospital admission is not required.

Design: This was a single-center retrospective study.

Setting: This study was conducted in Zhongda Hospital affiliated with Southeast University.

Participants: Patients from January 2015 to December 2020 for the derivation cohort and from January 2021 to June 2022 for the validation cohort were enrolled in this study. A total of 822 patients (derivation cohort; 606 and validation cohorts; 216) were included in this study. Patients aged ⩾ 65 years with coffee-ground vomiting, melena, or/and hematemesis were included in the analysis. Patients who had been admitted but had UGIB or who were transferred between hospitals were excluded.

Methods: Baseline demographic characteristics and clinical parameters were recorded at the first visit. Data were collected from the electronic records and the databases. Multivariable logistic regression modelling was performed to identify predictors of safe discharge.

Results: 304/606 (50.2%) and 132/216 (61.1%) patients were not safely discharged in the derivation and validation cohorts, respectively. A clinical risk score of 5 variables was entered into UGIB risk stratification: Charlson Comorbidity (CCM) > 2 , SBP < 100 mmHg, Hb < 10 g/dL, BUN≥6.5mmol/L, albumin <30 g/L. The optimal cut-off value was ⩾ 1, and the sensitivity was 97.37 %, and the specificity was 19.21%, for predicting not safely discharged (NSD). The area under the curve (AUC) was 0.806.

Conclusions: A novel clinical risk score was developed with good discriminative performance to identify elderly patients with UGIB who were suitable for safe outpatient management. This can avoid unnecessary hospitalization of patients.

Keywords: Validation; UGIB; Elderly patients; Risk score; Safe discharge

Strengths and limitations of this study

This was the first study on the construction of a risk score for upper gastrointestinal bleeding in elderly patients.

This risk score utilized simple and easily available parameters that can be implemented in almost every hospital.

This study applied other group of data to verify the validity of the risk score.

This was a single-center retrospective study.

The patients discharged from the ED were not included in the analysis, which might introduce some bias.

Background

Upper gastrointestinal bleeding (UGIB), defined as bleeding within the gastrointestinal tract proximal to the ligament of Treitz, is a common medical emergency. In recent years, the reported incidence of UGIB were 67/100 000 adults per year in the USA and 134/ 100 000 in the United

Kingdom, with mortality rates ranging from 2 to 8.6%[1,2]. UGIB was a major cause of morbidity and mortality in elderly patients, with more than $ 1 billion indirect medical costs annually in the United States [1,3]. The incidence increased with increasing age, meaning elderly patients had a higher incidence of UGIB (197/100,000 in those aged 65–75 and 425/100,000 in those over 75 years)[4]. By 2030, approximately 0.3 billion people will be over 65 years old in China. It is necessary to carry out research in elderly patients. Several risk scoring systems such as the Rockall score (RS), Glasgow Blatchford score (GBS), and AIMS65 had been developed to predict outcomes including mortality, need for hospital-based intervention, and need for blood transfusion [5-9]. The Asia-Pacific working group consensus suggested that UGIB can be managed using "early risk stratification" with influential prognostic factors [10]. However, the latest UGIB guidelines for elderly patients were released in 2013 by the American Society for Gastrointestinal Endoscopy (ASGE) [11].

A systematic review including 16 studies showed that the Glasgow Blatchford score (GBS) was more sensitive and specific than the Full Rockall score (RS) and AIMS65 in predicting hospital intervention and 30-day mortality requirements[12]. Implementation of GBS prognostic assessment was associated with a 15% to 20% reduction in hospitalizations due to UGIB[13]. It was therefore recommended to identify patients who are at very low risk and managed as outpatients. However, to date, there

have been few studies on these scoring systems for upper gastrointestinal bleeding in elderly patients. CY Wang et al. reported that the RS is accurate in predicting rebleeding and mortality outcomes in order adults with AUGIB. Still, the area under the ROC curve was lower than 0.8 [14]. Kalkan Ç et al. also documented the RS is more beneficial for predicting mortality and rebleeding than the GBS and AIMS65 [15]. The sample of both studies above was small (341 and 335).

The international consensus Group guidelines recommended using risk scores to assess UGIB patients; However, their precise role in the management of geriatric patients remains unclear. Therefore, the guidelines did not fully address specific issues important to the management of UGIB in the geriatric population [5,16].

When dealing with UGIB patients, the challenge faced by emergency department (ED) physicians was to determine the cause and prognosis and decide whether to be hospitalized for investigation or intervention. However, for elderly patients, there was no internationally recognized effective scoring system to stratify the disease.

We aimed to derive and validate a simple risk score system that can be used to distinguish between elderly patients who can be safely managed as outpatients and those who will benefit from inpatient care. In addition, we also compared the discriminative ability of the new score system with the previously published risk scoring systems to evaluate its effectiveness.

Methods

Design: We conducted two groups of retrospective study: one was from January 2015 to December 2020 for the derivation cohort, and the other was from January 2021 to June 2022 for the validation cohort.

Setting: This study was conducted in Zhongda Hospital affiliated with Southeast University.

Operational definition

UGIB: Bleeding that developed in the gastrointestinal tract proximal to the ligament of Treitz, presenting with coffee-ground vomiting, melena, or/and hematemesis [5,16].

Safe discharge: No following symptoms after presentation [17]: rebleeding, blood transfusion; therapeutic intervention to control bleeding; all causes of death.

Rebleeding: The presentation of melena or/and fresh hematemesis associated with the development of shock (systolic blood pressure < 100 mmHg or/and pulse > 100 beats/minute or hemoglobin decreased by more than 2 g/dL after successful initial treatment) [5].

Blood transfusion: The indication for blood transfusion was that the average patient's hemoglobin level decreased to < 7 g/dL or the hemoglobin level of patients at high risk of heart disease decreased to 8 g / dL [18].

Therapeutic intervention: Endoscopic, radiological, or surgical

hemostasis.

Endoscopic management: The indication for endoscopic treatment was Forrest Ia-IIb ulcer bleeding [19].

Elderly patients: Aged⩾65 years old [20].

Patient and Public Involvement

No patients or members of the public were involved in the design, conduct or reporting of this study. The study results were not disseminated to study participants.

Data collection

Patients with coffee-ground vomiting, melena, or/and hematemesis were included in the analysis. Inclusion criteria: ① Patients presented in the emergency department with black stool and/or hematemesis; ② Aged ⩾65 years old; ③ Fecal occult blood was positive. Exclusion criteria: ① Patients with upper gastrointestinal bleeding during hospitalization; ② Patients with incomplete information; ③ Patients transferred from other hospitals; ④ Patients with lower gastrointestinal bleeding manifested by blood stool.

Through the electronic medical record system， demographic data (sex and age), clinical presentation, comorbidities, medications history (including antiplatelet drugs, oral anticoagulants, and/or nonsteroidal anti-

inflammatory drugs), hemodynamic parameters, hemoglobin, biochemical parameters (coagulation panel, albumin, creatinine, and urea nitrogen) were recorded. The need for endoscopic treatment, blood transfusion, radiologic intervention, or surgery was also analyzed.

Data analysis

Eleven candidate predictors were selected from both biological and clinical perspectives: age, sex, Charlson comorbidities, systolic blood pressure (SBP), heart rate, use of oral anticoagulants or oral antiplatelet, hemoglobin (g/dL), international normalized ratio (INR), albumin (g/L), serum urea nitrogen (mmol/L), and creatinine (μmol/L). Charlson comorbidity index [21] was used to define comorbidities.

We use SPSS version 22.0 and MedCalc version 19 for statistical calculations. Count data were expressed as the number of cases (*n, %*), and the $\chi 2$ test was used for comparison. Measurement data with normal distribution were expressed as mean ± standard deviation ($x \pm s$), and independent sample t-test or univariate analysis was used to compare between groups. The measurement data with non-normal distribution were expressed as median (quartile) [M (Q1, Q3)], and the Mann-Whitney U test was used for comparison. Regression models were constructed. Statistically significant variables in univariate analysis were included in multivariate regression analysis. Regression models were constructed

using backward elimination. The variables in the final regression model were classified according to the thresholds most closely related to safe discharge, resulting in easy-to-calculate scores. Results were expressed as ORs with 95% CIs. The Hosmer--Lemeshow test was used to evaluate the goodness of fit.

Based on the established logistic regression model, a new risk score was generated. ROC curves with 95% CIs were used for predicting the identified ability of outcomes. Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were also calculated [22]. The Delong test was used to compare different AUCs in the scoring system.

Results

A total of 822 patients (derivation cohort; 606 and validation cohorts; 216) were included in this study. The incidence of not safely discharged (NSD) was 50.2% (304/606) and 61.1% (132/216) in the derivation and validation cohorts, respectively.

Most patients (404/606, 66.7%, and 158/216, 73.1%) were men (Table 1). The median age was 74 (68,79) and 77.5 (71, 84). In terms of complications, diabetes, any malignancy and renal failure were statistically significant between the two groups, and almost one-fifth of patients had a Charlson Comorbidity (CCM) [21] score of greater than 2, which had

higher morbidity in the NSD cohort (27.6% vs. 9.3%, P <0.01) . (Table 2).

Table 1 Comparison of demographic and mean clinical parameters of the two cohort study populations

Variable	Derivation cohort	Validation cohort	P
	Total（n =606）	Total（n =216）	
Male,n (%)	404 (66.7）	158 (73.1)	0.079
Median age, year (IQR)	74 (68,79)	77.5 (71, 84)	**<0.01**
Findings at endoscopy			
peptic ulcer	302 (49.8)	91(42.1)	
Variceal bleeding	44 (7.3)	20 (9.3)	
Upper GI cancer	75 (12.3)	27(12.5)	
Erosions	86 (14.2)	26 (12.0)	
others	99 (16.4)	52 (24.1)	
Comorbidities,n (%)			
Any malignancy	110 (18.2)	30 (13.9)	0.180
Hypertention	346 (57.1)	124 (57.4)	0.937
Diabetes	145 (23.9)	48 (22.2)	0.855
CHD	130 (21.5)	54 (25)	0.158
Heart failure	16 (2.6）	2 (0.1)	0.139
Stroke	174 (28.7)	66 (30.1)	0.609
Renal failure	72 (11.9)	22 (10.2)	0.641
Liver disease	65 (10.7)	16 (7.4)	0.160
CCM >2	112 (18.5)	62 (28.7)	0.518
⩾2 Comorbidities	395 (65.0)	144 (66.7)	0.693
Antiplatelet/ anticoagulant use	220 (36.3)	70 (32.1)	0.304
HR (SD)	82 (15)	82 (16)	0.752
SBP, mmHg (SD)	122 (20)	126 (23)	0.261
Hb, g/dL (SD)	91 (29)	84 (24)	0.147
Coagulopathy, INR ≥ 1.5	19 (3.1)	14 (6.5)	0.032
BUN,mmol/L (SD)	12.5 (8.7)	11.4 (6.5)	0.221
Creatinine,μmol/L (SD)	107 (86)	109 (97)	0.820
Albumin,g/L(SD)	33.7 (6.0)	35.6 (6.0)	0.820

CCM Charlson comorbidity, HR heart rate, SBP systolic blood pressure, Hb hemoglobin,INR international normalized ratio.

Table 2 Demographics and Mean clinical parameters of the study population in the derivation cohort

Variable	Total cohort（n =606）	Not safely discharged,NSD（n=304）	safely discharged,SD（n=302）	P- value
Male,n(%)	404 (66.7）	196 (64.5)	208 (68.9)	0.075
Median age, year(IQR)	74(68-79)	73（67-78）	75（69-79）	0.417
Comorbidities,n(%)				
Any malignancy	110 (18.2)	70 (23.0)	40 (13.2)	<0.01
Hypertention	346 (57.1)	168(55.3)	178 (58.9）	0.360
Diabetes	145 (23.9)	61 (20.1)	84 (27.8)	<0.05
Coronary heart disease	130 (21.5)	62 (0.4)	68 (22.5)	0.611
Heart failure	16 (2.6）	8 (2.6)	8 (2.6)	0.989
Stroke	174 (28.7)	78 (25.7)	96 (31.8)	0.095
Renal failure	72 (11.9)	48 (15.8)	26 (8.6)	<0.01
Liver disease	65 (10.7)	40 (13.2)	25 (8.3)	0.052
CCM SCORE >2	112 (18.5)	84 (27.6）	28 (9.3)	<0.01
Antiplatelet/anticoagulant use	220 (36.3)	102 (33.6)	118 (39.1)	0.318
HR (SD)	82 (15)	84 (16)	80 (13)	0.019
≥ 100	76 (12.5)	52 (17.2)	24 (7.9)	
SBP, mmHg (SD)	122 (20)	119 (21)	128 (19)	<0.01
< 100	60 (10.0)	50 (16.4)	10 (3.3）	
Hb, g/dL (SD)	91 (29)	76 (26)	106 (23)	<0.01
< 10	390 (64.4)	260 (85.5)	130 (43.0)	
Coagulopathy, INR ≥ 1.5	19 (3.1)	17 (5.6)	2 (0.7）	<0.01
BUN,mmol/L (SD)	12.5 (8.7)	14.4 (9.5)	10.7 (7.4)	<0.01
≥ 6.5	436 (71.9)	244 (80.3)	192 (63.6)	
Creatinine,μmol/L (SD)	107 (86)	114 (97)	100 (73)	0.954
>100	182 (30.0)	114 (37.5)	68 (22.5)	
Albumin,g/L(SD)	33.7 (6.0)	31.6 (5.9)	35.9 (5.1)	<0.01
<30	160 (26.4)	128 (42.1)	32 (10.6)	

CCM Charlson comorbidity, HR heart rate, SBP systolic blood pressure, Hb hemoglobin, INR international normalized ratio.

Patients in the NSD cohort were more likely to have tachycardia (HR ≥ 100, 17.2% vs 7.9%, P =0.019), hypotension (SBP < 100 mmHg,

16.4% vs 3.3%, P < 0.01) and their hemoglobin (Hb) and albumin level were lower (Hb < 10 g/dL, 85.5% vs 43.0%, P < 0.01 and albumin<30g/L, 42.1% vs 10.6%, P < 0.01), Urea nitrogen was higher (BUN≥ 6.5mmol/L, 80.3% vs 63.6%, P < 0.01). Coagulopathy was more frequent (INR≥1.5 5.6% vs 0.7%, P < 0.01).

Table 3 Severity outcome and therapeutic interventions of the study population in the derivation cohort

Variable	N(%)
Rebleeding	124 (20.5%)
Required blood transfusion	268 (44.2%)
therapeutic intervention (total)	108(17.8%)
Endoscopic treatment	80 (13.2)
Radiologic intervention	6 (1.0)
surgery	15 (2.8)
Endoscopy+radiology	4 (0.7)
Endoscopy+surgery	2 (0.3)
radiology+surgery	1 (0.2)
mortality	52 (8.6%)
ICU admission	50 (8.4%)

Table 3 outlines the clinical outcomes and therapeutic interventions in the study population. More than a third of patients required blood transfusion (n = 268/606, 44.2%), and 124 (20.5%) patients suffer rebleeding. Overall, 108 patients (17.8%) underwent therapeutic intervention during admission. 50 patients (8.4%) required admission to the Intensive Care Unit (ICU). The mortality rate was 8.6% (52 patients).

Logistic regression

Based on calculations from the derivative cohort, significant

predictors ($P < 0.05$) included: CCM > 2, HR ≥ 100, SBP < 100 mmHg, BUN≥6.5mmol/L, Hb < 10 g/dL, albumin <30g/L, Coagulopathy (INR≥ 1.5), and Creatinine >100μmol/L (Table 4).

Table 4 Univariable analysis for predictive factors of NSD in the derivation cohort

Variable	Univariate analysis	
	Odds ratio (95% CI)	P value
Age ≥65	1.51 (0.96-2.38)	0.075
Gender, male	0.82 (0.51-1.32)	0.417
CCM > 2	3.74 (1.94-7.20)	<0.001
Antiplatelet/anticoagulant use	0.79 (0.49-1.26）	0.318
HR ≥ 100	2.39 (1.16-4.94)	0.019
SBP< 100mmHg	5.75 (2.14-15.46)	<0.001
BUN ≥6.5mmol/L	2.33 (1.39-3.92)	<0.001
Hb< 10g/dL	7.82 (4.49-13.62)	<0.001
Albumin<30g/L	6.14 (3.33-11.30)	<0.001
INR ≥1.5	9.38 (2.13-41.36)	0.003
Creatinine >100μmol/L	1.93(1.17-3.19)	0.010

CCM Charlson comorbidity, HR heart rate, SBP systolic blood pressure, Hb hemoglobin,INR international normalized ratio.

Table 5 Multivariable logistic regression analysis for predictive factors of NSD in the derivation cohort

Variable	*β*	*Ward*	*OR*	*P*	95%*CI*
CCM > 2	0.455	5.616	1.576	0.018	1.082-2.295
SBP< 100mmHg	1.479	6.735	4.726	0.009	0.955-23.377
BUN ≥6.5mmol/L	0.636	3.969	1.890	0.046	1.010-3.534
Hb< 10g/dL	1.616	27.883	5.033	<0.001	2.763-9.169
Albumin<30g/L	1.065	9.339	2.901	0.002	1.465-5.743
	-2.193	38.259	-	<0.001	-

These variables were included in a multivariate logistic regression model— CCM > 2, SBP < 100 mmHg, BUN≥6.5mmol/L, Hb < 10 g/dL, and albumin <30g/L were statistically significant in predicting NSD

(Table 5). The final logistic regression function was: log (odds of NSD)= 0.636 (BUN) + 1.616 (Hb) +1.065 (albumin) + 0.455 (CCM) +1.479 (SBP)-2.193. These 5 variables were used to develop a prognostic scoring model (Table 6).

Table 6 Prognostic factors for NSD for inclusion in our clinical risk score

Clinical predictive risk factor	Score
S: SBP< 100mmHg	3
A: Albumin<30g/L	2
H: Hb< 10g/dL	3
C: CCM > 2	1
N: BUN ≥6.5mmol/L	1

The optimum cut-off was ≥ 1 point(s), the sensitivity was 97.37%, the specificity 19.21%, the positive predictive value (PPV) was 54.8%, and the negative predictive value (NPV) was 87.9% in predicting NSD (Table 7). Among the clinical risk scores, only GBS ⩽ 1 and our risk score=0 achieved a sensitivity at 97.37%; AIMS65=0 and MAP(ASH)=0 had maximal sensitivities of 96.71% and 79.61%, respectively. Our risk score performed better than GBS⩽1 in correctly classifying patients who could safely be discharged ($p<0.05$): our risk score had a specificity of 19.21% at sensitivity 97.37% compared to a specificity of 11.92% at sensitivity of 97.37% with GBS⩽1.

Table 7 Clinical risk score for NSD with sensitivity, specificity, PPV and NPV

Scores	Cutoff value	Sensitivity (%)	Specificity (%)	PPV (%) (95%*CI*)	NPV (%) (95%*CI*)
CSHAN	≥1	97.37	19.21	54.8(52.8-56.8)	87.9(72.3-95.3)
GBS	≥2	97.37	11.92	52.7(51.1-54.3)	81.8(60.9-92.8)
AIMS65	≥1	96.71	9.27	51.8(50.3-53.2)	73.7(50.8-88.3)
MAP(ASH)	≥1	79.61	41.06	57.6(53.8-61.4)	66.7(58.1-74.3)

The AUCs of our risk score, GBS, MAP(ASH), and AIMS65 were shown in Table 8 and Figure 1. For both cohorts, our risk score had the largest AUCs of 0.806 and 0.807, which were significantly higher than that of GBS, MAP(ASH), and AIMS65 ($p<0.05$).

Table 8 Values of the three scoring systems in the prediction of NSD

Derivation cohort	AUC (95%*CI*)	P			
		CSHAN	GBS	AIMS65	MAP(ASH)
CSHAN	0.806 (0.756-0.849)	*	0.019	0.025	0.031
GBS	0.762 (0.708-0.815)	0.019	*	0.034	0.035
AIMS65	0.711 (0.661-0.781)	0.025	0.034	*	0.030
MAP(ASH)	0.669 (0.612-0.721)	0.031	0.035	0.030	*
Validation cohort	AUC (95%*CI*)	P			
		CSHAN	GBS	AIMS65	MAP(ASH)
CSHAN	0.807 (0.722-0.892)	*	0.046	0.053	0.034
GBS	0.788 (0.698-0.878)	0.046	*	0.060	0.049
AIMS65	0.689 (0.587-0.792)	0.053	0.060	*	0.062
MAP(ASH)	0.767	0.034	0.034	0.062	*

	(0.720-0.877)				

Discussion

As reported, the mortality rate for non-variceal UGIB decreased from 4.5% in 1989 to 2.1% in 2009, and the incidence decreased from 108 to 78 cases per 100,000 population in 1994 and 2009. However, the economic burden of immediate hospitalization for UGIB increased from $3.3 billion to $7.6 billion, a similar trend was observed for variceal UGIB [23]. How to save medical expenses will become an important issue concerned by scholars around the world. Barkun AN. et al proposed that using a prognostic score system and early discharge with low risk could reduce the associated costs without increasing harm [16]. The primary aim of the initial assessment was to determine whether the admission was required or whether endoscopic intervention was required urgently or even managed in the outpatient setting [24].

Several risk-scoring systems have been used for UGIB patients, but most of them were used to predict mortality, rebleeding and intervention as endpoints [6-10]. The full Rockall score (RS), was derived in 1996 from 4185 cases of AUGIB in the United Kingdom (UK) and designed to predict mortality [6]. As the full RS relied on endoscopic findings, its use in initial ED assessment was limited. Blatchford O et al. Cited hemoglobin, blood urea, pulse, systolic blood pressure, a presentation with syncope or melaena, and evidence of hepatic disease or cardiac failure as predictive factors to predict the need for intervention[25]. The 2019 guidelines from

the International Consensus Group (ICG) stated that using a GBS≤ 1 to identify patients who are at very low risk for rebleeding or mortality and thus may not require hospitalization or inpatient endoscopy for patients with acute UGIB [16]. GBS is clinically useful, but it is evaluated using eight factors, making calculations cumbersome and decreasing its use in clinical practice in China. Saltzman JR et al. constructed a prediction model named AIMS65 comprising albumin, international normalized ratio, altered mental status, blood pressure, and age to predict death; they reported an AUROC of 0.77 for the prediction of death [7]. AIMS65 provided a more age-appropriate score and might be a beneficial supplement to a risk stratification model for distinguishing high-risk patients. While the ICG recommends against using the AIMS65 prognostic score to predict the need for hospitalization [16]. MAP (ASH) score was established in 2020. MAP (ASH) has good predictive accuracy for intervention and mortality [10]. However, it was a new risk score, and further research is needed to confirm its predictive effect. Furthermore, there were few studies on those score systems on geriatric patients to validate whether they are suitable for elderly patients. In our previous research [26], we found MAP, GBS, AIMS65, and pRS only performed fairly in predicting mortality and intervention with the AUROCs all below 0.8, indicating they might not be very suitable for elderly patients.

It was not simple to determine the most important clinical outcome in

patients with UGIB. Initially, death was a priority, but studies showed that the mortality rate of UGIB had been decreasing in the last 2 decades [23]. Increasing attentions were paid to the use of risk scores to predict profitable outcomes such as safe discharge [16], in which low-risk patients could avoid hospitalization, and conduct to outpatient management.

We derived a simple risk score system with five variables that can be used to distinguish between patients who can be safely managed as outpatients and those who will benefit from inpatient care. The system was designed to ensure the absence of rebleeding, blood transfusion, and hospital-based intervention to control bleeding and death to capture adverse events. Previous studies had reported that unstable vital signs, anemia, hypoproteinemia, azotemia, and existing comorbidities were predictive of adverse outcomes [25,27]. In our research, we identified CCM > 2, SBP < 100 mmHg, Hb < 10 g/dL, BUN≥6.5mmol/L, and albumin <30g/L as risk factors. We included the use of antiplatelet/ anticoagulant medications, INR≥ 1.5, age, sex, heart rate, and creatinine in the model but these were not statistical predictors and therefore were not included in the score. Previous research suggested that the use of antiplatelet/ anticoagulant medications and coagulopathy might be related to the increased severity of bleeding [7,28]. Several studies also indicated that advancing age and creatinine were risk factors for predicting adverse outcomes [25,27]. This is inconsistent with our results, probably because

the target population is different.

In practice, risk stratification scores were used to guide clinical care, with the goal to select thresholds that maximize sensitivity and minimize false negatives. The guidelines recommended that patients with GBS≤ 1 might be discharged through outpatient management because very few of these patients needed hospital-based intervention or blood transfusion or die. In our study, the GBS≤1 recommended by the guidelines as a cutoff value had a sensitivity of 97.37 % and a specificity of 11.92 % for the composite outcome of blood transfusion, rebleeding, hospital-based intervention, or death. At the matched sensitivity of 97.37%, the specificity of our score was 19.21 %. Compared with GBS, the specificity was significantly increased from 11.92 % to 19.21 %, and the sensitivity of both was 97.37 %, indicating that our score could increase the number of patients who could be safely discharged by more than 1.5 times.

In the present cohort, we found that our risk score predicted the composite outcome better than the current commonly used clinical risk scores: GBS, AIMS65 and MAP(ASH). Therefore, the score improves the ability to identify very low-risk patients who can be SD. It suggested that our score was more suitable for predicting NSD in geriatric patients.

A patient with a score of 0 point at presentation has an 87.9% chance of safe discharge from ED. We recommend using this threshold for patients with no other hospitalization indications. In our research cohort, almost 30-

50% of patients presenting with UGIB could be safely discharged. According to a large micro cost study in UGIB indicated the average cost per patient at £2,458 in the UK, and 60% of the cost was attributed to the cost of the inpatient bed. A 30-50% reduction in hospital admissions would reduce the financial burden [29].

This study has several limitations. This was a single-center retrospective study, patients discharged directly from ED were not included, which might have led to selection bias. However, the patients who were suitable for discharge directly from ED were likely at "safely discharged" with UGIB, which might not have a significant impact on our risk score. An integral part of the safe discharge outcome depends on the absence of blood transfusion, which might be inaccurate because many transfusions might be considered unneeded when layered according to life signs and anemia [30,31]. It might lead to an underestimation of the ratio of patients who can be discharged safely.

Our study was based on clinically accessible risk stratification for elderly patients with UGIB. To the best of our knowledge, this is the first analysis of this nature in the world. The ROC curve showed higher predictive accuracy and sensitivity for patients with a threshold ≥1 point, which could direct the possible discharge of low-risk patients. The model was easy to implement and could be used to assist clinical decision-making and early identification of patients with severe UGIB requiring aggressive

blood cell transfusion, entering monitoring units, and requiring intervention.

In conclusion, our risk score used five easily quantifiable basic predictors and was easy to calculate. Compared with the previously available three risk scores, the forecasting of safe discharge was the best. The score could be routinely included in the acute medical triage route to determine UGIB patients who can be safely discharged without requiring hospital admission. Further research is required to be externally verified in the results presented in this study.

Abbreviations

UGIB: Upper gastrointestinal bleeding; GBS: Glasgow Blatchford score; RS: the full Rockall score; AUCs: area under the receiver operator characteristics curves;

Acknowledgments

Not applicable.

Authors' contributions

YL, QL,and XO conceived of the study. YL, MS, and KW contributed to data collection. XO was responsible for data analyses. All authors contributed to interpretation of the results. YL drafted the manuscript. All authors contributed to the refinements of the

manuscript and approved the final manuscript for publication. XO is the guarantor of the manuscript.

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Availability of data and materials

YL, MS and KW began to collect data from 3rd July 2022 to 6th September. The datasets generated and/or analyzed during the current study are not publicly available due [Belong to Zhongda Hospital] but are available from the corresponding author upon reasonable request.

Ethics approval and consent to participate

This study was approved by the Ethics Committee for Clinical Research of Zhongda Hospital, affiliated to Southeast University. This study used the medical records obtained from the past clinical diagnosis and treatment. Upon application, the Ethics committee agreed that informed consent was not required. All methods were carried out in accordance with relevant guidelines and regulations. The ethics reference number: 2021ZDSYLL333-P01.

Consent for publication

Not available.

Competing interests

All the authors declare that they have no conflicts of interest.

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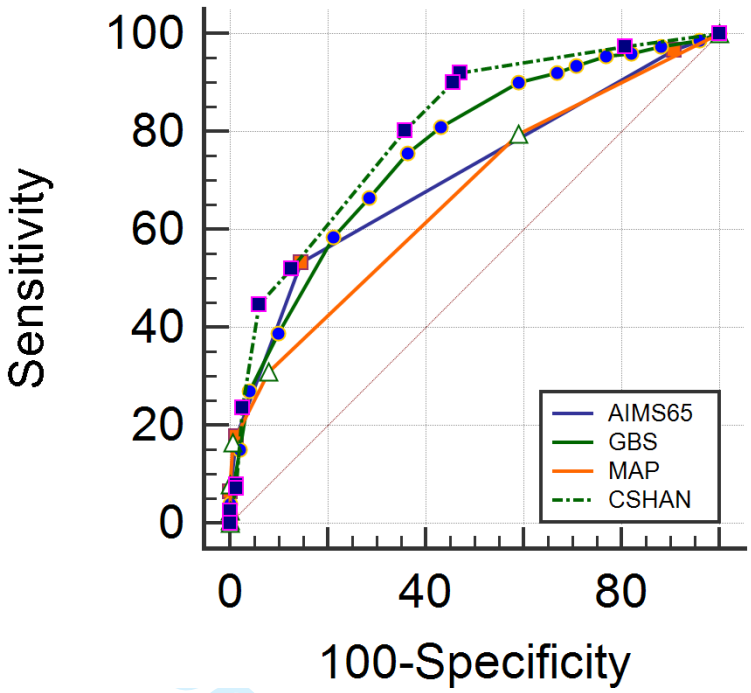
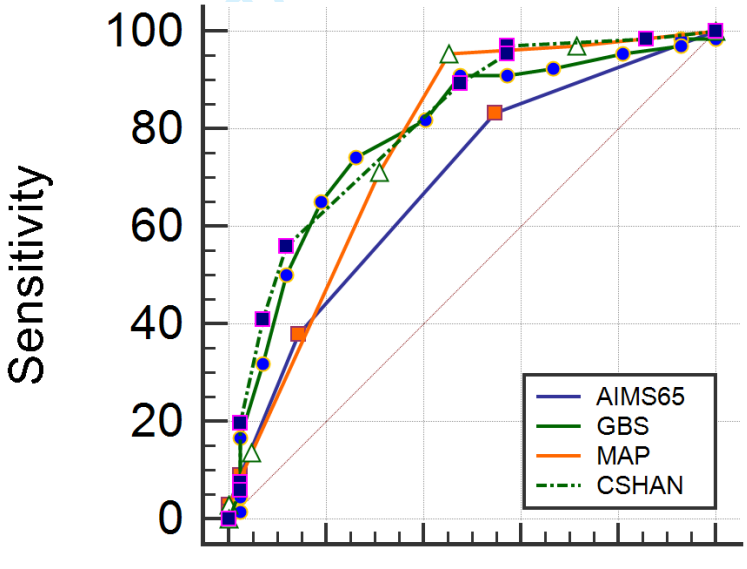
Figure legend

Fig 1 curves for three scoring systems in evaluation of NSD



1(a) Derivation cohort



1(b) Validation cohort

Fig 1 curves for three scoring systems in evaluation of NSD

TRIPOD Checklist: Prediction Model Development and Validation

Section/Topic	Item		Checklist Item	Page
Title and abstract				
Title	1	D;V	Identify the study as developing and/or validating a multivariable prediction model, the target population, and the outcome to be predicted.	1
Abstract	2	D;V	Provide a summary of objectives, study design, setting, participants, sample size, predictors, outcome, statistical analysis, results, and conclusions.	1-2
Introduction				
Background and objectives	3a	D;V	Explain the medical context (including whether diagnostic or prognostic) and rationale for developing or validating the multivariable prediction model, including references to existing models.	3-4
	3b	D;V	Specify the objectives, including whether the study describes the development or validation of the model or both.	4
Methods				
Source of data	4a	D;V	Describe the study design or source of data (e.g., randomized trial, cohort, or registry data), separately for the development and validation data sets, if applicable.	5
	4b	D;V	Specify the key study dates, including start of accrual; end of accrual; and, if applicable, end of follow-up.	5
Participants	5a	D;V	Specify key elements of the study setting (e.g., primary care, secondary care, general population) including number and location of centres.	
	5b	D;V	Describe eligibility criteria for participants.	
	5c	D;V	Give details of treatments received, if relevant.	
Outcome	6a	D;V	Clearly define the outcome that is predicted by the prediction model, including how and when assessed.	5
	6b	D;V	Report any actions to blind assessment of the outcome to be predicted.	
Predictors	7a	D;V	Clearly define all predictors used in developing or validating the multivariable prediction model, including how and when they were measured.	6
	7b	D;V	Report any actions to blind assessment of predictors for the outcome and other predictors.	
Sample size	8	D;V	Explain how the study size was arrived at.	
Missing data	9	D;V	Describe how missing data were handled (e.g., complete-case analysis, single imputation, multiple imputation) with details of any imputation method.	7
Statistical analysis methods	10a	D	Describe how predictors were handled in the analyses.	6-7
	10b	D	Specify type of model, all model-building procedures (including any predictor selection), and method for internal validation.	6-7
	10c	V	For validation, describe how the predictions were calculated.	7
	10d	D;V	Specify all measures used to assess model performance and, if relevant, to compare multiple models.	10
	10e	V	Describe any model updating (e.g., recalibration) arising from the validation, if done.	
Risk groups	11	D;V	Provide details on how risk groups were created, if done.	5
Development vs. validation	12	V	For validation, identify any differences from the development data in setting, eligibility criteria, outcome, and predictors.	8
Results				
Participants	13a	D;V	Describe the flow of participants through the study, including the number of participants with and without the outcome and, if applicable, a summary of the follow-up time. A diagram may be helpful.	
	13b	D;V	Describe the characteristics of the participants (basic demographics, clinical features, available predictors), including the number of participants with missing data for predictors and outcome.	8
	13c	V	For validation, show a comparison with the development data of the distribution of important variables (demographics, predictors and outcome).	8
Model development	14a	D	Specify the number of participants and outcome events in each analysis.	
	14b	D	If done, report the unadjusted association between each candidate predictor and outcome.	
Model specification	15a	D	Present the full prediction model to allow predictions for individuals (i.e., all regression coefficients, and model intercept or baseline survival at a given time point).	10
	15b	D	Explain how to the use the prediction model.	11
Model performance	16	D;V	Report performance measures (with CIs) for the prediction model.	12
Model-updating	17	V	If done, report the results from any model updating (i.e., model specification, model performance).	
Discussion				
Limitations	18	D;V	Discuss any limitations of the study (such as nonrepresentative sample, few events per predictor, missing data).	17-18
Interpretation	19a	V	For validation, discuss the results with reference to performance in the development data, and any other validation data.	16
	19b	D;V	Give an overall interpretation of the results, considering objectives, limitations, results from similar studies, and other relevant evidence.	13-15
Implications	20	D;V	Discuss the potential clinical use of the model and implications for future research.	13-17
Other information				
Supplementary information	21	D;V	Provide information about the availability of supplementary resources, such as study protocol, Web calculator, and data sets.	
Funding	22	D;V	Give the source of funding and the role of the funders for the present study.	

*Items relevant only to the development of a prediction model are denoted by D, items relating solely to a validation of a prediction model are denoted by V, and items relating to both are denoted D;V. We recommend using the TRIPOD Checklist in conjunction with the TRIPOD Explanation and Elaboration document.

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A novel risk score for acute upper gastrointestinal bleeding in elderly patients: a single-center retrospective study

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Abstract

Objectives: Acute upper gastrointestinal bleeding (UGIB) is a common reason for emergency hospital admission. Identifying low-risk patients suitable for outpatient management is a clinical and research priority. This study aimed to develop a simple risk score to identify elderly patients with UGIB for whom hospital admission is not required.

Design: This was a single-center retrospective study.

Setting: This study was conducted at Zhongda Hospital affiliated with Southeast University in China.

Participants: Patients from January 2015 to December 2020 for the derivation cohort and from January 2021 to June 2022 for the validation cohort were enrolled in this study. A total of 822 patients (derivation cohort = 606 and validation cohorts = 216) were included in this study. Patients aged ⩾ 65 years with coffee-grounds vomiting, melena, or/and hematemesis were included in the analysis. Patients admitted but had UGIB or transferred between hospitals were excluded.

Methods: Baseline demographic characteristics and clinical parameters were recorded at the first visit. Data were collected from electronic records and databases. Multivariable logistic

regression modeling was performed to identify predictors of safe discharge.

Results: 304/606 (50.2%) and 132/216 (61.1%) patients were not safely discharged in the derivation and validation cohorts, respectively. A clinical risk score of five variables was entered into UGIB risk stratification: Charlson Comorbidity Index > 2, systolic blood pressure < 100 mmHg, hemoglobin < 10 g/dL, blood urea nitrogen ≥ 6.5 mmol/L, albumin < 30 g/L. The optimal cutoff value was ≥ 1, the sensitivity was 97.37%, and the specificity was 19.21% for predicting the inability to discharge safely. The area under the receiver operating characteristic curve was 0.806.

Conclusions: A novel clinical risk score with good discriminative performance was developed to identify elderly patients with UGIB who were suitable for safe outpatient management. This score can reduce unnecessary hospitalizations.

Keywords: UGIB; Elderly patients; Risk score

Strengths and limitations of this study

This was the first study on the construction of a risk score for UGIB in elderly patients.

This risk score utilized simple and easily available parameters that can be implemented in almost every hospital.

This study applied other group of data to verify the validity of the risk score.

This was a single-center retrospective study.

The patients discharged from the emergency department were not included in the analysis, which might introduce some bias.

Background

Upper gastrointestinal bleeding (UGIB) is defined as bleeding within the gastrointestinal tract proximal to the ligament of Treitz and is a common medical emergency. In recent years, the incidence of UGIB was 67/100 000 adults per year in the US and 134/100,000 in the UK, with mortality rates ranging from 2% to 8.6% [1, 2]. UGIB is a significant cause of morbidity and mortality in elderly patients, with more than $1 billion in indirect medical costs annually in the US [1,3]. The incidence increased with age, meaning elderly patients had a higher

incidence of UGIB (197/100,000 in those aged 65–75 and 425/100,000 in those over 75 years) [4]. By 2030, approximately 0.3 billion people in China will be over 65 years old. Several risk-scoring systems have been developed to predict outcomes, including mortality, the need for hospital-based intervention, and the need for blood transfusion; these include the Rockall score (RS), Glasgow Blatchford score (GBS), the AIMS65 and MSP(ASH) [5–9]. The Asia-Pacific working group consensus suggested that UGIB can be managed using "early risk stratification" with influential prognostic factors [10]. However, the latest UGIB guidelines for elderly patients were released in 2013 by the American Society for Gastrointestinal Endoscopy [11].

A systematic review of 16 studies showed that the GBS was more sensitive and specific than the RS and AIMS65 in predicting hospital intervention and 30-day mortality requirements [12]. Implementing GBS prognostic assessment was associated with a 15% to 20% reduction in hospitalizations due to UGIB [13]. Therefore, it was recommended to identify patients at very low risk and manage them as outpatients. However, to date, there have been few studies on these scoring systems for UGIB in elderly patients: Wang et al. reported that the RS accurately predicted rebleeding and mortality outcomes in order adults with acute UGIB; however, the area under the receiver operating characteristic curve was lower than 0.8 [14]. Kalkan et al. also reported that the RS predicted mortality and rebleeding more accurately than the GBS or the AIMS65 [15]. The sample sizes of both studies were small (341 and 335).

An international consensus group guideline recommended using risk scores to assess UGIB patients; nevertheless, its role in managing geriatric patients remains unclear [5,16]. When managing UGIB patients, the challenge faced by emergency department (ED) physicians is determining the cause and whether the patient should be hospitalized for further management. However, there is no internationally recognized effective scoring system elderly patients to stratify the disease.

We aimed to develop and validate a simple risk score system to identify elderly patients who can be safely managed as outpatients and those who will benefit from inpatient care. We also compared the discriminative ability of the new score system with the previously published risk-scoring systems.

Methods

Design: We conducted two retrospective studies: one from January 2015 to December 2020 for the derivation cohort and the other from January 2021 to June 2022 for the validation cohort.

Setting: This study was conducted at Zhongda Hospital affiliated with Southeast University in China.

Operational definitions

UGIB: Bleeding in the gastrointestinal tract proximal to the ligament of Treitz, presenting with coffee-ground vomiting, melena, or/and hematemesis [5,16].

Safe discharge: None of the following symptoms after presentation [17]: rebleeding or blood transfusion; therapeutic intervention to control bleeding; all causes of death.

Rebleeding: The presentation of melena or/and fresh hematemesis associated with the development of shock (systolic blood pressure [SBP] < 100 mmHg or/and pulse > 100 beats/minute or/and hemoglobin decreased by more than 2 g/dL after successful initial treatment) [5].

Blood transfusion: The indication for blood transfusion was a hemoglobin level decreasing an average of < 7 g/dL or 8 g/dL in patients at high risk of heart disease [18].

Therapeutic intervention: Endoscopic, radiological, or surgical hemostasis.

Endoscopic management: The indication for endoscopic treatment was Forrest Ia-IIb ulcer bleeding [19].

Elderly patients: Age ⩾ 65 years [20].

Patient and public involvement

No patients or members of the public were involved in the design, conduct, or reporting of study results. The study results were not disseminated to study participants.

Data collection

Patients with coffee-grounds vomiting, melena, or/and hematemesis were included. The

inclusion criteria were presentation in the ED with black stool and/or hematemesis, age ⩾65 years old, and fecal occult blood positivity. The exclusion criteria were UGIB during hospitalization, incomplete data, transfer from other hospitals, and lower gastrointestinal bleeding manifested as bloody stool.

We recorded the following from the electronic medical record system: demographic data (sex and age), clinical presentation, comorbidities, medications history (including antiplatelet drugs, oral anticoagulant agents, and/or nonsteroidal anti-inflammatory drugs), hemodynamic parameters, hemoglobin, biochemical parameters (coagulation panel, albumin, creatinine, and urea nitrogen) were recorded. The need for endoscopic treatment, blood transfusion, radiologic intervention, or surgery was also analyzed.

Data analysis

Eleven predictors were selected from both biological and clinical perspectives: age, sex, Charlson Comorbidity Index (CCI), SBP, heart rate, use of oral anticoagulants or oral antiplatelet agents, hemoglobin (g/dL), international normalized ratio (INR), albumin (g/L), serum urea nitrogen (mmol/L), and creatinine (μmol/L). The CCI was used to define comorbidities [21].

We use SPSS version 22.0 and MedCalc version 19 for statistical calculations. Count data were expressed as the number of cases (*n, %*), and the $\chi 2$ test was used for comparisons. Measurement data with normal distribution were expressed as mean ± standard deviation ($x \pm s$), and independent sample t-test or univariate analysis was used to compare groups. The measurement data with non-normal distribution were expressed as median (quartile) [M (Q1, Q3)], and the Mann-Whitney U test was used for comparisons. Regression models were constructed. Statistically significant variables in univariate analyses were included in the multivariate regression analyses. Regression models were constructed using backward elimination. The variables in the final regression model were classified according to the thresholds most closely related to safe discharge, resulting in easily calculated scores. Results were expressed as odds ratios with 95% CIs. The Hosmer-Lemeshow test was used to evaluate the goodness of fit.

A new risk score was generated based on the established logistic regression model.

Receiver operating characteristic (ROC) curves with 95% confidence intervals (Cis) were used for predicting the identified ability of outcomes. Sensitivity, specificity, positive predictive value, and negative predictive value were also calculated [22]. The Delong test was used to compare areas under the curve (AUCs).

Results

We included 822 patients (derivation cohort = 606 and validation cohort = 216). The incidence of not safely discharged (NSD) was 50.2% (304/606) and 61.1% (132/216) in the derivation and validation cohorts, respectively.

Most patients (404/606, 66.7%, and 158/216, 73.1%) were men (Table 1); the median ages were 74 (68,79) and 77.5 (71, 84), respectively. The incidence of diabetes, any malignancy, and renal failure differed significantly between the groups, and almost one-fifth of patients had a CCI score of greater than 2, which suggests higher morbidity in the NSD cohort (27.6% vs. 9.3%, $P < 0.01$) (Table 2).

Patients in the NSD cohort were more likely to have tachycardia (heart rate ⩾ 100, 17.2% vs. 7.9%, $P = 0.019$), hypotension (SBP < 100 mmHg, 16.4% vs. 3.3%, $P < 0.01$) and lower hemoglobin (Hb) and albumin (Hb < 10 g/dL, 85.5% vs. 43.0%, $P < 0.01$ and albumin < 30 g/L, 42.1% vs. 10.6%, $P < 0.01$). Blood urea nitrogen (BUN) was higher (⩾ 6.5 mmol/L, 80.3% vs. 63.6%, $P < 0.01$). Coagulopathy was more frequent (INR ⩾ 1.5 5.6% vs. 0.7%, $P < 0.01$).

Table 1 Comparison of demographic and mean clinical parameters of the two cohort study populations

Variable	Derivation cohort	Validation cohort	P
	Total（n =606）	Total（n =216）	
Male,n (%)	404 (66.7）	158 (73.1)	0.079
Median age, year (IQR)	74 (68,79)	77.5 (71, 84)	**<0.01**
Findings at endoscopy			
peptic ulcer	302 (49.8)	91(42.1)	
Variceal bleeding	44 (7.3)	20 (9.3)	
Upper GI cancer	75 (12.3)	27(12.5)	
Erosions	86 (14.2)	26 (12.0)	

others	99 (16.4)	52 (24.1)	
Comorbidities,n (%)			
Any malignancy	110 (18.2)	30 (13.9)	0.180
Hypertention	346 (57.1)	124 (57.4)	0.937
Diabetes	145 (23.9)	48 (22.2)	0.855
CHD	130 (21.5)	54 (25)	0.158
Heart failure	16 (2.6）	2 (0.1)	0.139
Stroke	174 (28.7)	66 (30.1)	0.609
Renal failure	72 (11.9)	22 (10.2)	0.641
Liver disease	65 (10.7)	16 (7.4)	0.160
CCI>2	112 (18.5)	62 (28.7)	0.518
⩾2 Comorbidities	395 (65.0)	144 (66.7)	0.693
Antiplatelet/ anticoagulant use	220 (36.3)	70 (32.1)	0.304
HR (SD)	82 (15)	82 (16)	0.752
SBP, mmHg (SD)	122 (20)	126 (23)	0.261
Hb, g/dL (SD)	91 (29)	84 (24)	0.147
Coagulopathy, INR ≥ 1.5	19 (3.1)	14 (6.5)	0.032
BUN,mmol/L (SD)	12.5 (8.7)	11.4 (6.5)	0.221
Creatinine,μmol/L (SD)	107 (86)	109 (97)	0.820
Albumin,g/L(SD)	33.7 (6.0)	35.6 (6.0)	0.820

CCI Charlson comorbidity index, HR heart rate, SBP systolic blood pressure, Hb hemoglobin,INR international normalized ratio.

Table 2 Demographics and Mean clinical parameters of the study population in the derivation cohort

Variable	Total cohort （n =606）	Not safely discharged,NSD （n=304）	safely discharged,SD （n=302）	P- value
Male,n(%)	404 (66.7）	196 (64.5)	208 (68.9)	0.075
Median age, year(IQR)	74(68-79)	73（67-78）	75（69-79）	0.417
Comorbidities,n(%)				
Any malignancy	110 (18.2)	70 (23.0)	40 (13.2)	**<0.01**
Hypertention	346 (57.1)	168(55.3)	178 (58.9）	0.360
Diabetes	145 (23.9)	61 (20.1)	84 (27.8)	**<0.05**
Coronary heart disease	130 (21.5)	62 (0.4)	68 (22.5)	0.611
Heart failure	16 (2.6）	8 (2.6)	8 (2.6)	0.989
Stroke	174 (28.7)	78 (25.7)	96 (31.8)	0.095
Renal failure	72 (11.9)	48 (15.8)	26 (8.6)	**<0.01**
Liver disease	65 (10.7)	40 (13.2)	25 (8.3)	0.052
CCI SCORE >2	112 (18.5)	84 (27.6）	28 (9.3)	**<0.01**
Antiplatelet/anticoagulant	220 (36.3)	102 (33.6)	118 (39.1)	0.318

use				
HR (SD)	82 (15)	84 (16)	80 (13)	**0.019**
≥ 100	76 (12.5)	52 (17.2)	24 (7.9)	
SBP, mmHg (SD)	122 (20)	119 (21)	128 (19)	**<0.01**
< 100	60 (10.0)	50 (16.4)	10 (3.3）	
Hb, g/dL (SD)	91 (29)	76 (26)	106 (23)	**<0.01**
< 10	390 (64.4)	260 (85.5)	130 (43.0)	
Coagulopathy, INR ≥ 1.5	19 (3.1)	17 (5.6)	2 (0.7）	**<0.01**
BUN,mmol/L (SD)	12.5 (8.7)	14.4 (9.5)	10.7 (7.4)	**<0.01**
≥ 6.5	436 (71.9)	244 (80.3)	192 (63.6)	
Creatinine,μmol/L (SD)	107 (86)	114 (97)	100 (73)	0.954
>100	182 (30.0)	114 (37.5)	68 (22.5)	
Albumin,g/L(SD)	33.7 (6.0)	31.6 (5.9)	35.9 (5.1)	**<0.01**
<30	160 (26.4)	128 (42.1)	32 (10.6)	

CCI Charlson comorbidity index, HR heart rate, SBP systolic blood pressure, Hb hemoglobin, INR international normalized ratio.

Table 3 displays the clinical outcomes and therapeutic interventions. More than a third of patients required blood transfusion (n = 268/606, 44.2%), and 124 (20.5%) suffered rebleeding. Overall, 108 patients (17.8%) underwent a therapeutic intervention during admission. Fifty (8.4%) required admission to the intensive care unit. The mortality rate was 8.6% (52 patients).

Table 3 Severity outcome and therapeutic interventions of the study population in the derivation cohort

Variable	N(%)
Rebleeding	124 (20.5%)
Required blood transfusion	268 (44.2%)
therapeutic intervention (total)	108(17.8%)
Endoscopic treatment	80 (13.2)
Radiologic intervention	6 (1.0)
surgery	15 (2.8)
Endoscopy+radiology	4 (0.7)
Endoscopy+surgery	2 (0.3)
radiology+surgery	1 (0.2)
mortality	52 (8.6%)
ICU admission	50 (8.4%)

Logistic regression

Based on calculations from the derivative cohort, significant predictors ($P < 0.05$)

included: CCI > 2, HR ⩾ 100, SBP < 100 mmHg, BUN ⩾ 6.5mmol/L, Hb < 10 g/dL, albumin < 30 g/L, coagulopathy (INR ⩾ 1.5), and creatinine >100 μmol/L (Table 4).

Table 4 Univariable analysis for predictive factors of NSD in the derivation cohort

Variable	Univariate analysis	
	Odds ratio (95% CI)	P value
Age ≥65	1.51 (0.96-2.38)	0.075
Gender, male	0.82 (0.51-1.32)	0.417
CCI > 2	3.74 (1.94-7.20)	**<0.001**
Antiplatelet/anticoagulant use	0.79 (0.49-1.26）	0.318
HR ≥ 100	2.39 (1.16-4.94)	**0.019**
SBP< 100mmHg	5.75 (2.14-15.46)	**<0.001**
BUN ≥6.5mmol/L	2.33 (1.39-3.92)	**<0.001**
Hb< 10g/dL	7.82 (4.49-13.62)	**<0.001**
Albumin<30g/L	6.14 (3.33-11.30)	**<0.001**
INR ≥1.5	9.38 (2.13-41.36)	**0.003**
Creatinine >100μmol/L	1.93(1.17-3.19)	**0.010**

CCI Charlson comorbidity index, HR heart rate, SBP systolic blood pressure, Hb hemoglobin,INR international normalized ratio.

These variables were included in a multivariate logistic regression model—CCI > 2, SBP < 100 mmHg, BUN ⩾ 6.5mmol/L, Hb < 10 g/dL, and albumin <30g/L were statistically significant in predicting NSD (Table 5). The final logistic regression function was log (odds of NSD) = 0.636 (BUN) + 1.616 (Hb) +1.065 (albumin) + 0.455 (CCI) +1.479 (SBP)-2.193. These variables were used to develop a prognostic scoring model (Table 6).

Table 5 Multivariable logistic regression analysis for predictive factors of NSD in the derivation cohort

Variable	*β*	*Ward*	*OR*	*P*	95%*CI*
CCI > 2	0.455	5.616	1.576	0.018	1.082-2.295
SBP< 100mmHg	1.479	6.735	4.726	0.009	0.955-23.377
BUN ≥6.5mmol/L	0.636	3.969	1.890	0.046	1.010-3.534
Hb< 10g/dL	1.616	27.883	5.033	<0.001	2.763-9.169
Albumin<30g/L	1.065	9.339	2.901	0.002	1.465-5.743
	-2.193	38.259	-	<0.001	-

Table 6 Prognostic factors for NSD for inclusion in our clinical risk score

Clinical predictive risk factor	Score
S: SBP< 100mmHg	3
A: Albumin<30g/L	2
H: Hb< 10g/dL	3
C: CCI > 2	1
N: BUN ≥6.5mmol/L	1

The optimum cutoff was ≥ 1 point(s), the sensitivity was 97.37%, the specificity was 19.21%, the positive predictive value was 54.8%, and the negative predictive value was 87.9% for predicting NSD (Table 7). Only GBS ≤ 1 and our risk score = 0 achieved a sensitivity at 97.37%; AIMS65 = 0 and MAP(ASH) = 0 had maximal sensitivities of 96.71% and 79.61%, respectively. Our risk score performed better than GBS ≤ 1 for correctly classifying patients who could safely be discharged ($p < 0.05$). Our risk score had a specificity of 19.21% at a sensitivity of 97.37% compared to a specificity of 11.92% and sensitivity of 97.37% with GBS ≤ 1.

Table 7 Clinical risk score for NSD with sensitivity, specificity, PPV and NPV

Scores	Cutoff value	Sensitivity (%)	Specificity (%)	PPV (%) (95%*CI*)	NPV (%) (95%*CI*)
CSHAN	≥1	97.37	19.21	54.8(52.8-56.8)	87.9(72.3-95.3)
GBS	≥2	97.37	11.92	52.7(51.1-54.3)	81.8(60.9-92.8)
AIMS65	≥1	96.71	9.27	51.8(50.3-53.2)	73.7(50.8-88.3)
MAP(ASH)	≥1	79.61	41.06	57.6(53.8-61.4)	66.7(58.1-74.3)

The AUCs of our risk score, GBS, MAP(ASH), and AIMS65 are displayed in Table 8 and Figure 1. For both cohorts, our risk score had the largest AUCs of 0.806 and 0.807, respectively, which were significantly higher than those of GBS, MAP(ASH), or AIMS65 ($p < 0.05$).

Table 8 Values of the three scoring systems in the prediction of NSD

Derivation cohort	AUC (95%*CI*)	P			
		CSHAN	GBS	AIMS65	MAP(ASH)
CSHAN	0.806	*	0.019	0.025	0.031

	(0.756-0.849)				
GBS	0.762 (0.708-0.815)	0.019	*	0.034	0.035
AIMS65	0.711 (0.661-0.781)	0.025	0.034	*	0.030
MAP(ASH)	0.669 (0.612-0.721)	0.031	0.035	0.030	*
Validation cohort	AUC (95%*CI*)	P			
		CSHAN	GBS	AIMS65	MAP(ASH)
CSHAN	0.807 (0.722-0.892)	*	0.046	0.053	0.034
GBS	0.788 (0.698-0.878)	0.046	*	0.060	0.049
AIMS65	0.689 (0.587-0.792)	0.053	0.060	*	0.062
MAP(ASH)	0.767 (0.720-0.877)	0.034	0.034	0.062	*

Discussion

The mortality rate for non-variceal UGIB decreased from 4.5% in 1989 to 2.1% in 2009, and the incidence decreased from 108 to 78 cases per 100,000 population in 1994 and 2009. However, the economic burden of immediate hospitalization for UGIB increased from $3.3 billion to $7.6 billion, and a similar trend was observed for variceal UGIB [23].

Barkun et al. proposed that using a prognostic score system and early discharge with low risk would reduce the associated costs without increasing harm [16]. The initial assessment aimed to determine whether admission was required or an endoscopic intervention was required urgently or could be managed in the outpatient setting [24].

Several risk-scoring systems have been used for UGIB patients; however, most are used to predict mortality, rebleeding, and intervention as endpoints [5-9]. The full RS was derived in 1996 from 4185 cases of UGIB in the UK and designed to predict mortality [5]. Because the full RS relied on endoscopic findings, its use in initial ED assessment was limited.

Blatchford et al. cited hemoglobin, blood urea, pulse, SBP, presentation with syncope or melena, and evidence of hepatic disease or cardiac failure as factors predicting the need for intervention [25]. The 2019 International Consensus Group guidelines recommended a GBS≤ 1 to identify patients at very low risk for rebleeding or mortality and thus may not require

hospitalization or inpatient endoscopy [16]. GBS is clinically useful; however, it is evaluated using eight factors, making calculations cumbersome and decreasing its use in clinical practice in China.

Saltzman et al. constructed a prediction model named AIMS65 comprising albumin, INR, altered mental status, blood pressure, and age to predict death; they reported an area under the ROC of 0.77 for predicting death [6]. AIMS65 provided a more age-appropriate score and might be a beneficial supplement to a risk stratification model for distinguishing high-risk patients. The International Consensus Group recommended against using the AIMS65 prognostic score to predict the need for hospitalization [16]. MAP (ASH) score was established in 2020. MAP (ASH) has good predictive accuracy for intervention and mortality [9]. However, it was a new risk score, and further research is needed to confirm its predictive effect. Furthermore, there were few studies on those score systems on geriatric patients to validate whether they suit elderly patients. Our previous research [26] found that MAP (ASH), GBS, AIMS65, and pRS only performed reasonably in predicting mortality and intervention with the AUROCs all below 0.8, indicating they might not be very suitable for elderly patients.

It is challenging to determine the most critical outcomes in patients with UGIB. Initially, death was the priority; however, studies showed that the mortality rate of UGIB had decreased in the last two decades [23]. Increasing attention was paid to risk scores to predict profitable outcomes such as safe discharge [16], in which low-risk patients could avoid hospitalization and be managed as outpatients.

We derived a simple risk score system with five variables that can be used to distinguish between patients who can be safely managed as outpatients and those who will benefit from inpatient care. The system was designed to prevent rebleeding, blood transfusion, and hospital-based intervention to control bleeding and death to capture adverse events. Previous studies had reported that unstable vital signs, anemia, hypoproteinemia, azotemia, and existing comorbidities were predictive of adverse outcomes [25, 27]. In our study, we identified CCI > 2, SBP < 100 mmHg, Hb < 10 g/dL, BUN $\geqslant$ 6.5 mmol/L, and albumin < 30 g/L as risk factors. We included the use of antiplatelet/anticoagulant medications, INR $\geqslant$ 1.5, age, sex, heart rate, and creatinine in the model; however, these were not statistical predictors and therefore were not included in the score. Other studies suggested that the use of antiplatelet or anticoagulant

medications and coagulopathy might be related to the increased severity of bleeding [7, 28]. Still other studies found that advancing age and creatinine were risk factors for predicting adverse outcomes [25, 27]. These findings are inconsistent with our results, probably because the target populations differ.

In practice, risk stratification scores are used to guide clinical care to select thresholds that maximize sensitivity and minimize false negatives. The guidelines suggest that patients with GBS $\leqslant$ 1 might be discharged to outpatient management because very few of these patients require hospital-based intervention or blood transfusion or die. In our study, the GBS $\leqslant$ 1 recommended by the guidelines as a cutoff value had a sensitivity of 97.37% and a specificity of 11.92 % for the composite outcome. At the matched sensitivity of 97.37% (compared with GBS), the specificity significantly increased from 11.92% to 19.21%, suggesting that our score could increase the number of patients who could be safely discharged by more than 1.5-fold.

Our risk score predicted the composite outcome in the present cohort better than the current commonly used clinical risk scores (GBS, AIMS65, and MAP[ASH]). Our score improves the ability to identify very low-risk elderly patients who can be safely discharged.

A patient scoring 0 points at presentation has an 87.9% chance of safe discharge from the ED. We recommend using this threshold for patients with no other hospitalization indications. In our cohort, 30–50% of patients presenting with UGIB could be safely discharged. A large micro-cost study in UGIB found that the average cost per patient was £2,458 in the UK, and 60% of the cost was attributed to the cost of an inpatient bed. A 30–50% reduction in hospital admissions would reduce the financial burden [29].

This study has several limitations. This was a single-center retrospective study; patients discharged directly from ED were omitted, which might have led to selection bias. However, the patients suitable for discharge directly from ED were likely to be safely discharged with UGIB and might not significantly impact our risk score. An integral part of the safe discharge outcome is the absence of blood transfusion, which might be inaccurate because many transfusions might be considered unneeded when layered according to vital signs and anemia [30, 31]. These factors might lead to underestimating the ratio of patients who can be discharged safely.

Our study was based on clinically accessible risk stratification for elderly patients with

UGIB. To our knowledge, ours is the first analysis of this type. The ROC curve showed higher predictive accuracy and sensitivity for patients with a threshold $\geqslant$ 1 point, which would facilitate the discharge of low-risk patients. The model is easy to implement and can assist clinical decision-making and early identification of patients with severe UGIB requiring aggressive blood cell transfusion, entering monitoring units, and requiring intervention.

In conclusion, our risk score uses five easily quantifiable fundamental predictors and is easy to calculate. Compared with the previously available four risk scores, our prediction of safe discharge was the best. The score could be included in the acute medical triage route to identify UGIB patients who can be safely discharged. Further research is required to validate these findings.

Abbreviations

UGIB: Upper gastrointestinal bleeding; GBS: Glasgow Blatchford score; RS: the full Rockall score; AUCs: area under the receiver operator characteristics curves;

Acknowledgments

Not applicable.

Authors' contributions

YL, QL,and XO conceived of the study. YL, MS, and KW contributed to data collection. XO was responsible for data analyses. All authors contributed to interpretation of the results. YL drafted the manuscript. All authors contributed to the refinements of the manuscript and approved the final manuscript for publication. XO is the guarantor of the manuscript.

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Availability of data and materials

YL, MS and KW began to collect data from 3rd July 2022 to 6th September. The datasets generated and/or analyzed during the current study are not publicly available due [Belong to Zhongda Hospital] but are available from the corresponding author upon reasonable request.

Ethics approval and consent to participate

This study was approved by the Ethics Committee for Clinical Research of Zhongda Hospital, affiliated to Southeast University. This study used the medical records obtained from the past clinical diagnosis and treatment. Upon application, the Ethics committee agreed that informed consent was not required. All methods were carried out in accordance with relevant guidelines and regulations. The ethics reference number: 2021ZDSYLL333-P01.

Consent for publication

Not available.

Competing interests

All the authors declare that they have no conflicts of interest.

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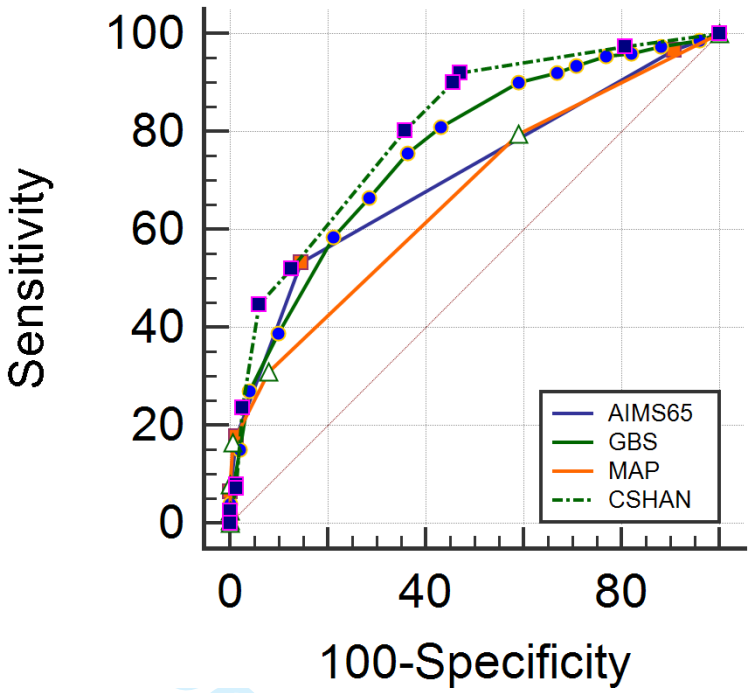
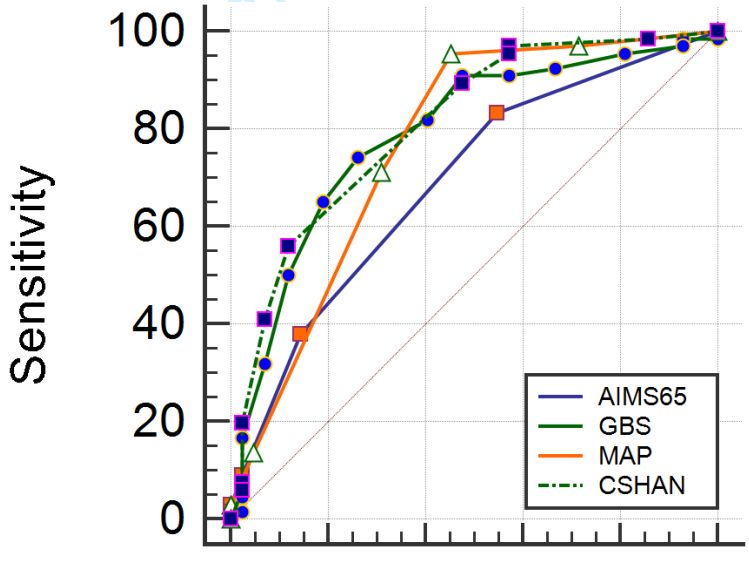
Figure legend

Fig 1 curves for three scoring systems in evaluation of NSD



1(a) Derivation cohort



1(b) Validation cohort

Fig 1 curves for three scoring systems in evaluation of NSD

TRIPOD Checklist: Prediction Model Development and Validation

Section/Topic	Item		Checklist Item	Page
Title and abstract				
Title	1	D;V	Identify the study as developing and/or validating a multivariable prediction model, the target population, and the outcome to be predicted.	1
Abstract	2	D;V	Provide a summary of objectives, study design, setting, participants, sample size, predictors, outcome, statistical analysis, results, and conclusions.	1-2
Introduction				
Background and objectives	3a	D;V	Explain the medical context (including whether diagnostic or prognostic) and rationale for developing or validating the multivariable prediction model, including references to existing models.	3-4
	3b	D;V	Specify the objectives, including whether the study describes the development or validation of the model or both.	4
Methods				
Source of data	4a	D;V	Describe the study design or source of data (e.g., randomized trial, cohort, or registry data), separately for the development and validation data sets, if applicable.	5
	4b	D;V	Specify the key study dates, including start of accrual; end of accrual; and, if applicable, end of follow-up.	5
Participants	5a	D;V	Specify key elements of the study setting (e.g., primary care, secondary care, general population) including number and location of centres.	
	5b	D;V	Describe eligibility criteria for participants.	
	5c	D;V	Give details of treatments received, if relevant.	
Outcome	6a	D;V	Clearly define the outcome that is predicted by the prediction model, including how and when assessed.	5
	6b	D;V	Report any actions to blind assessment of the outcome to be predicted.	
Predictors	7a	D;V	Clearly define all predictors used in developing or validating the multivariable prediction model, including how and when they were measured.	6
	7b	D;V	Report any actions to blind assessment of predictors for the outcome and other predictors.	
Sample size	8	D;V	Explain how the study size was arrived at.	
Missing data	9	D;V	Describe how missing data were handled (e.g., complete-case analysis, single imputation, multiple imputation) with details of any imputation method.	7
Statistical analysis methods	10a	D	Describe how predictors were handled in the analyses.	6-7
	10b	D	Specify type of model, all model-building procedures (including any predictor selection), and method for internal validation.	6-7
	10c	V	For validation, describe how the predictions were calculated.	7
	10d	D;V	Specify all measures used to assess model performance and, if relevant, to compare multiple models.	10
	10e	V	Describe any model updating (e.g., recalibration) arising from the validation, if done.	
Risk groups	11	D;V	Provide details on how risk groups were created, if done.	5
Development vs. validation	12	V	For validation, identify any differences from the development data in setting, eligibility criteria, outcome, and predictors.	8
Results				
Participants	13a	D;V	Describe the flow of participants through the study, including the number of participants with and without the outcome and, if applicable, a summary of the follow-up time. A diagram may be helpful.	
	13b	D;V	Describe the characteristics of the participants (basic demographics, clinical features, available predictors), including the number of participants with missing data for predictors and outcome.	8
	13c	V	For validation, show a comparison with the development data of the distribution of important variables (demographics, predictors and outcome).	8
Model development	14a	D	Specify the number of participants and outcome events in each analysis.	
	14b	D	If done, report the unadjusted association between each candidate predictor and outcome.	
Model specification	15a	D	Present the full prediction model to allow predictions for individuals (i.e., all regression coefficients, and model intercept or baseline survival at a given time point).	10
	15b	D	Explain how to the use the prediction model.	11
Model performance	16	D;V	Report performance measures (with CIs) for the prediction model.	12
Model-updating	17	V	If done, report the results from any model updating (i.e., model specification, model performance).	
Discussion				
Limitations	18	D;V	Discuss any limitations of the study (such as nonrepresentative sample, few events per predictor, missing data).	17-18
Interpretation	19a	V	For validation, discuss the results with reference to performance in the development data, and any other validation data.	16
	19b	D;V	Give an overall interpretation of the results, considering objectives, limitations, results from similar studies, and other relevant evidence.	13-15
Implications	20	D;V	Discuss the potential clinical use of the model and implications for future research.	13-17
Other information				
Supplementary information	21	D;V	Provide information about the availability of supplementary resources, such as study protocol, Web calculator, and data sets.	
Funding	22	D;V	Give the source of funding and the role of the funders for the present study.	

*Items relevant only to the development of a prediction model are denoted by D, items relating solely to a validation of a prediction model are denoted by V, and items relating to both are denoted D;V. We recommend using the TRIPOD Checklist in conjunction with the TRIPOD Explanation and Elaboration document.