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A Novel Nomogram for Predicting Rebleeding in Patients with Acute Non-variceal Upper Gastrointestinal Bleeding: A Retrospective Cohort Study

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Abstract

Rebleeding remains a substantial complication in patients with acute non-variceal upper gastrointestinal bleeding (ANVUGIB), often leading to extended hospitalization and adverse outcomes. This study aimed at developing a clinically useful predictive model for identifying ANVUGIB patients with an increased risk of rebleeding. This retrospective study included 638 patients diagnosed with ANVUGIB at the Central Hospital of Wuhan between January 2016 and December 2020. Data on patient demographics, hemodynamic parameters, clinical characteristics, and factors potentially influencing rebleeding were collected. Predictor variables were identified using least absolute shrinkage and selection operator (LASSO) regression, followed by multivariable logistic regression to develop a nomogram for predicting in-hospital rebleeding. The model's discriminative ability was evaluated using the area under the receiver operating characteristic curve (AUROC). Calibration plots were utilized to assess model calibration. Internal validation was performed through bootstrap resampling, and the clinical utility of the nomogram was examined using decision curve analysis(DCA). The DeLong test was employed to statistically assess the differences in discriminatory ability between the proposed model and established prognostic tools, including the AIMS65, Glasgow-Blatchford score, and Rockall score. The study included 638 ANVUGIB patients, with 61(9.6%) experienced rebleeding during their hospitalization. A prediction model was constructed based on three predictors of rebleeding: serum albumin levels, endoscopic risk classification, and the American Society of Anesthesiologists (ASA) score. The model exhibited excellent discrimination performance with an AUROC of 0.870 (95% confidence interval: 0.820-0.921). The calibration curve indicated good consistency between predicted and observed rebleeding events. The calibration-in-the-large value was 0.001, with a calibration slope of 0.994. DCA suggested that the nomogram offered considerable clinical net benefit across a threshold probability range of 2% to 70%. Furthermore, the new nomogram demonstrated significantly superior discrimination compared to established scoring systems. To sum up, the novel model exhibited robust predictive performance for rebleeding risk among patients with ANVUGIB, providing a reliable tool to assist clinical decision-making.

Introduction

Acute upper gastrointestinal bleeding (AUGIB) is defined as bleeding originating from the gastrointestinal tract proximal to the ligament of Treitz. Clinical guidelines usually classify AUGIB into variceal (AVUGIB) and non-variceal bleeding (ANVUGIB) owing to the substantial differences in management strategies and clinical outcomes across these two bleeding types.[1, 2]. The most common causes of AUGIB are nonvariceal. The common causes include gastric and duodenal peptic ulcers, mucosal erosive disease of the esophagus, stomach, and duodenum, malignancy, and other less frequent causes include Mallory-Weiss syndrome, vascular malformation such as Dieulafoy lesions[2]. Although the overall incidence of ANVUGIB has declined over the past two decades, the reduction in global mortality related to ANVUGIB has not been significant[3-5]. Rebleeding is a well-established predictor of mortality in AUGIB[6, 7]. It also significantly impacts other critical outcomes, including transfusion requirements, the need for surgical intervention, prolonged hospital stays, and higher healthcare costs. Therefore, accurate identification of patients at high risk of rebleeding is crucial for optimizing patient management, facilitating precise risk stratification, and guiding customized treatment plans.

Although a wealth of risk factors for rebleeding have been documented to date in AUGIB, developing optimized predictive models remains challenging[8-14]. Well validated scoring systems, such as the Glasgow-Blatchford score(GBS)[15], Rockall score[6], ABC score[16], and AIMS65 score[17], are valuable tools for assessing adverse outcomes in AUGIB. These scores provide insights into mortality risk (Rockall, AIMS65, ABC) as well as the need for intervention (GBS). However, their predictive performance for rebleeding is limited[18, 19], which may be attributed to the substantial differences in risk factors between variceal and non-variceal upper gastrointestinal bleeding. Major risk factors for variceal bleeding include portal hypertension, the Child-Pugh classification, and variceal diameter[20-22], while non-variceal rebleeding is mainly influenced by factors defined by the Forrest classification[2]. Current scoring systems fail to account for these heterogeneous risk profiles, leading to unsatisfactory predictive performance for rebleeding across all subtypes of AUGIB.

This study aimed to develop and validate a novel predictive model for accurately estimating the

risk of post-endoscopic rebleeding in patients with ANVUGIB. We performed a comparative analysis to evaluate the new model's performance against existing scoring systems. We hypothesize that the model will improve risk stratification, enabling clinicians to identify patients at high risk of rebleeding earlier and to implement timely, appropriate therapeutic interventions.

Methods

Patient population and study design

This study is a retrospective cohort study that collected data from patients hospitalized for hematemesis/coffee ground vomiting, melena, hematochezia, or a combination of any of the above within 24 hours before admission, with or without peripheral circulation disorders (dizziness, palpitation, amaurosis, transient syncope, shock, etc.) at the Central Hospital of Wuhan from December 2021 to December 2023. Inclusion criteria were: (1) patients with age exceeding 18 years, (2) Patients with non-variceal upper gastrointestinal bleeding confirmed by endoscopy within 24 hours after admission. Exclusion criteria included: (1) upper gastrointestinal UGIB during hospitalization; (2) transfer from other hospitals; (3) endoscopic confirmation of variceal bleeding; (4)lower gastrointestinal bleeding manifested as bloody stool. (5) bleeding attributed to systemic diseases such as disseminated intravascular coagulation (DIC) and hematological disorders; (6) significant missing and incomplete clinical records; (7) patients who either requested early discharge or declined gastroscopy; (8) death within 48 h after admission. This study followed the Transparent Reporting of a Multivariable Prediction Model for Individual Prognosis or Diagnosis (TRIPOD) reporting guidelines[23]. The study flowchart is depicted in Figure 1.

Study groups: Patients were stratified into rebleeding group and non-rebleeding group based on whether rebleeding occurred.

Ethics Statement: The study received approval from the Ethics Committee of the Central Hospital of Wuhan and was conducted strictly according to the ethical principles delineated in the Declaration of Helsinki. Due to the retrospective nature of the study, the ethics committee was granted a waiver for the requirement of signed informed consent from participants. All personally

identifiable information concerning the enrolled patients was anonymized and replaced with a coding system to ensure confidentiality.

Data collection and definition

The following clinical data were collected: (1) demographic data (sex and age), any significant comorbidities, and medication history in the 7 days preceding the bleeding episode (including antiplatelet drugs, oral anticoagulant agents and/or non-steroidal anti-inflammatory drugs); (2) clinical symptoms and physical examination findings recorded at the time of admission, including hematemesis and melena, hemodynamic data; (3) baseline laboratory data, obtained upon admission and completed before endoscopy; (4) endoscopy findings including major stigmata of recent hemorrhage (dark spot; presence of blood in the upper gastrointestinal tract; adherent clot; visible or spurting vessel); (5) Pre-endoscopy scores such as GBS, AIMS65, ABC, and MAP(ASH) scores were calculated based on information available before endoscopy. The Rockall score is acquired after endoscopy.

Clinical management and endoscopic hemostasis followed standard guideline-based principles[24-26]. All patients received standard high-dose proton pump inhibitors (PPIs) therapy (intravenous loading dose followed by continuous infusion) before and after endoscopy for 72 hours. The endoscopic procedures were conducted by experienced endoscopists within 24 hours of patient admission. A single-channel endoscope (GIF-XQ290, Olympus Optical Co., Ltd., Japan) was used during the procedure. Endoscopic hemostasis techniques (injection of epinephrine, sclerosing agent, electrocoagulation, argon plasma coagulation, and hemoclip placement) were selected based on the cause of bleeding as recommended by guidelines[27, 28]. Post-endoscopic medical management (proton pump inhibitor administration at a standardized dose, fluid resuscitation, vital sign monitoring) followed a unified protocol. For patients experiencing rebleeding, repeat endoscopy was conducted, and then salvage intervention strategies (endoscopic therapy, transcatheter arterial embolization, or surgical intervention) were determined by a multidisciplinary team (gastroenterologists, interventional radiologists and surgeons) through clinical consultation. The management of antithrombotic therapy is typically individualized. During the acute bleeding phase, all anticoagulant and antiplatelet medications were temporarily discontinued upon admission to facilitate hemodynamic stabilization and successful endoscopic

hemostasis. For patients at high thrombotic risk (e.g., those with recent coronary stenting or mechanical heart valves), clinical decisions were made through multidisciplinary consultation involving cardiologists or neurologists. The resumption of antithrombotic agents was not fixed but was tailored to each patient, typically occurring 1 to 7 days after successful hemostasis, provided there were no clinical signs of rebleeding.

Rebleeding was defined as the recurrence of bleeding stigmata after initial successful hemostasis, confirmed by the presence of at least one of the following criteria[29-31]: (1) recurrent hematemesis, or the recurrence of melena or hematochezia following the normalization of stool color (i.e., turning yellow); (2) recurrent tachycardia (heart rate ≥110 beats/min) or hypotension (systolic blood pressure ≤ 90 mmHg) after initial hemodynamic stabilization, following the exclusion of other explanatory clinical causes; (3) a hemoglobin decrease of ≥2 g/dL within 24 hours of stabilization; or (4) presentation of active hemorrhage or the presence of fresh blood pooling and adherent clots during repeat endoscopy. The physical status of the patient was evaluated according to the American Society of Anesthesiologists (ASA) classification at the time of admission[32]. Endoscopic rebleeding risk classification was stratified into high-risk and low-risk groups based on the stigmata of recent hemorrhage, adapted from the Forrest classification and the Rockall scoring system[6]. Specifically, the 'High-Risk' group was defined by the presence of active stigmata (active spurting or oozing bleeding), a non-bleeding visible vessel, or an adherent clot at the bleeding source. Conversely, the 'Low-Risk' group was defined by the presence of inactive findings, including a flat pigmented spot or a clean-based lesion.

Sample size determination.

The minimum sample size required for the development of a new multivariable prediction model with a binary outcome was computed using the "pmsampsize" R package[33]. Given an anticipated C-statistic of 0.85 and a maximum of 10 candidate predictor parameters to be considered for inclusion, the required minimum sample size was determined to be 523. The final sample size included in this study was 638, fulfilling the requirements for model development.

Statistical analysis

The normality of measurement data was assessed using the Kolmogorov–Smirnov method. Normally distributed data were reported as mean ± standard deviation(SD), with comparisons

between groups conducted using the independent samples t-test. non-normally distributed data were reported as median (interquartile range), and the Mann-Whitney U test was utilized for between-group comparisons. Categorical variables were described as counts (percentages), with comparisons between groups performed using the chi-square test, adjusted chi-square test, or Fisher's exact test as appropriate. Univariate logistic regression was utilized to identify potential risk factors for rebleeding, with variables achieving $P < 0.05$ included in a multivariate logistic regression. The least absolute shrinkage and selection operator (LASSO) regression, suitable for high-dimensional data, was employed for predictor selection and regularization. The nonlinear relationships among variables were assessed using restricted cubic splines (RCS). Logistic regression analysis was then applied to develop a predictive model for rebleeding events. A nomogram was constructed based on this model. The area under the curve (AUC) was computed to evaluate the model's discriminative ability, and internal validation was performed using a bootstrap resampling method with 1,000 iterations. The DeLong test was used to compare the AUC between the nomogram and other scoring systems. Additionally, decision curve analysis (DCA) was utilized to assess the model's clinical utility by quantifying the net benefits across various threshold probabilities. All statistical analyses were conducted using R 4.2.1 (www.r-project.org), and P-values < 0.05 are considered statistically significant.

Missing Data

Missing data patterns are summarized in Table S1. K-nearest neighbors (KNN) imputation was chosen to handle missing values. The "impute_knn" function from the "simputation" package was utilized to fill in missing values based on the similarity of observations in the feature space.

Results

Baseline Characteristics

638 patients met the inclusion criteria and were included in the analysis. Among these patients, 61 (9.6%) experienced rebleeding during hospitalization. Table 1 presents the general characteristics of all enrolled patients. Of the 638 patients, 505 (79.2%) were male and 133 (20.8%) were female. The overall median age was 63 years, with 61 years in the non-rebleeding group and 69 years in the rebleeding group. Melena was the chief complaint in 73.7% of the patients, while hematemesis

was reported in 39.2% of cases. Patients with underlying conditions such as chronic kidney disease, pulmonary disease, and liver disease had significantly higher rebleeding rates. Significant intergroup differences were observed in the following laboratory parameters: hemoglobin concentration (HGB), platelet count (PLT), prothrombin time (PT), blood urea nitrogen (BUN), creatinine (Cr), and albumin (ALB) levels (all $P < 0.01$). The most frequent sites of bleeding were the duodenum(48.4%) and the stomach(38.9%). Gastrointestinal anastomotic bleeding occurred in fewer cases yet carried a higher rebleeding rate (25.7%). The etiology of non-variceal upper gastrointestinal bleeding was significantly associated with the risk of rebleeding in the univariate analysis ($p < 0.001$, Table 1). Peptic ulcers remained the primary cause of bleeding in both the rebleeding (75.4%) and non-rebleeding (84.6%) groups. Notably, the rebleeding rate among patients with vascular malformations was remarkably high at 53.3% (8/15), whereas the rebleeding rate was as low as only 2.1% (1 /48) among patients presenting with mucosal erosions.. Mallory–Weiss tears and tumors accounted for 6.6% and 3.3% of the rebleeding events, respectively. Patients classified as high-risk according to endoscopic criteria exhibited a significantly higer risk of rebleeding compared to low-risk patients ($P < 0.001$). Among the 428 patients initially identified with low-risk endoscopic findings, the rebleeding rate was about 3.0% (n=13). Despite the low incidence in this subgroup, these cases accounted for 21.3% (13/61) of the total rebleeding events in the cohort. Furthermore, individuals classified as ASA III or IV also presented a higher incidence of rebleeding ($P < 0.001$). The rebleeding cohort had a greater proportion of patients requiring transfusion and endoscopic treatment ($P< 0.001$). No association was found between the use of anticoagulants or antiplatelet antiplatelet and the risk of rebleeding($P=0.112$).

Variable Selection

Baseline demographics, clinical parameters, and endoscopic findings were subjected to univariate logistic regression. A relaxed threshold of $P < 0.05$ was used to screen potential candidates, which yielded 16 eligible variables. These 16 variables were included in the multivariate logistic regression analysis, and the results showed that only three variables (albumin level, endoscopic risk classification, and ASA classification) were independently associated with the risk of rebleeding(Table 2). To address potential collinearity among variables and to prevent overfitting of

the model, feature selection was performed using Lasso regression with the "glmnet" package (version 4.2.2) in R. This process included 86 candidate variables, and ten-fold cross-validation was performed to determine the optimal penalty parameter. We selected the lambda.1-se criterion as the optimal cutoff to enforce maximum sparsity and model interpretability. Three variables with non-zero coefficients were retained in the final model(Figure S1). Notably, these variables aligned with the results of the initial multivariate analysis. To explore potential nonlinear relationships, a restricted cubic spline (RCS) analysis of albumin level and rebleeding risk was conducted (Figure S2). As no significant nonlinearity was detected(p=0.308), the final model retained albumin as a continuous variable. Furthermore, the analysis presented in Table 1 indicated no significant differences in rebleeding rates between ASA I and II(5.8% vs 4.8%). In line with the findings of previous studies[16, 34-36], these two groups were combined for further analysis.

Development and Validation of the Rebleeding- prediction Nomogram

After identifying the final set of variables for the ANVUGIB rebleeding prediction model, the model was constructed using the “rms” package in R, and a nomogram was generated using the “nomogram” function (Figure 2). Patients were stratified into low and high-risk groups based on the classification threshold(P=0.143) determined by maximizing the Youden index. The nomogram achieved favorable accuracy in estimating the risk of rebleeding, with the area under the receiver operating characteristic curve (AUROC) of 0.870 (95%CI: 0.820–0.921). To assess the optimism-corrected discriminative performance of the predictive model, internal validation was employed via bootstrap resampling. Over 1000 bootstrap iterations, the model's bias-corrected AUROC for predicting rebleeding was estimated at 0.859 (95% CI: 0.841-0.876) (Figure 3).

Calibration curves were utilized to visually evaluate the concordance between predicted and observed rebleeding outcomes. The calibration plot presented in Figure 4A demonstrates good agreement between predicted and observed rebleeding risks, supported by a Hosmer-Lemeshow goodness-of-fit P-value of 0.977, a slope of 0.994 and an intercept of 0.001. Additionally, comparison of the predicted rebleeding probabilities derived from the nomogram model with the observed rebleeding rates showed a close match across different levels of risk groups (Figure 4B).

Clinical decision curve analysis was conducted to assess the practical utility of the model by quantifying the net benefit under different threshold probabilities [37]. The analysis showed that the

application of the nomogram model yielded an increased net benefit across threshold probabilities from 2% to 70% (Figure 5), outperforming both the "treat all" and "treat none" strategies. This suggests that the model has the potential to guide clinical decision-making and intervention strategies for ANVUGIB patients.

Comparison with Existing Scoring Systems

The Forrest classification is widely used in the prediction and management of gastrointestinal bleeding, and is typically employed to assess the risk of rebleeding and guide endoscopic treatment strategies. The widely used scoring systems including AIMS65, ABC, GBS, MAP (ASH)[35], CANUKA[38], and Rockall, which are commonly utilized as reference tools, are designed to predict mortality or the need for clinical intervention. We assessed their utility for forecasting rebleeding and compared their performance to that of the nomogram model. The nomogram demonstrated superior discriminative ability, achieving an AUC of 0.870, which was significantly higher than those of the Forrest classification(0.784; $P < 0.001$) and other scoring systems: including the GBS score (0.702; $P < 0.001$), full Rockall score (0.787; $P < 0.001$), ABC score (0.753; $P < 0.001$), AIMS65 score (0.694; $P < 0.001$), MAP score (0.757; $P < 0.001$), and CANUKA score (0.721; $P < 0.001$). The Forrest classification exhibited satisfactory sensitivity but lower specificity compared with the nomogram model. The CANUKA model had the highest sensitivity at 83.6% but a relatively low specificity of 49.4%, indicating a high rate of false positives. AIMS65 demonstrated the highest specificity at 92.7%, effectively predicting low-risk patients, yet it had a low sensitivity of 37.7%, which may overlook high-risk patients. Most of the compared models exhibit high NPV but relatively low PPV. In contrast, the nomogram had the highest PPV at 38.8%, and NPV at 96.9%(Table 3).

Discussion

Risk stratification in ANVUGIB is crucial for optimal patient care. The effective management of ANVUGIB relies on accurate risk stratification, resuscitation, pre-endoscopy and post-endoscopy management. Existing score systems are inadequate for accurately capturing the risk of rebleeding after initial treatment[39, 40]. Recent studies have developed nomogram-based models to predict

rebleeding in patients with ANVUGIB. For instance, Lai et al. (2022) proposed a nomogram focusing on specific high-risk ulcer patients within a 3-day rebleeding window, incorporating five predictors such as Albumin, prothrombin time, shock, hematemesis/melena, and Forrest classification. Li et al. (2023) employed age, hematemesis, PLT count, and D-dimer as predictos, while this study had a small sample size. In contrast, the present study included a broader ANVUGIB population and evaluated 7-day clinical outcome, and only employed three easily obtainable predictors—serum albumin, ASA score, and endoscopic classification. Our model achieved comparable discriminatory ability (AUROC $\approx$ 0.86) to those previously reported (~0.85 –0.88). Therefore, this study developed a simplified, broadly applicable, and efficient model for predicting rebleeding in patients with ANVUGIB.

It is reported that active bleeding at endoscopy was a major predictor for rebleeding in patients receiving endoscopic therapy[41-43]. The Forrest classification, widely employed to characterize the endoscopic presentation of ulcers, has been the mainstay for predicting rebleeding risk. It is recommended that clinicians employ this resource to inform clinical decisions about the requirement for endoscopic or surgical interventions[2]. However, its limitations are becoming increasingly apparent. Firstly, The perception and interpretation of the Forrest classification vary among different endoscopists[44, 45], which may affect their clinical decisions and, consequently, patient outcomes. Advancements in endoscopic techniques and standardized care practices bring significant improvements to patient clinical prognosis. Timely endoscopy (often within 24 hours) allows for early intervention on high-risk lesions, potentially changing rebleeding risk[46]. The Forrest classification relies solely on endoscopic stigmata and does not incorporate patient-related or physiological factors that also contribute to rebleeding risk, such as comorbidity status or nutritional reserve. In contrast, this study adopted a simplified classification method derived from the Forrest classification system, alongside the stigmata of recent hemorrhage criteria defined by the Rockall score. Endoscpic findings were categorized into high-risk and low-risk groups, which helps reduce the likelihood of misclassification among clinicians and also enables application to bleeding sources other than ulcers. In this study, our model demonstrated superior discriminative ability compared with the Forrest classification alone, indicating that integrating simple clinical

indicators with endoscopic findings can yield a more reliable and risk prediction of rebleeding in ANVUGIB patients.

ASA physical status classification is a widely adopted grading system for preoperative assessment of patients' baseline physical reserve and systemic comorbidity burden. Originally designed to stratify perioperative anesthetic and surgical risks, this scoring system has also been validated for risk prediction in multiple medical emergency settings, including acute gastrointestinal bleeding. Score systems and previous cohort studies have demonstrated that elevated ASA grades are strongly correlated with all-cause mortality in patients with acute GI bleeding[16, 35, 47-49]. Consistent with these observations, our study further identified that ASA III and IV classifications were significantly associated with an increased risk of post-endoscopic rebleeding. This association can be reasonably explained from two clinical perspectives. On one hand, higher ASA grades indicate severe, multiple underlying systemic disorders, which impair vascular healing and coagulation function, reduce microcirculatory perfusion, and diminish tissue repair capacity, thereby predisposing patients to recurrent bleeding. On the other hand, poor overall physical status restricts clinical therapeutic strategies. Endoscopic examination may be delayed, prolonging the vulnerable window and increasing patients' risk of rebleeding.

Albumin levels represent another pivotal prognostic indicator in gastrointestinal bleeding patients. Multiple studies have affirmed a significant association between hypoalbuminemia and increased rates of both mortality and rebleeding[11, 35, 50, 51]. Low albumin levels, a common laboratory finding in patients suffering from gastrointestinal bleeding, often indicate malnutrition, chronic illness, or acute systemic stress. Firstly, hypoalbuminemia decreases plasma oncotic pressure, transudating fluid into the interstitial space and triggering prominent mucosal and submucosal edema. This localized edema, coupled with compromised microcirculatory perfusion, severely destabilizes the bleeding lesion and hinders active wound healing. Secondly, hypoalbuminemia delays granulation tissue formation and epithelial repair, weakens the adhesion between blood clots and surrounding tissues, and thereby elevates the risk of recurrent bleeding.

Although the etiology of bleeding exhibited a strong correlation with rebleeding in univariate

analysis, their predictive value was likely superseded by more dominant endoscopic markers and systemic indicators in the multivariable analysis. This further implies that 'what the lesion looks like' is more predictive of rebleeding than 'what the lesion is'.

There are several strengths of the present study. First, the predictive variables included in the nomogram are objectively and clearly defined, which minimizes clinical ambiguity and ensures consistent assessment across different practitioners. In addition, the selection of a relatively small set of variables not only simplifes calculations but also reduces the risk of overfitting, thereby potentially enhancing the model's generalizability. Second, rather than relying solely on traditional univariate analysis, we employed the LASSO method. This approach enables the robust identification of optimal predictors from multidimensional data while effectively mitigating collinearity and multiplicity problems. Third, the nomogram model exhibited excellent discriminative performance and calibration, and the graphical presentation renders the model intuitive and readily applicable in clinical practice.

However, certain limitations must be acknowledged. First, the model was developed within a single medical center. This single-center design may inevitably limit the generalizability of our findings to other healthcare settings with different patient demographics. Single-center data are susceptible to biases arising from institutional treatment variations, such as specific endoscopic modalities, clinician preferences, which may fail to reflect broader clinical practices. Second, although regularization techniques were strictly applied during model construction, the absence of an external validation means that the risk of overfitting cannot be fully eliminated. Third, despite selecting variables based on both stringent statistical criteria and established clinical relevance, the potential influence of unmeasured baseline or intraprocedural confounders cannot be completely ruled out. Consequently, our nomogram warrants further prospective validation in a large, independent, and multi-center patient cohort in the future.

Conclusion

We developed and validated a novel risk prediction model to estimate the in-hospital and post-endoscopic rebleeding risk among patients presenting with ANVUGIB. This model enables effective risk stratification by categorizing patients into low- and high-rebleeding-risk subgroups. Furthermore, it delivers valuable prognostic evidence to guide clinical decision-making, which

may optimize therapeutic strategies and improve long-term patient outcomes.

Declarations

Ethical Approval and Consent to participate

This study was approved by the local Research Ethics Committee at the Central Hospital of Wuhan, with a waiver of informed consent granted.

Human Ethics

The study involving human participants conforms to the provisions of the Declaration of Helsinki.

Consent for publication

Consent for publication was obtained from the participants and all named authors.

Data availability statement

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

Code Availability

The R code utilized for statistical modeling, LASSO variable selection, and DeLong pairwise ROC comparisons in this study is publically available in the Zenodo repository at https://zenodo.org/records/21039234

Competing interests

The authors declare no competing interests.

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Authors' contributions

Junwei yan made substantial contributions to the conception, designed and performed most of the analysis, and wrote the manuscript. Shao Su'e, Zheng Yi, Chen Deqiong, and Xia Miao helped to collect and check the data. Heng Zhang revised the article critically for important intellectual content. All authors read and approved the final manuscript.

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References

[1] Kaplan D E, Ripoll C, Thiele M, et al. AASLD Practice Guidance on risk stratification and management of portal hypertension and varices in cirrhosis [J]. Hepatology, 2024, 79(5): 1180-211. DOI: 10.1097/HEP.0000000000000647.

[2] Gralnek I M, Stanley A J, Morris A J, et al. Endoscopic diagnosis and management of nonvariceal upper gastrointestinal hemorrhage (NVUGIH): European Society of Gastrointestinal Endoscopy (ESGE) Guideline - Update 2021 [J]. Endoscopy, 2021, 53(3): 300-32. DOI: 10.1055/a-1369-5274.

[3] Vora P, Pietila A, Peltonen M, et al. Thirty-Year Incidence and Mortality Trends in Upper and Lower Gastrointestinal Bleeding in Finland [J]. JAMA Netw Open, 2020, 3(10): e2020172. DOI: 10.1001/jamanetworkopen.2020.20172.

[4] Saydam Ş S, Molnar M, Vora P. The global epidemiology of upper and lower gastrointestinal bleeding in general population: A systematic review [J]. World J Gastrointest Surg, 2023, 15(4): 723-39. DOI: 10.4240/wjgs.v15.i4.723.

[5] Oakland K. Changing epidemiology and etiology of upper and lower gastrointestinal bleeding [J]. Best Pract Res Clin Gastroenterol, 2019, 42-43: 101610. DOI: 10.1016/j.bpg.2019.04.003.

[6] Rockall T A, Logan R F, Devlin H B, et al. Risk assessment after acute upper gastrointestinal haemorrhage [J]. Gut, 1996, 38(3): 316-21. DOI:

[7] Han Y J, Cha J M, Park J H, et al. Successful Endoscopic Hemostasis Is a Protective Factor for Rebleeding and Mortality in Patients with Nonvariceal Upper Gastrointestinal Bleeding [J]. Digestive Diseases and Sciences, 2016, 61(7): 2011-8. DOI: 10.1007/s10620-016-4082-9.

[8] Guglielmi A, Ruzzenente A, Sandri M, et al. Risk assessment and prediction of rebleeding in bleeding gastroduodenal ulcer [J]. Endoscopy, 2002, 34(10): 778-86. DOI: 10.1055/s-2002-34261.

[9] Lee H H, Park J M, Lee S W, et al. C-reactive protein as a prognostic indicator for rebleeding in patients with nonvariceal upper gastrointestinal bleeding [J]. Dig Liver Dis, 2015, 47(5): 378-83. DOI: 10.1016/j.dld.2015.02.008.

[10] Kim J S, Kim B-W, Park S M, et al. Factors Associated with Rebleeding in Patients with Peptic Ulcer Bleeding: Analysis of the Korean Peptic Ulcer Bleeding (K-PUB) Study [J]. Gut and Liver, 2018, 12(3): 271-7. DOI: 10.5009/gnl17138.

[11] Yue W, Liu Y, Jiang W, et al. Prealbumin and D-dimer as Prognostic Indicators for Rebleeding in Patients with Nonvariceal Upper Gastrointestinal Bleeding [J]. Dig Dis Sci, 2021, 66(6): 1949-56. DOI: 10.1007/s10620-020-06420-1.

[12] Tatliparmak A C, Dikme O, Dikme O, et al. Cancer, platelet distribution width, and total protein levels as predictors of rebleeding in upper gastrointestinal bleeding [J]. PeerJ, 2022, 10: e14061. DOI: 10.7717/peerj.14061.

[13] Tari E, Frim L, Stolcz T, et al. At admission hemodynamic instability is associated with increased mortality and rebleeding rate in acute gastrointestinal bleeding: a systematic review and meta-analysis [J]. Therap Adv Gastroenterol, 2023, 16: 17562848231190970. DOI: 10.1177/17562848231190970.

[14] Ito N, Funasaka K, Fujiyoshi T, et al. Risk factors for rebleeding in gastroduodenal ulcers

[J]. Ir J Med Sci, 2024, 193(1): 173-9. DOI: 10.1007/s11845-023-03450-2.

[15] Blatchford O, Murray W R, Blatchford M. A risk score to predict need for treatment for upper-gastrointestinal haemorrhage [J]. Lancet 2000, 356(9238): 1318-21. DOI:

[16] Laursen S B, Oakland K, Laine L, et al. ABC score: a new risk score that accurately predicts mortality in acute upper and lower gastrointestinal bleeding: an international multicentre study [J]. Gut, 2021, 70(4): 707-16. DOI: 10.1136/gutjnl-2019-320002.

[17] Saltzman J R, Tabak Y P, Hyett B H, et al. A simple risk score accurately predicts in-hospital mortality, length of stay, and cost in acute upper GI bleeding [J]. Gastrointest Endosc, 2011, 74(6): 1215-24. DOI: 10.1016/j.gie.2011.06.024.

[18] Orpen-Palmer J, Stanley A J. A Review of Risk Scores within Upper Gastrointestinal Bleeding [J]. J Clin Med, 2023, 12(11). DOI: 10.3390/jcm12113678.

[19] Kalkan C, Soykan I, Karakaya F, et al. Comparison of three scoring systems for risk stratification in elderly patients with acute upper gastrointestinal bleeding [J]. Geriatr Gerontol Int, 2017, 17(4): 575-83. DOI: 10.1111/ggi.12757.

[20] Xu L, Ji F, Xu Q-W, et al. Risk factors for predicting early variceal rebleeding after endoscopic variceal ligation [J]. World Journal of Gastroenterology, 2011, 17(28): 3347-52. DOI: 10.3748/wjg.v17.i28.3347.

[21] Bambha K, Kim W R, Pedersen R, et al. Predictors of early re-bleeding and mortality after acute variceal haemorrhage in patients with cirrhosis [J]. Gut, 2008, 57(6): 814-20. DOI: 10.1136/gut.2007.137489.

[22] Drolz A, Schramm C, Seiz O, et al. Risk factors associated with bleeding after prophylactic endoscopic variceal ligation in cirrhosis [J]. Endoscopy, 2021, 53(3): 226-34. DOI: 10.1055/a-1214-5355.

[23] Collins G S, Moons K G M, Dhiman P, et al. TRIPOD+AI statement: updated guidance for reporting clinical prediction models that use regression or machine learning methods [J]. BMJ 2024, 385: e078378. DOI: 10.1136/bmj-2023-078378.

[24] Barkun A N, Almadi M, Kuipers E J, et al. Management of Nonvariceal Upper Gastrointestinal Bleeding: Guideline Recommendations From the International Consensus Group [J]. Annals of Internal Medicine, 2019, 171(11): 805-22. DOI: 10.7326/M19-1795.

[25] Mullady D K, Wang A Y, Waschke K A. AGA Clinical Practice Update on Endoscopic Therapies for Non-Variceal Upper Gastrointestinal Bleeding: Expert Review [J]. Gastroenterology, 2020, 159(3): 1120-8. DOI: 10.1053/j.gastro.2020.05.095.

[26] Sung J J Y, Laine L, Kuipers E J, et al. Towards personalised management for non-variceal upper gastrointestinal bleeding [J]. Gut, 2021, 70(5): 818-24. DOI: 10.1136/gutjnl-2020-323846.

[27] Gralnek I M, Stanley A J, Morris A J, et al. Endoscopic diagnosis and management of nonvariceal upper gastrointestinal hemorrhage (NVUGIH): European Society of Gastrointestinal Endoscopy (ESGE) Guideline - Update 2021 [J]. Endoscopy, 2021, 53(3): 300-32. DOI: 10.1055/a-1369-5274.

[28] Laine L, Barkun A N, Saltzman J R, et al. ACG Clinical Guideline: Upper Gastrointestinal and Ulcer Bleeding [J]. Am J Gastroenterol, 2021, 116(5): 899-917. DOI: 10.14309/ajg.0000000000001245.

[29] Soriani P, Biancheri P, Bonura G F, et al. Over-the-scope clip as first-line treatment of

peptic ulcer bleeding: a multicenter randomized controlled trial (TOP Study) [J]. Endoscopy, 2024, 56(9): 665-73. DOI: 10.1055/a-2303-4824.

[30] Shin J, Cha B, Hong J, et al. Prevention of rebleeding after primary haemostasis using haemostatic powder in non-variceal upper gastrointestinal bleeding: a multicentre randomised controlled trial [J]. Gut, 2025, 74(11): 1821-7. DOI: 10.1136/gutjnl-2024-332459.

[31] Nigam G B, Oakland K, Hearnshaw S, et al. Acute upper gastrointestinal bleeding in the UK: 2022 audit update [J]. Gut, 2026, 75(4): 760-71. DOI: 10.1136/gutjnl-2025-335134.

[32] Doyle D J, Hendrix J M, Garmon E H. American Society of Anesthesiologists Classification [M]. StatPearls. Treasure Island (FL) ineligible companies. 2024.

[33] Riley R D, Ensor J, Snell K I E, et al. Calculating the sample size required for developing a clinical prediction model [J]. BMJ, 2020, 368: m441. DOI: 10.1136/bmj.m441.

[34] Marmo R, Koch M, Cipolletta L, et al. Predictive factors of mortality from nonvariceal upper gastrointestinal hemorrhage: a multicenter study [J]. Am J Gastroenterol, 2008, 103(7): 1639-47; quiz 48. DOI: 10.1111/j.1572-0241.2008.01865.x.

[35] Redondo-Cerezo E, Vadillo-Calles F, Stanley A J, et al. MAP(ASH): A new scoring system for the prediction of intervention and mortality in upper gastrointestinal bleeding [J]. Journal of Gastroenterology and Hepatology, 2020, 35(1): 82-9. DOI: 10.1111/jgh.14811.

[36] Marmo R, Koch M, Cipolletta L, et al. Predicting mortality in non-variceal upper gastrointestinal bleeders: validation of the Italian PNED Score and Prospective Comparison with the Rockall Score [J]. The American Journal of Gastroenterology, 2010, 105(6): 1284-91. DOI: 10.1038/ajg.2009.687.

[37] Vickers A J, Elkin E B. Decision curve analysis: a novel method for evaluating prediction models [J]. Med Decis Making, 2006, 26(6): 565-74. DOI: 10.1177/0272989X06295361.

[38] Oakland K, Kahan B C, Guizzetti L, et al. Development, Validation, and Comparative Assessment of an International Scoring System to Determine Risk of Upper Gastrointestinal Bleeding [J]. Clin Gastroenterol Hepatol, 2019, 17(6): 1121-9 e2. DOI: 10.1016/j.cgh.2018.09.039.

[39] Stanley A J, Laine L, Dalton H R, et al. Comparison of risk scoring systems for patients presenting with upper gastrointestinal bleeding: international multicentre prospective study [J]. BMJ, 2017, 356: i6432. DOI: 10.1136/bmj.i6432.

[40] Yang L, Sun R, Wei N, et al. Systematic review and meta-analysis of risk scores in prediction for the clinical outcomes in patients with acute variceal bleeding [J]. Ann Med, 2021, 53(1): 1806-15. DOI: 10.1080/07853890.2021.1990394.

[41] Elmunzer B J, Young S D, Inadomi J M, et al. Systematic review of the predictors of recurrent hemorrhage after endoscopic hemostatic therapy for bleeding peptic ulcers [J]. Am J Gastroenterol, 2008, 103(10): 2625-32; quiz 33. DOI: 10.1111/j.1572-0241.2008.02070.x.

[42] García-Iglesias P, Villoria A, Suarez D, et al. Meta-analysis: predictors of rebleeding after endoscopic treatment for bleeding peptic ulcer [J]. Aliment Pharmacol Ther, 2011, 34(8): 888-900. DOI: 10.1111/j.1365-2036.2011.04830.x.

[43] Chiu P W Y, Joeng H K M, Choi C L Y, et al. Predictors of peptic ulcer rebleeding after scheduled second endoscopy: clinical or endoscopic factors? [J]. Endoscopy, 2006, 38(7): 726-9. DOI:

[44] Mondardini A, Barletti C, Rocca G, et al. Non-variceal upper gastrointestinal bleeding and Forrest's classification: diagnostic agreement between endoscopists from the same area [J]. Endoscopy, 1998, 30(6): 508-12. DOI:

[45] Laine L, Freeman M, Cohen H. Lack of uniformity in evaluation of endoscopic prognostic features of bleeding ulcers [J]. Gastrointest Endosc, 1994, 40(4): 411-7. DOI:

[46] Jensen D M, Eklund S, Persson T, et al. Reassessment of Rebleeding Risk of Forrest IB (Oozing) Peptic Ulcer Bleeding in a Large International Randomized Trial [J]. The American Journal of Gastroenterology, 2017, 112(3): 441-6. DOI: 10.1038/ajg.2016.582.

[47] Rao V L, Gupta N, Swei E, et al. Predictors of mortality and endoscopic intervention in patients with upper gastrointestinal bleeding in the intensive care unit [J]. Gastroenterol Rep (Oxf), 2020, 8(4): 299-305. DOI: 10.1093/gastro/goaa009.

[48] Koo C Y, Hyder J A, Wanderer J P, et al. A meta-analysis of the predictive accuracy of postoperative mortality using the American Society of Anesthesiologists' physical status classification system [J]. World J Surg, 2015, 39(1). DOI: 10.1007/s00268-014-2783-9.

[49] Marmo R, Soncini M, Bucci C, et al. Derivation and validation of Re.Co.De death score risk in patients with acute nonvariceal upper GI bleeding [J]. Gastrointest Endosc, 2022, 96(1): 36-43 e8. DOI: 10.1016/j.gie.2022.01.024.

[50] Zhuang Y, Xia S, Chen J, et al. Construction of a prediction model for rebleeding in patients with acute upper gastrointestinal bleeding [J]. Eur J Med Res, 2023, 28(1): 351. DOI: 10.1186/s40001-023-01349-3.

[51] Matsuhashi T, Hatta W, Hikichi T, et al. A simple prediction score for in-hospital mortality in patients with nonvariceal upper gastrointestinal bleeding [J]. 2021, 56(8): 758-68. DOI:

Figure legends

Fig. 1 Flowchart of patients included in this study.

Fig. 2
The nomogram for the prediction of in-hospital rebleeding in patients with ANVUGIB. ASA, American Society of Anesthesiologists;

Fig. 3
The nomogram's area under receiver operating characteristic (AUROC) curve in predicting rebleeding in ANVUGIB patients and internal validation using a bootstrapping technique.

Fig. 4
Calibration Curve for the nomogram model(A). Observed rebleeding frequency versus Predicted rebleeding risk derived from the nomogram model(B).

Fig. 5
Decision curve analysis (DCA) of a nomogram predicting rebleeding in ANVUGIB. The nomogram is irrelevant at a threshold probability of < 2%, > 70%.

Table 1 Clinical characteristics of patients in the non-rebleeding and rebleeding groups

Variables	Total (n = 638)	Non-rebleeding (n = 577)	Rebleeding (n = 61)	*P*-value
Sex, n (%)				0.687
Female	133 (20.8)	122 (21.1)	11 (18)	
Male	505 (79.2)	455 (78.9)	50 (82)	
Age	63 (51, 72)	61 (51, 71)	69 (60, 76)	< 0.001
Melena, n (%)				0.023
No	168 (26.3)	144 (25)	24 (39.3)	
Yes	470 (73.7)	433 (75)	37 (60.7)	
Haematemesis, n (%)				0.205
No	388 (60.8)	356 (61.7)	32 (52.5)	
Yes	250 (39.2)	221 (38.3)	29 (47.5)	
Syncope, n (%)				0.452
No	558 (87.5)	507 (87.9)	51 (83.6)	
Yes	80 (12.5)	70 (12.1)	10 (16.4)	
Lung disease, n (%)				0.01
No	569 (89.2)	521 (90.3)	48 (78.7)	
Yes	69 (10.8)	56 (9.7)	13 (21.3)	
Coronary heart disease, n (%)				0.968
No	485 (76)	438 (75.9)	47 (77)	
Yes	153 (24)	139 (24.1)	14 (23)	
Hypertension, n (%)				0.363
No	302 (47.3)	277 (48)	25 (41)	
Yes	336 (52.7)	300 (52)	36 (59)	
Diabetes, n (%)				0.52
No	497 (77.9)	447 (77.5)	50 (82)	
Yes	141 (22.1)	130 (22.5)	11 (18)	
Chronic kidney disease, n (%)				< 0.001
No	573 (89.8)	528 (91.5)	45 (73.8)	
Yes	65 (10.2)	49 (8.5)	16 (26.2)	
Liver disease, n (%)				0.034
No	591 (92.6)	539 (93.4)	52 (85.2)	
Yes	47 (7.4)	38 (6.6)	9 (14.8)	
Antiplatelet/Anticoagulants, n (%)				0.112
No	451 (70.7)	402 (69.7)	49 (80.3)	
Yes	187 (29.3)	175 (30.3)	12 (19.7)	
Systolic blood pressure (mmHg)	119.5 (108, 131)	120 (108, 131)	114 (100, 130)	0.034
Heart rate (beats/min)	88 (78, 99)	88 (79, 99)	87 (78, 105)	0.7
Location, n (%)				0.02
Duodenal	309 (48.4)	284 (49.2)	25 (41)	
Gastric	248 (38.9)	226 (39.2)	22 (36.1)	
Esophageal	46 (7.2)	41 (7.1)	5 (8.2)	
Gastrointestinal anastomotic	35 (5.5)	26 (4.5)	9 (14.8)	
Etiology, n (%)				< 0.001
Ulcer	534 (83.7)	488 (84.6)	46 (75.4)	

Vascular malformation	15 (2.4)	7 (1.2)	8 (13.1)	
Mucosal erosion	48 (7.5)	47 (8.1)	1 (1.6)	
Mallory–Weiss	26 (4.1)	22 (3.8)	4 (6.6)	
Tumor	15 (2.4)	13 (2.3)	2 (3.3)	
Endoscopic risk classification, n (%)				< 0.001
Low Risk	428 (67.1)	415 (71.9)	13 (21.3)	
High Risk	210 (32.9)	162 (28.1)	48 (78.7)	
Forrest classification*, n (%)				< 0.001
III	318 (59.6)	309 (63.3)	9 (19.6)	
IIc	40 (7.5)	39 (8)	1 (2.2)	
IIb	41 (7.7)	34 (7)	7 (15.2)	
IIa	81 (15.2)	69 (14.1)	12 (26.1)	
Ib	48 (9)	35 (7.2)	13 (28.3)	
Ia	6 (1.1)	2 (0.4)	4 (8.7)	
ASA classification, n (%)				< 0.001
I	156 (24.5)	147 (25.5)	9 (14.8)	
II	357 (56)	340 (58.9)	17 (27.9)	
III	102 (16)	77 (13.3)	25 (41)	
IV	23 (3.6)	13 (2.3)	10 (16.4)	
WBC (× 109/L)	8.6 (6.4, 11.2)	8.6 (6.3, 11.1)	9 (7, 12.1)	0.268
HGB (g/L)	91.5 (72, 116)	94 (74, 117)	78 (56, 91)	< 0.001
PLT (× 109/L)	216 (174.2, 264)	221 (176, 267)	187 (139, 238)	0.004
PT (sec)	12.1 (11.4, 12.8)	12.1 (11.4, 12.8)	12.4 (11.7, 13.5)	0.01
APTT (sec)	25.2 (22.2, 28.6)	25.1 (22.1, 28.4)	26.2 (22.6, 30.9)	0.064
TT (sec)	17.6 (16.1, 19)	17.6 (16.1, 18.9)	18 (16.3, 19)	0.134
FIB (g/L)	2.4 (2.1, 2.8)	2.4 (2.1, 2.8)	2.3 (1.9, 3)	0.719
BUN (mmol/L)	11.7 (7.7, 16.7)	11.4 (7.5, 16.1)	15.2 (9.9, 20.6)	< 0.001
Cr(umol/L)	79.7 (64.7, 106.3)	78.5 (64.4, 102.3)	95.6 (77, 159.7)	< 0.001
Albumin(g/L)	37.7 (34, 41.1)	37.9 (34.7, 41.3)	32.3 (28.7, 36.9)	< 0.001

ASA, American Society of Anesthesiologists; WBC, white blood cell count; HGB, hemoglobin; PLT, platelet; PT, prothrombin time; APTT, activated partial thromboplastin time; TT, thrombin time; FIB, fibrinogen; BUN, blood urea nitrogen; Cr, creatinine;

*The Forrest classification was evaluated exclusively for the 534 patients with peptic ulcers

Table 2 Univariate and Multivariate logistic regression analysis of predictors for rebleeding

Variables	Univariate analysis OR (95% CI)	*P*-value	Multivariate analysis OR (95% CI)	*P*-value
Age	1.03 (1.01, 1.05)	0.001	1.007 (0.98, 1.035)	0.622
Lung disease	2.52 (1.24, 4.82)	0.007	1.38 (0.512, 3.447)	0.505
Chronic kidney disease	3.83 (1.97, 7.17)	<0.001	2.629 (0.825, 7.884)	0.091
Liver disease	2.45 (1.06, 5.16)	0.024	1.422 (0.455, 4.052)	0.525
Systolic blood pressure (mmHg)	0.98 (0.97, 1)	0.04	0.989 (0.972, 1.007)	0.235
Location				
Duodenal	Ref			
Gastric	1.11 (0.6, 2.01)	0.742	0.949 (0.435, 2.042)	0.893
EsophAgeal	1.39 (0.45, 3.55)	0.529	1.895 (0.232, 12.596)	0.526
Gastroduodenal anastomotic	3.93 (1.6, 9.1)	0.002	2.191 (0.584, 7.555)	0.226
Etiology				
Ulcer	Ref			
Vascular malformation	12.12 (4.17, 36.05)	<0.001	1.534 (0.326, 6.796)	0.576
Mucosal erosion	0.23 (0.01, 1.07)	0.145	0.291 (0.013, 2.129)	0.305
Mallory–Weiss	1.93 (0.55, 5.31)	0.245	0.479 (0.06, 3.876)	0.479
Tumor	1.63 (0.25, 6.15)	0.527	2.136 (0.274, 11.187)	0.404
Endoscopic risk classification	9.46 (5.14, 18.63)	<0.001	8.708 (4.14, 19.616)	<0.001
ASA classification				
I~II	Ref			
III	6.08 (3.33, 11.11)	<0.001	3.658 (1.601, 8.44)	0.002
IV	14.41 (5.68, 35.98)	<0.001	8.535 (2.233, 31.085)	0.001
HGB (g/L)	0.98 (0.97, 0.99)	<0.001	0.993 (0.979, 1.008)	0.385
PLT (× 109/L)	1 (0.99, 1)	0.013	1 (0.996, 1.004)	0.997
PT (sec)	1.08 (1.01, 1.16)	0.021	1.056 (0.955, 1.167)	0.26
APTT (sec)	1.06 (1.02, 1.1)	0.002	0.953 (0.884, 1.027)	0.21
BUN (mmol/L)	1.04 (1.02, 1.07)	0.001	0.964 (0.912, 1.017)	0.192
Cr(μmol/L)	1 (1, 1)	0.001	1.001 (0.997, 1.004)	0.71

Albumin(g/L)	0.85 (0.81, 0.89)	<0.001	0.895 (0.833, 0.956)	0.001

Table 3 Comparison of the nomogram with existing scoring systems with estimated optimal cut-off values for rebleeding

Models	AUC	95% CI	ΔAUC	95% CI	P-value	Cut-off	Sensitivity(%)	Specificity(%)	PPV(%)	NPV(%)	Youden	High risk patients (%)
Nomogram	0.87	[0.82-0.921]	Ref	Ref	Ref	0.143	73.8	87.7	38.8	96.9	0.615	116 (18.2)
Forrest	0.784	[0.723-0.845]	0.086	[0.04-0.132]	<0.001	IIb	78.7	71.9	22.9	97	0.506	210 (32.9)
GBS	0.702	[0.63-0.774]	0.168	[0.091-0.245]	<0.001	11	70.5	61.9	16.3	95.2	0.324	263 (41.2)
Rockall	0.787	[0.729-0.844]	0.083	[0.036-0.131]	0.001	5	70.5	73.8	22.2	95.9	0.443	194 (30.4)
ABC	0.753	[0.689-0.818]	0.117	[0.054-0.18]	<0.001	4	60.7	76.1	21.1	94.8	0.368	175 (27.4)
AIMS65	0.694	[0.62-0.767]	0.177	[0.102-0.251]	<0.001	2	37.7	92.7	35.4	93.4	0.304	65 (10.2)
MAP	0.757	[0.687-0.827]	0.113	[0.051-0.175]	<0.001	3	63.9	78	23.5	95.3	0.419	166 (26)
CANUKA	0.721	[0.659-0.782]	0.149	[0.081-0.218]	<0.001	8	83.6	49.4	14.9	96.6	0.33	343 (53.8)

Fig. 1

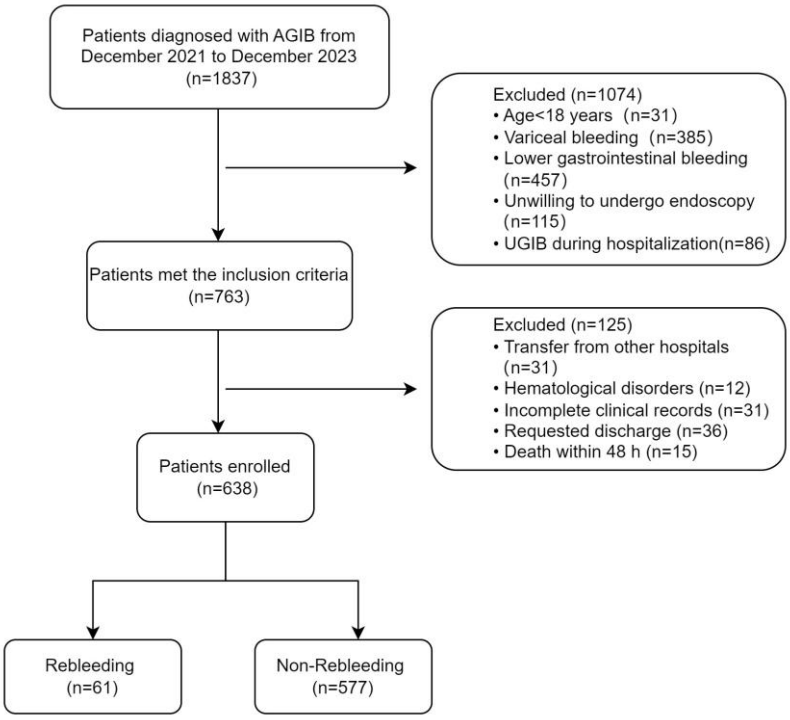

Patients diagnosed with AGIB from December 2021 to December 2023 (n=1837)
Excluded (n=1074)
• Age<18 years (n=31)
• Variceal bleeding (n=385)
• Lower gastrointestinal bleeding (n=457)
• Unwilling to undergo endoscopy (n=115)
• UGIB during hospitalization(n=86)
Patients met the inclusion criteria (n=763)
Excluded (n=125)
• Transfer from other hospitals (n=31)
• Hematological disorders (n=12)
• Incomplete clinical records (n=31)
• Requested discharge (n=36)
• Death within 48 h (n=15)
Patients enrolled (n=638)
Rebleeding (n=61)
Non-Rebleeding (n=577)

Fig. 2

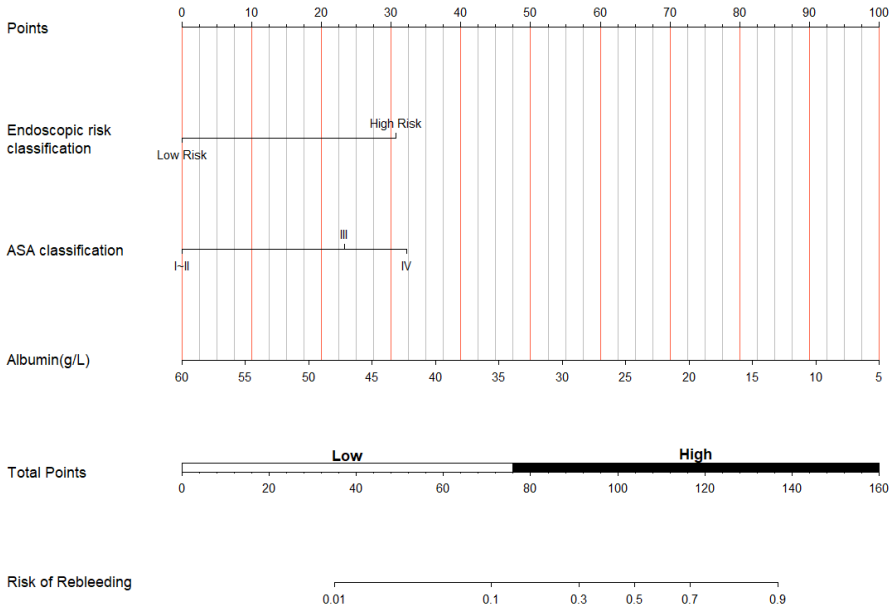

Points
0 10 20 30 40 50 60 70 80 90 100
Endoscopic risk classification
High Risk
Low Risk
ASA classification
III
I~II
IV
Albumin(g/L)
60 55 50 45 40 35 30 25 20 15 10 5
Total Points
Low
High
0 20 40 60 80 100 120 140 160
Risk of Rebleeding
0.01 0.1 0.3 0.5 0.7 0.9

Fig. 3

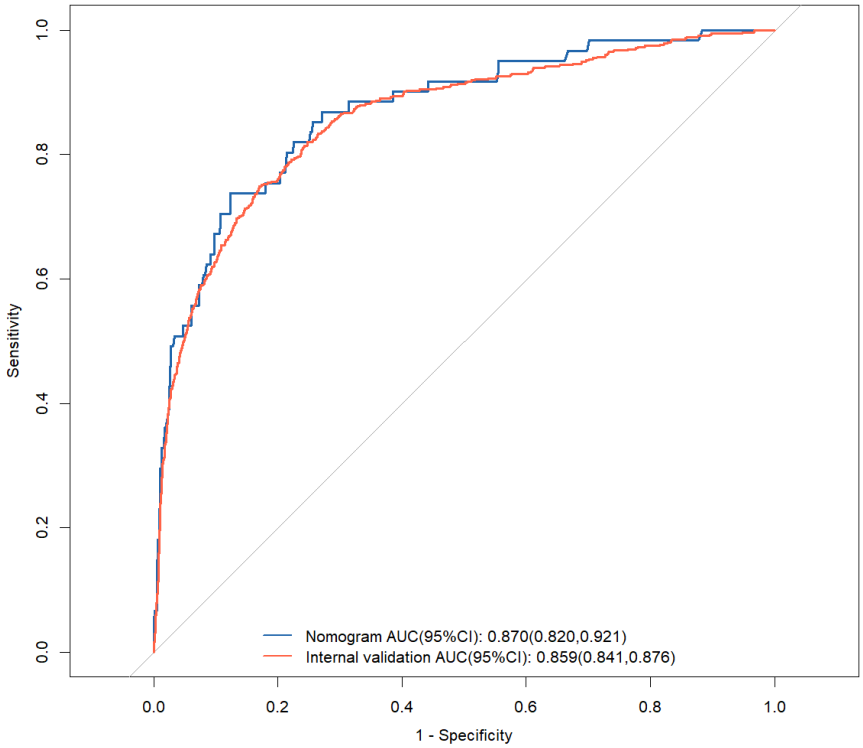


Fig. 4

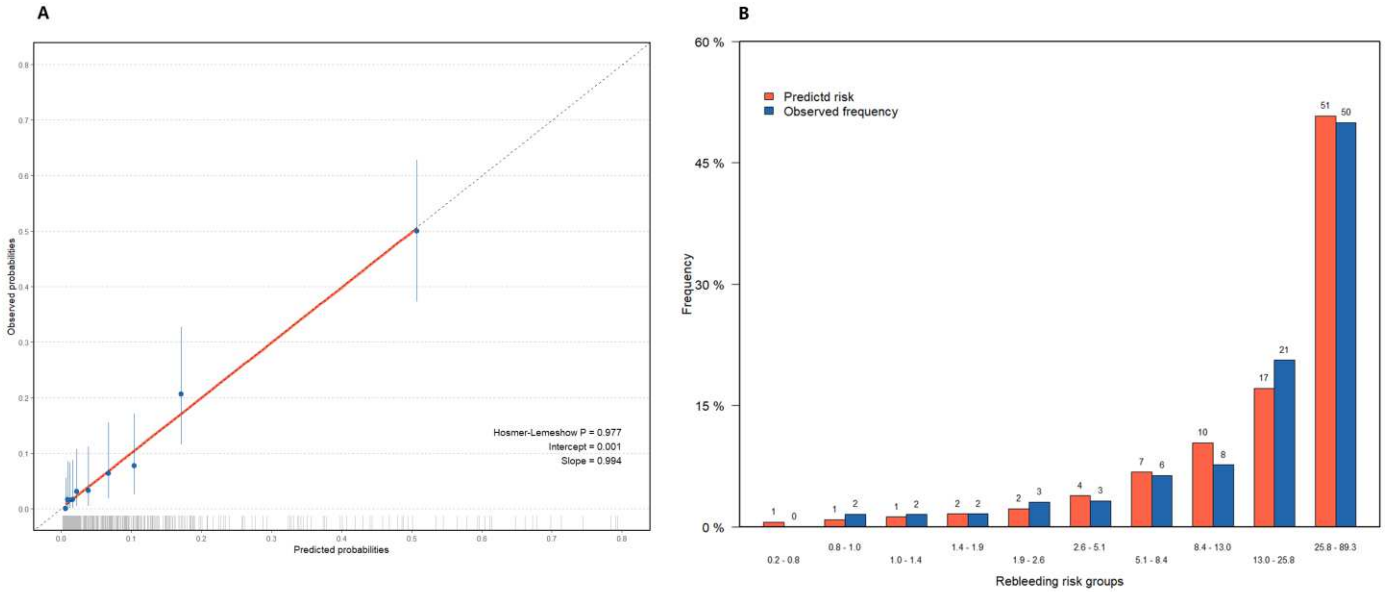
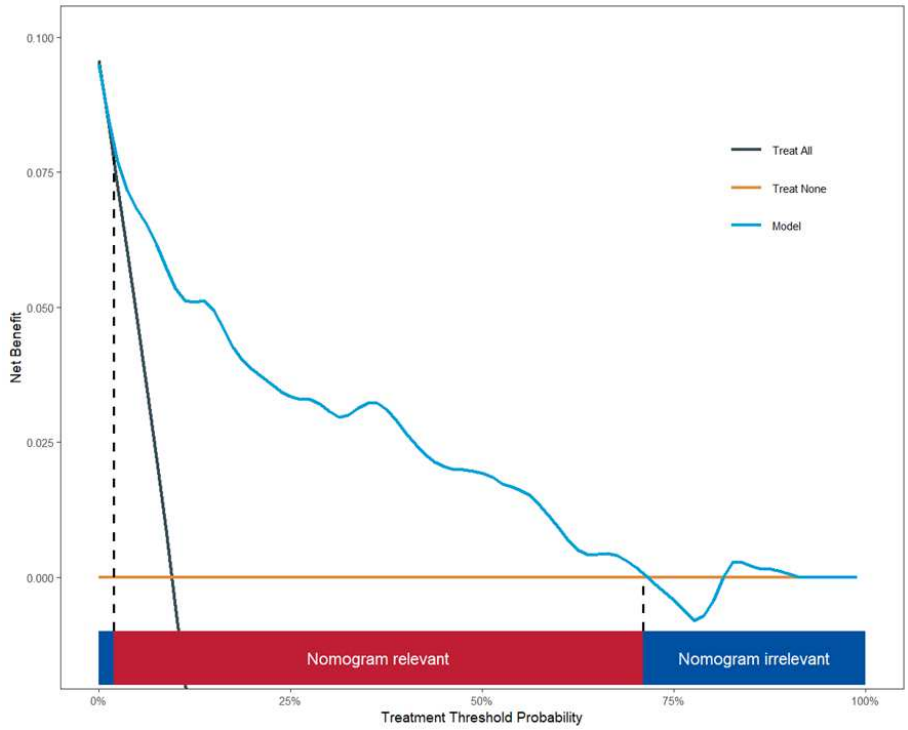


Fig. 5


0.100
0.075
0.050
0.025
0.000
Net Benefit
Treat All
Treat None
Model
Nomogram relevant
Nomogram irrelevant
0%
25%
50%
75%
100%
Treatment Threshold Probability

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