



# Assessing the Risk of Early Hemorrhage in Patients with Acute Cholangitis Undergoing Endoscopic Retrograde Cholangiopancreatography with Biliary Stent Placement

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## Abstract

**Background:** Early postoperative hemorrhage is a serious complication of endoscopic retrograde cholangiopancreatography (ERCP) with biliary stent placement for acute cholangitis, but its patient-related risk factors remain insufficiently defined.

**Objective:** We aimed to identify the potential risk factors for early postoperative hemorrhage in patients undergoing ERCP with biliary stent placement for acute cholangitis.

**Methods:** A retrospective cohort study was conducted, including 150 patients undergoing ERCP with biliary stent placement at Yangpu Hospital from January 2017 to December 2020 as the training set, and all patients were followed up for six months to assess postoperative complications. The least absolute shrinkage and selection operator and multivariate logistic regression were performed to identify independent risk factors associated with early postoperative hemorrhage, and a dynamic nomogram model was constructed. Another 40 patients treated between January 2023 and December 2023 were used for external validation. Model prediction performance was evaluated using the receiver operating characteristic (ROC) curve, calibration plot, and decision curve analysis.

**Results:** Inflammatory and liver function indicators recovered rapidly after the operation. The incidence of early postoperative hemorrhage, defined as a hemoglobin (Hb) drop exceeding 20.0 g/L, was 26.0% in the training set and 12.5% in the validation set. Multivariate analysis identified the neutrophil proportion, presence of pancreatitis, total bilirubin (TBIL), and baseline Hb levels as significant predictors of early hemorrhage. The area under the ROC curve was 0.848 in the training set and 0.846 in the validation set, which indicated favorable predictive performance.

**Conclusion:** Preoperative presence of pancreatitis, higher TBIL levels, higher neutrophil proportion, and higher baseline Hb were independent predictors of early postoperative hemorrhage risk in patients undergoing ERCP with biliary stent placement

**Keywords:** Biliary stent, Choledocholithiasis, Endoscopic retrograde cholangiopancreatography, Hemorrhage, Pancreatitis, Risk factors

## INTRODUCTION

Choledocholithiasis is the most common etiology of biliary obstruction,<sup>1</sup> leading to severe complications such as acute cholangitis, a life-threatening condition characterized by bacterial infection and inflammation of the biliary tree, necessitating prompt intervention.<sup>2</sup> Endoscopic therapies, particularly endoscopic retrograde cholangiopancreatography (ERCP) with biliary stent placement, are established as the first-line treatment for acute cholangitis. ERCP with biliary stent placement is not only the gold standard for managing malignant biliary obstruction but also a widely employed intervention for choledocholithiasis.<sup>3</sup>

In addition, ERCP with biliary stent placement is associated with significant complications, including post-procedural pancreatitis, perforation, and hemorrhage.<sup>4,5</sup> Among these, postoperative hemorrhage is the most common severe complication.<sup>6</sup> Recent studies indicate a decline in postoperative mortality but a concurrent increase in hemorrhage rates.<sup>7</sup>

Previous studies have shown that exogenous procedural factors, such as precut sphincterotomy (pre-EST) and endoscopic sphincterotomy (EST), are associated with postoperative hemorrhage.<sup>8</sup> Intraprocedural visible bleeding has also been reported as a potential predictor.<sup>9</sup> However, endogenous factors, which may play a key role in postoperative hemorrhage, remain poorly understood.<sup>6</sup>

Post-ERCP hemorrhage is defined as hematemesis and/or melena, or a hemoglobin (Hb) drop exceeding 20.0 g/L.<sup>10</sup> Correspondingly, this study defined clinically significant Hb decrease as a reduction in Hb level of more than 20.0 g/L. The postoperative decline in Hb levels is an objective marker of intraoperative blood loss and correlates more closely with actual blood loss than subjective estimates. Early Hb reduction is indeed a marker of the likelihood of significant injury and indicates a poor prognosis after surgery.<sup>11</sup> Furthermore, the degree of Hb decline has been identified as an independent risk factor for postoperative complications.<sup>12</sup>

Therefore, clinically useful predictors of hemorrhage are urgently needed to improve post-ERCP clinical outcomes and reduce mortality rates. Accordingly, this study aimed to explore early hemorrhage after endoscopic biliary stent placement in patients with acute cholangitis, elucidate possible factors associated with early hemorrhage, and construct a prediction model that could serve as a valuable tool for the prevention of post-procedural bleeding in these patients.

We hypothesized that, after adjustment for exogenous factors such as EST and pre-EST, endogenous factors may also contribute to early post-ERCP hemorrhage. Accordingly, endogenous factors may serve as valuable indicators for the incidence and severity of this complication. Furthermore, we aimed to explore and identify additional poten-

tial predictors of postoperative hemorrhage in this study cohort.

## METHODS

### Study design

This was a retrospective study of patients undergoing ERCP with biliary stent placement for acute cholangitis, conducted by the Department of General Surgery, Yangpu Hospital, Tongji University School of Medicine. A total of 150 patients from January 2017 to December 2020 were enrolled as the training set, and 40 patients from January to December 2023 were enrolled as the validation set. The study involving human participants was reviewed and approved by the Ethics Committee of Yangpu Hospital (LL-2021-SCI-007). All included patients were inpatients, and discharged patients were followed up for six months via telephone and outpatient clinic visits.

Early postoperative hemorrhage was defined as a Hb drop exceeding 20.0 g/L; observational indicators, including hematemesis and melena, were not incorporated into the bleeding definition.

The inclusion criteria were as follows: (i) patients aged > 18 years; (ii) patients with choledocholithiasis who voluntarily provided signed informed consent for ERCP; and (iii) patients who met the diagnostic criteria for acute cholangitis as outlined in the Tokyo Guidelines.<sup>4</sup>

The exclusion criteria were as follows: (i) patients with severe comorbidities that might confound the interpretation of blood biochemical parameters,

specifically: a. malignant tumors of any type; b. renal impairment: chronic kidney disease stage 4 or 5, defined as an estimated glomerular filtration rate < 30 mL/min/1.73 m<sup>2</sup> using the Chronic Kidney Disease Epidemiology Collaboration equation; c. hepatic dysfunction: Child–Pugh grade B or C (Child–Pugh score ≥ 7); (ii) patients with incomplete medical records; (iii) patients lost to follow-up; and (iv) patients using nonsteroidal anti-inflammatory drugs.

### Endoscopic retrograde cholangiopancreatography procedure

The procedures were performed by two experienced endoscopists (HW and EP), who performed more than 200 procedures annually. Analgesic (pethidine; Northeast Pharmaceutical, China) and sedative (diazepam; Shanghai Xudong-Haipu, China) drugs were administered to patients before the procedure. Biliary stenting was performed using standard duodenoscopes (TJF-260V, EVIS LUCERA, Olympus, Japan). Two types of biliary stents (8.5F, 9 cm; 7F, 14 cm) were mainly used. Procedure success was defined as successful biliary stent placement with restoration of biliary drainage. After ERCP, the patients were kept fasting and were administered intravenous fluid resuscitation and nutritional support. Blood samples were routinely collected at 6 and 24 h after ERCP for complete blood count, biochemical testing, and measurement of amylase and lipase activities. All patients were monitored for at least 48 h to screen for potential ERCP-related acute complications.

### Collected variables

Variables collected included age, sex, hospitalization-related data, preoperative laboratory parameters such as white blood cell (WBC), Hb, platelets, C-reactive protein, proportion of neutrophils, total bilirubin (TBIL), alanine transaminase (ALT), aspartate aminotransferase (AST), alkaline phosphatase, creatinine, prothrombin time, fibrinogen, D-dimer, and comorbidities such as hypertension, diabetes, and pancreatitis. Postoperative laboratory tests were performed 24 h after ERCP.

### Statistical analysis

The data were obtained by checking the hospital's medical system and reviewing the corresponding case records, laboratory tests, endoscopic reports, and other relevant examination results. The analyses were performed using SPSS version 25.0 (IBM Corp., United States of America) and R software (version 4.0.2). The normality of variables was investigated using the Shapiro–Wilk test. The characteristics of patients were described using descriptive statistics. Continuous variables were presented as mean ± standard deviation or median (interquartile range, IQR) and compared with the Student's *t*-test or Mann–Whitney *U* test. Categorical variables were compared using the chi-square test. All statistical tests were 2-sided, and *p* < 0.05 indicated a statistically significant difference.

Least absolute shrinkage and selection operator (LASSO) regression analysis was used to identify non-zero coefficients that best predict early hemorrhage

risk in patients undergoing ERCP with endoscopic biliary stent placement in the training set. Then, all non-zero coefficient variables identified by LASSO regression were included in the multivariate logistic regression model. Based on multivariate logistic regression analysis, a dynamic nomogram was developed to predict the probability of early hemorrhage. Another 40 patients were selected for external validation. A receiver operating characteristic (ROC) curve and a calibration curve were used to evaluate the performance of the early hemorrhage risk nomogram. Decision curve analysis (DCA) was performed to assess the clinical applicability of the early hemorrhage risk model.

## RESULTS

A total of 190 patients who underwent ERCP with biliary stent placement were enrolled and followed up at Yangpu Hospital, School of Medicine, Tongji University, including 150 in the training set and 40 in the validation set. During the six months' follow-up, no serious procedural complications other than the studied early hemorrhage events were observed. The incidence of postoperative hemorrhage was 26.0% in the training set and 12.5% in the validation set.

Blood samples were analyzed to evaluate short-term laboratory changes after ERCP with biliary stent placement in the training set. ERCP with biliary stent placement induced significant reductions in WBC count (*p* = 0.006), proportion of neutrophils (*p* = 0.009), TBIL level (*p* < 0.001), as well as levels of ALT and AST (both *p* < 0.001; [Table 1](#)).

**Table 1. Comparison of laboratory findings after ERCP with biliary stent placement in the training set**

Variable	Preoperative laboratory findings	Postoperative laboratory findings	Z value	<i>p</i> -value
WBC (×10 <sup>9</sup> /L)	9.6 (6.9–13.1)	8.3 (6.2–11.9)	−2.758	0.006
Proportion of neutrophils (%)	85.8 (74.2–91.4)	83.0 (75.0–88.3)	−2.611	0.009
TBIL (μmol/L)	55.9 (25.3–98.5)	32.7 (19.4–62.9)	−6.449	<0.001
ALT (U/L)	137.0 (70.3–248.5)	73.5 (42.8–139.8)	−8.325	<0.001
AST (U/L)	139.5 (59.8–294.0)	47.0 (28.8–86.0)	−8.974	<0.001

Notes: Data are presented as median (interquartile range). Preoperative and postoperative values were compared using the Mann–Whitney *U* test. All variables were statistically significant.  
Abbreviations: AST: Aspartate aminotransferase; ALT, alanine transaminase; ERCP: Endoscopic retrograde cholangiopancreatography; TBIL, total bilirubin; WBC, white blood cell.

Based on the data from 150 patients in the training set, after conducting LASSO regression with five-fold cross-validation, 20 sociodemographic and clinical characteristics were reduced to 10 potential predictors with non-zero coefficients. The pathway of variable shrinkage and cross-validation was illustrated in **Figure 1**. The LASSO analysis showed that early hemorrhage was significantly associated with baseline Hb levels, the proportion of neutrophils, TBIL levels, and the presence of pancreatitis.

Based on these findings, we conducted a multiple logistic regression analysis. The results showed that four baseline variables, including the proportion of neutrophils (odds ratio [OR] = 1.072, 95% confidence interval [CI] = 1.017–1.137;  $p = 0.014$ ), the presence of pancreatitis (OR = 3.314, 95% CI = 1.048–10.929;  $p = 0.043$ ), TBIL levels (OR = 1.012, 95% CI = 1.004–1.019;  $p = 0.002$ ), and baseline Hb levels (OR = 1.069, 95% CI = 1.038–1.107;  $p < 0.001$ ) were identified to predict early hemorrhage risk in patients undergoing ERCP with biliary stent placement (**Table 2**). The nomogram in **Figure 2** visually represents the results of the logistic regression analysis.

No significant differences were observed in the baseline predictor vari-

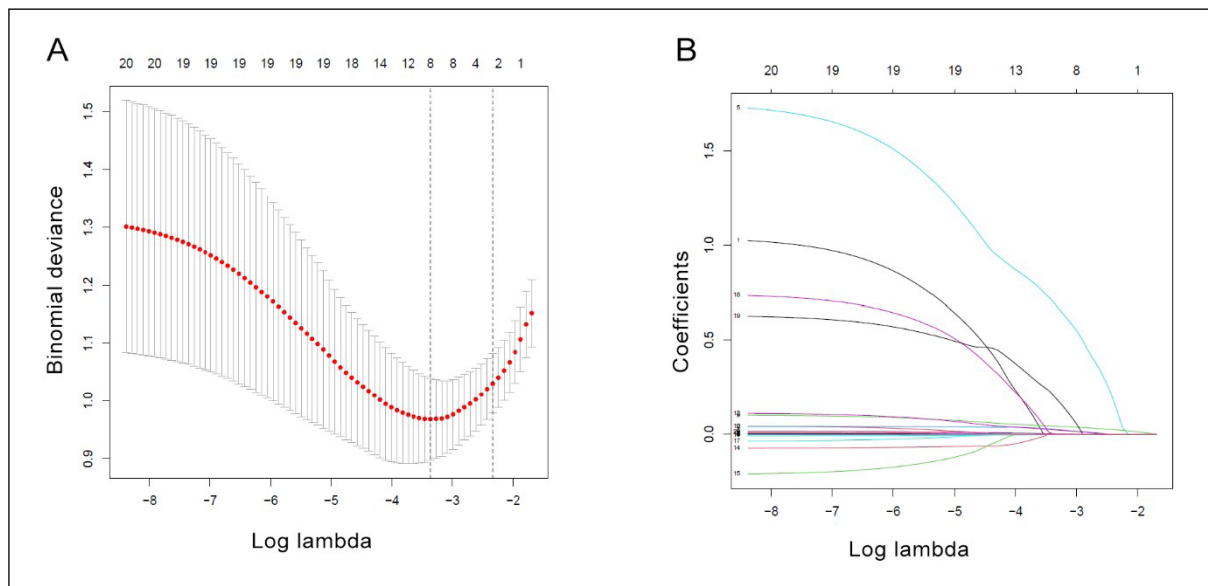
ables between the training and validation sets (**Table 3**). Model discrimination was assessed by calculating the area under the curve (AUC) of the ROC curve. As shown in **Figure 3A**, the AUC of the training set was 0.848 (95% CI = 0.780–0.916), while the AUC of the validation set was 0.846 (95% CI = 0.703–0.989) in **Figure 3B**, which demonstrated good predictive performance. The calibration curves of the nomogram illustrated excellent agreement between the predicted probabilities of early hemorrhage and actual observations in the training set (**Figure 3C**). Furthermore, on DCA analysis, the nomogram net benefit rate (the red line) was found to be above the All and None lines, indicating that the model exhibited good clinical utility (**Figure 3D**).

## DISCUSSION

This study examined 190 acute cholangitis patients who underwent ERCP with biliary stent placement at Yangpu Hospital. The cohort comprised a training set ( $n = 150$ ), in which the hemorrhage incidence was 26.0%, and a validation set ( $n = 40$ ), in which the incidence was 12.5%. A machine learning-derived model was developed and validated to assess early hemorrhage risk in these patients. The model construction incor-

porated LASSO regression for feature selection followed by multiple logistic regression analysis, ultimately identifying four significant baseline predictors: the proportion of neutrophils, the presence of pancreatitis, TBIL, and baseline Hb levels. Notably, we observed a counterintuitive finding that a higher baseline Hb level is a risk factor for early hemorrhage. This finding may partly reflect the use of an absolute Hb-drop threshold, because patients with higher baseline Hb may be more likely to meet a  $>20$  g/L decline criterion. In addition, studies have shown that elevated Hb is associated with bleeding in many specific populations.<sup>13,14</sup> The nomogram from this model provides clinicians with a visual representation to estimate the risk of early hemorrhage in acute cholangitis patients undergoing ERCP with biliary stent placement.

Endoscopic retrograde cholangiopancreatography with biliary stent placement has been established as a safe and effective treatment for acute cholangitis,<sup>15</sup> especially in patients with biliary obstruction secondary to common bile duct stones.<sup>16</sup> Open surgery may pose a substantial risk in frail older patients with multiple comorbidities, especially in the state of systemic inflammatory stress, whereas endoscopic treatment is



**Figure 1.** Demographic and clinical feature selection was performed using the LASSO regression model. (A) Based on the logarithmic (lambda) sequence, a coefficient profile was generated, and non-zero coefficients were determined by the optimal lambda. (B) The optimal parameter (lambda) in the LASSO model was selected through five-fold cross-validation using a minimum criterion. The binomial deviation curve versus log(lambda) is shown, with vertical lines indicating the selected lambda values, including the 1-SE criterion.

Abbreviations: LASSO: Least absolute shrinkage and selection operator; SE: Standard error.

**Table 2. Multivariate logistic regression analysis of the 10 predictors selected by LASSO in the training set**

Variable	OR (95% CI)	p-value
WBC ( $\times 10^9/L$ )	1.056 (0.954–1.169)	0.292
Hb (g/L)	1.069 (1.038–1.107)	<0.001*
CRP (mg/L)	0.993 (0.983–1.002)	0.128
Proportion of neutrophils (%)	1.072 (1.017–1.137)	0.014*
TBIL ( $\mu\text{mol/L}$ )	1.012 (1.004–1.019)	0.002*
ALT (U/L)	1.001 (0.999–1.003)	0.370
PT (s)	0.82 (0.564–1.135)	0.263
Pancreatitis	3.314 (1.048–10.929)	0.043*
Diabetes	1.771 (0.583–5.402)	0.309
Hypertension	1.835 (0.672–5.201)	0.240

Note: Variables marked with an asterisk (\*) were statistically significant.

Abbreviations: ALT: Alanine transaminase; CI: Confidence interval; CRP: C-reactive protein; Hb: Hemoglobin; LASSO: Least absolute shrinkage and selection operator; PT: Prothrombin time; OR: Odds ratio; TBIL: Total bilirubin; WBC: White blood cell.

**Table 3. Demographics and clinical characteristics of training and validation sets**

Variable	Training set ( $n = 150$ )	Validation set ( $n = 40$ )	p-value
Hb (g/L)	128 (20.9)	132 (17.8)	0.187
Proportion of neutrophils (%)	82.0 (12.6)	80.2 (12.2)	0.408
TBIL ( $\mu\text{mol/L}$ )	77.2 (74.3)	69.3 (46.6)	0.412
Pancreatitis (%)	29 (19.3%)	12 (30.0%)	0.215

Notes: Continuous variables are presented as mean (standard deviation), and categorical variables are presented as number (%).

Abbreviations: Hb: Hemoglobin; TBIL: Total bilirubin.

relatively minimally invasive, safe, and effective.<sup>17</sup> In addition, recent evidence indicates that biliary sphincterotomy is not required for bile duct stent placement,<sup>18</sup> which further minimizes procedural trauma and enhances patient safety. In the present study, a six-month follow-up revealed no serious adverse events, with patients demonstrating marked improvement in inflammatory and liver function parameters after the procedure (Table 1).

Postoperative hemorrhage remains one of the most critical complications following ERCP. In the present study,

despite the exclusion of traumatic factors (i.e., not using EST in our operation) and the use of nonsteroidal anti-inflammatory drugs that could significantly affect the risk of bleeding, the incidence of postoperative hemorrhage, defined as a Hb drop exceeding 20.0 g/L, was still high at 26.0% in the training set and 12.5% in the validation set. Previous research showed that an early drop in Hb serves as a marker for significant injury risk.<sup>19,20</sup> The clinical significance of Hb decline extends beyond its immediate effects, as it compromises tissue oxygen delivery, potentially lead-

ing to poor postoperative prognosis.<sup>11</sup> Reducing operative blood loss improves patient outcomes and reduces healthcare costs.<sup>21</sup> Evidence from gastric cancer surgery indicates that the magnitude of postoperative Hb reduction constitutes an independent risk factor for surgical complications, with the nadir postoperative Hb level and requirement for blood transfusion emerging as particularly significant predictors of adverse outcomes.<sup>22</sup> Similar results were found in patients after percutaneous coronary intervention<sup>23</sup> and those with acute coronary syndromes.<sup>24</sup>

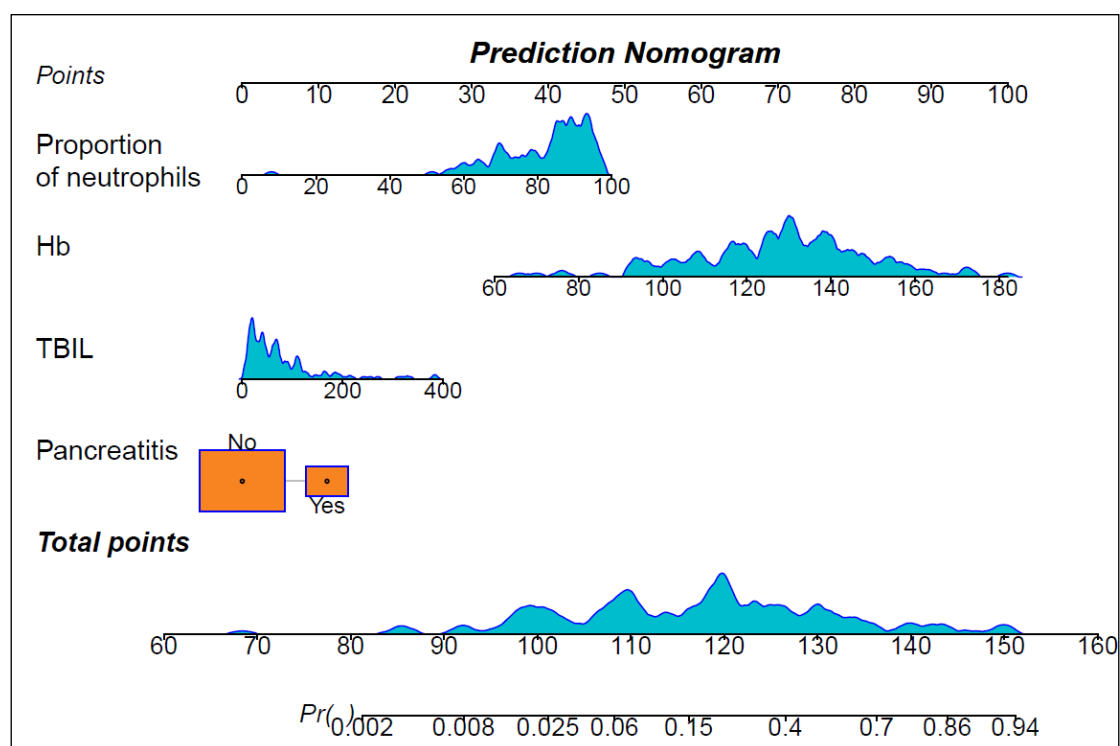


Figure 2. A prediction nomogram based on the combination of four indicators was developed using logistic regression analysis

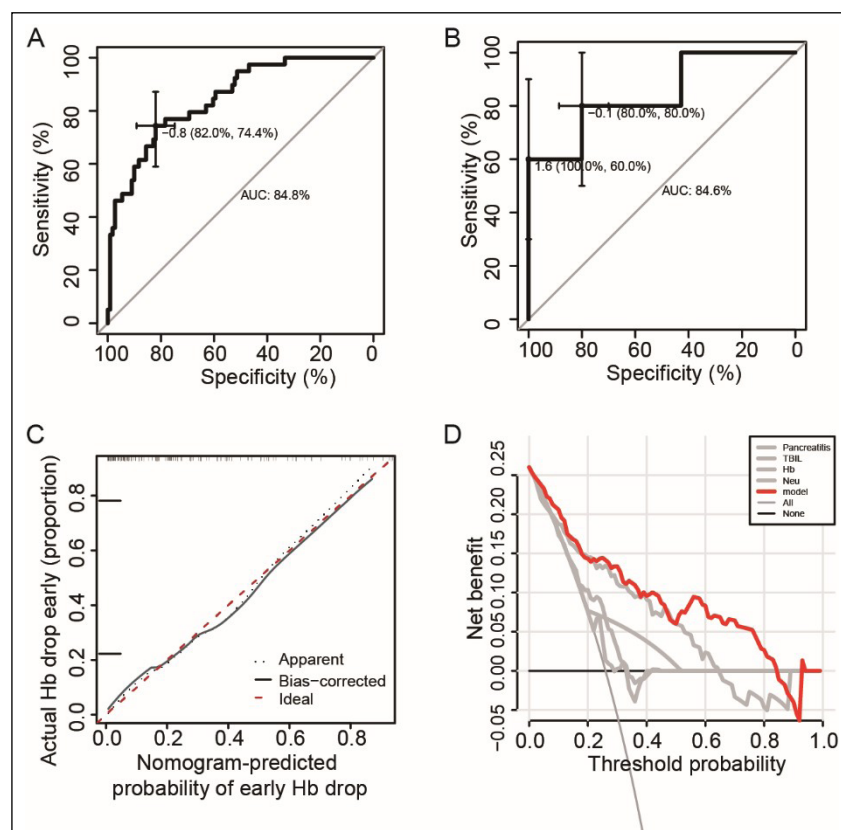


Figure 3. Performance evaluation of the nomogram for predicting early hemorrhage risk. (A) The ROC curve of the training set. (B) The ROC curve of the validation set. (C) Calibration curve of the early hemorrhage risk nomogram prediction in the training set. (D) Decision curve analysis for the early hemorrhage nomogram in the training set.

Abbreviations: AUC: Area under the curve; Hb: Hemoglobin; ROC: Receiver operator characteristic

Studies have focused on the issue of post-ERCP hemorrhage. In the study by Parvizian *et al.*,<sup>25</sup> a total of 1,323 articles were identified, of which 26 were included, with up to 25,121 subjects in each meta-analysis. This meta-analysis demonstrates that there is no apparent difference in the association of hemorrhage with the indication of ERCP, including acute cholangitis, choledocholithiasis, malignancy, acute pancreatitis (AP), or SOD. The median rate of hemorrhage was 3.7%, but differences in the timing of hemorrhage and the definition of hemorrhage may affect the applicability of the conclusions. Ye *et al.*<sup>8</sup> identified that EST, pre-EST, and activated partial thromboplastin time were independent risk factors for immediate hemorrhage, while high amylase at 24 h after ERCP, high postoperative urea, prolonged thromboplastin time, and coronary heart disease were independent risk factors for delayed hemorrhage through the analysis of more than 1,009 cases. Unlike Ye *et al.*,<sup>8</sup> we excluded the influence of factors such as EST and pre-EST, and we found that the proportion of neutrophils, the presence of pancreatitis, TBIL levels, and baseline Hb levels were associated with early hemorrhage in patients undergoing ERCP with biliary stent placement.

Biliary stones account for 30–70% of AP.<sup>26</sup> The pathogenesis of biliary pancreatitis involves gallstone migration affecting the main pancreatic duct, resulting in intraductal hypertension accompanied by impaired pancreatic exocrine drainage and subsequent regurgitation.<sup>27</sup> Hemorrhage is an infrequent but potentially fatal complication of AP, and it can increase the risk of mortality and the length of hospital stay in patients with AP.<sup>28</sup> Gastrointestinal bleeding is considered an essential form of pancreatitis-related bleeding.<sup>29</sup> Clinical evidence indicates that 50–65% of AP patients may develop acute gastrointestinal mucosal lesions;<sup>30</sup> especially in the setting of concurrent AP and acute cholangitis, stress ulcer-related bleeding is particularly likely to occur. Notably, the incidence of hemorrhage has been shown to be significantly higher in cases of infected pancreatic necrosis compared with sterile necrosis.<sup>31</sup> In addition, edema of the digestive tract with submucosal bleeding due to inflammatory processes and duodenoscopic intubation may cause gastrointestinal bleeding. Beyond gastrointestinal hemorrhage, vascular lesions and

vessel rupture caused by necroinflammatory factors are also considered to be causes of pancreatitis-associated hemorrhage.<sup>31</sup> In our study, preoperative gallstone-induced pancreatitis concurrent with acute cholangitis emerged as a significant independent predictor of postoperative hemorrhage (OR = 3.314;  $p = 0.043$ ), underscoring its critical role in bleeding risk stratification.

Acute Hb reduction is a common phenomenon in acute infection, mainly due to a decrease in the production of erythropoietin due to the release of inflammatory cytokines, such as tumor necrosis factor, interleukin (IL)-1, and IL-6, as well as increased destruction of red cells due to hemolysis and bleeding.<sup>32</sup> In the present study, the proportion of neutrophils (OR = 1.072,  $p = 0.014$ ), which reflects the level of inflammation, was identified to predict an early drop in Hb. As the principal component of erythrocytes, Hb levels provide valuable insights into the degree of erythrocyte damage. Multiple organ dysfunction resulting from acute cholangitis was associated with the presence of high levels of oxidative stress,<sup>33</sup> which could induce erythrocyte and Hb damage via altering the structure and function of Hb, causing the denaturation and precipitation of Hb, or directly penetrating red blood cell membrane and oxidizing Hb to ferric Hb. An increase in lipid peroxidation has been noted as evidence of oxidative damage in red blood cells.<sup>34</sup> After ERCP, the antioxidant capacity of red blood cells significantly improved and returned to normal. This finding is further supported by experimental evidence showing reduced blood loss in rats after the procedure following antioxidant administration.<sup>35</sup> Collectively, these findings strongly implicate inflammatory status as a critical determinant of early post-ERCP hemorrhage.

The obstruction of the biliary tree and the inability to excrete bile into the intestines lead to the continuous accumulation of bile. Hence, large amounts of endotoxins are produced, which can not only damage platelets and vascular endothelium but also cause systemic inflammatory response syndrome, multiple organ dysfunction syndrome, and sepsis.<sup>36</sup> Patients with obstructive jaundice were found to have an increased bleeding tendency;<sup>37</sup> this paradoxically occurs in the presence of normal platelet counts. Notably, the thromboelasto-

graphic parameter, maximum amplitude, which represents the strength of clots, was observed to be higher than normal. In addition, the mean prothrombin time was significantly prolonged in patients with jaundice.<sup>38</sup> The tissue factor pathway plays a critical role in the aforementioned phenomenon.<sup>36</sup> Increased levels of oxidative stress were found in patients with obstructive jaundice and in animal models.<sup>39</sup> Antioxidative and redox systems play more important roles in maintaining homeostasis of erythrocytes against oxidative insult compared with ordinary cells. Hence, erythrocytes are a preferential target of oxidative stress in the blood.<sup>40</sup> The present study also found an association between TBIL ( $p = 0.002$ ) and postoperative bleeding, further emphasizing the complex interplay between biliary obstruction and coagulation function.

This study has several limitations inherent to its single-center retrospective design. The small sample size and single-institution origin may limit the generalizability of our findings. This relatively modest sample size may reduce the statistical power of our analyses. Furthermore, certain confounding variables could not be controlled; retrospective supplementation of incomplete data was also challenging. For example, routine postoperative intravenous fluid resuscitation has been demonstrated to exert an impact on postoperative Hb and hematocrit levels.<sup>41</sup> To mitigate such confounding effects, we calculated the fluid volume based on body surface area and simultaneously controlled the fluid infusion rate. Previous evidence has indicated that hemodilution induced by routine postoperative fluid resuscitation typically causes only a mild reduction in Hb levels, which is far below the threshold of 20 g/L defined for hemorrhage.<sup>41</sup> Future research can focus on whether the incidence of post-ERCP bleeding will be reduced if endogenous factors are optimized.

## CONCLUSION

This study was designed to identify the factors influencing post-ERCP hemorrhage. We hypothesized that, in addition to exogenous factors such as EST and pre-EST, there might be other contributors to post-ERCP bleeding. In our study, we found that preoperative pancreatitis, elevated TBIL, inflammation, and higher baseline Hb were indepen-



dent predictors of postoperative hemorrhage risk in patients undergoing ERCP with biliary stent placement.

## AUTHORS' DISCLOSURE

This study was supported by Shanghai Municipal Health Commission Clinical Research Program (No. 20194Y0457 to Erli Pei) and Shanghai Municipal Health Commission Policy Program (No. 2022HP70 to Li Cai). The study involving human participants was reviewed and approved by the ethics committee of Yangpu Hospital (LL-2021-SCI-007). The data were extracted from the medical system of the hospital and the corresponding case records, laboratory tests, endoscopic reports, and other examination results.

## CONFLICT OF INTEREST

The authors declare that they have no competing interests.

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