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Prediction Model for Severe Complications in Patients with Failed Conservative Treatment of Acute Intestinal Obstruction Based on Clinical and Imaging Features: Development and Validation

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Abstract

Objective

To develop and validate a prediction model based on clinical and imaging features for identifying high-risk patients who develop Clavien–Dindo grade ≥ IIIa severe complications (including intestinal necrosis, perforation, sepsis, and reoperation) after failed conservative treatment of acute intestinal obstruction.

Methods

This was a clinical prediction study. Clinical data were collected, including age, sex, BMI, history of abdominal surgery, history of chronic disease, vital signs, laboratory parameters (NLR, CRP), obstruction characteristics, and CT findings (degree of bowel dilation, bowel wall thickening, fecal sign, mesenteric vascular sign, ascites). Univariate and multivariate logistic regression analyses were used to identify independent predictors, based on which a nomogram prediction model was constructed. Model discrimination was assessed by the area under the receiver operating characteristic curve, and internal validation was performed using 10-fold cross-validation.

Results

Multivariate logistic regression showed that history of abdominal surgery, development of peritonitis signs during conservative treatment, increased heart rate, elevated 24-hour NLR increase after admission, and CT findings of fecal sign and mesenteric vascular sign were independent predictors of severe complications. The prediction model showed good discrimination, with an AUC of 0.894 (95% CI: 0.851–0.936). The internally validated C-index was 0.872 (95% CI 0.825–0.920).

Conclusion

We successfully developed and internally validated a prediction model that combines clinical and CT features. This model effectively predicts the risk of severe complications in patients with acute intestinal obstruction who fail conservative treatment, facilitating early identification of high-risk patients and timely intervention.

Background

Acute intestinal obstruction is one of the most common acute abdominal diseases in general surgery. It is a pathological condition in which intestinal contents cannot pass through the bowel because of mechanical obstruction. Among all causes, postoperative intra-abdominal adhesions are the leading cause and account for about 60%–75% of small bowel obstruction cases[1, 2]. This is especially common in patients with a history of abdominal surgery. Other common causes include incarcerated

external hernia, colorectal tumors, volvulus, and inflammatory bowel disease[3, 4]. The main clinical manifestations are abdominal pain, abdominal distension, nausea, vomiting, and cessation of flatus and defecation. However, disease severity mainly depends on the anatomical location and duration of obstruction[3]. In developing countries with limited medical resources, delayed hospital visits, hesitation toward surgery, and poor access to medical information still lead to high morbidity and mortality. Therefore, complications such as bowel necrosis and perforation are more common than in developed countries[4, 5].

For acute adhesive intestinal obstruction without signs of strangulation, current guidelines and common clinical practice recommend nonoperative management as the initial treatment strategy. Main treatments include fasting, gastrointestinal decompression, fluid resuscitation, and the use of water-soluble contrast agents when needed for diagnostic evaluation[6, 7]. Previous studies showed that most patients with adhesive intestinal obstruction can improve after conservative treatment. Reported success rates range from about 58% to 80%[2, 8, 9]. However, conservative treatment is not effective in all patients. About 20%–30% of patients eventually require surgery because the obstruction does not resolve or because severe complications such as bowel ischemia and perforation develop[1, 8]. Clinical studies also found that about half of surgical patients first received conservative treatment for an average of 3–5 days before surgery was performed because symptoms did not improve[10]. Delayed surgery is closely related to poor outcomes. Fung et al. found that each additional day from admission to surgery increased the odds of severe complications (Clavien-Dindo grade ≥IIIa) by 7%. The risk of bowel resection also increased accordingly[11]. Cengarle et al. reported similar results. They found that a longer interval from admission to surgery was associated with longer postoperative hospital stay[2]. Severe complications after failed conservative treatment, including bowel necrosis, perforation, intra-abdominal sepsis, and death, are not rare. These complications greatly increase treatment difficulty and mortality risk. They may also turn preventable conditions into irreversible outcomes.

Identifying which patients may benefit from conservative treatment and which patients need early surgery remains a major challenge in the management of intestinal obstruction. However, traditional clinical judgment has important limitations. Classical signs of bowel strangulation, such as peritonitis, fever, tachycardia, and leukocytosis, have limited sensitivity and specificity[12]. Previous studies showed that serum lactate is an important biomarker for bowel ischemia. Dynamic changes in lactate after fluid resuscitation also have good negative predictive value for irreversible bowel ischemia[13]. In addition, the neutrophil-to-lymphocyte ratio (NLR) and its changes after admission are closely associated with bowel ischemia and the need for surgery[14]. In imaging evaluation, computed tomography (CT) has become the gold standard for diagnosing intestinal obstruction and assessing disease severity[5, 15]. Several studies confirmed that CT findings such as bowel wall thickening, mesenteric edema, ascites, pneumatosis intestinalis, and the serrated beak sign have high specificity for bowel ischemia[16]. Among these findings, mesenteric vascular twisting or crowding and large-volume ascites often suggest vascular injury caused by volvulus or adhesive traction[17]. Although evidence for individual predictors has increased, no single clinical or imaging finding can reliably predict failure of conservative treatment or severe complications. In clinical practice, combining multiple indicators often depends on subjective

experience. This makes it difficult to establish a unified and quantitative decision-making system. For example, the small bowel feces sign has traditionally been considered a benign sign of incomplete obstruction and possible success of conservative treatment. However, some patients still eventually require surgery because the obstruction does not resolve[18]. These “gray-zone” patients are often the most difficult to manage.

Several studies explored quantitative methods for predicting the need for surgery. Matsuda et al. developed a machine learning model and found that the random forest algorithm showed excellent performance in predicting surgical intervention in adhesive intestinal obstruction, with an AUC of 0.889. They also suggested that a 72-hour observation period was a reasonable decision point[19]. Other studies focused on dynamic changes in drainage volume. Nakao et al. proposed that a daily drainage volume ≥ 500 mL on day 7 could serve as an indication for surgery[20]. In pediatric patients, a drainage volume > 11.7 mL/kg on day 2 was also strongly associated with the eventual need for surgery[21]. These findings suggest that prediction models based on objective indicators may be more accurate than individual clinical judgment. However, most current models and scoring systems mainly focus on whether surgery is needed. Few studies use severe complications as the primary endpoint. This may limit their clinical value. Events such as bowel necrosis, perforation, sepsis, reoperation, and intensive care admission are the outcomes that truly affect prognosis and medical resource use. Albabtain et al. reported that patients who developed postoperative systemic inflammatory response syndrome or sepsis had significantly higher 30-day mortality. Many of these complications might have been prevented by earlier intervention[22]. Therefore, early identification of patients at high risk for severe complications after failed conservative treatment is particularly important.

Although imaging findings, blood biomarkers, and dynamic drainage changes have shown predictive value in previous studies, most evidence comes from univariable or multivariable regression analyses. Few studies have attempted to integrate these multidimensional clinical data into a single and intuitive prediction tool. Existing scoring systems mainly focus on predicting the need for surgery rather than predicting severe complications such as Clavien-Dindo grade ≥IIIa events. Since the importance of predictors differs among studies, a comprehensive evaluation within a unified framework is still needed. A nomogram is a useful tool that visualizes logistic regression results and provides intuitive clinical decision support. Based on this background, the present study used logistic regression analysis to integrate candidate predictors, including age, BMI, history of abdominal surgery, chronic disease history, admission and 24-hour dynamic NLR, CRP, obstruction site and etiology, and multiple CT findings such as bowel dilation, bowel wall thickening, small bowel feces sign, mesenteric vascular sign, and ascites. We aimed to construct and validate a nomogram for predicting Clavien-Dindo grade ≥IIIa severe complications, including bowel necrosis, perforation, sepsis, and reoperation, in patients with acute intestinal obstruction after failed conservative treatment. This model may provide clinicians with a more accurate, objective, and quantitative decision-support tool. It may help identify high-risk patients during the optimal treatment window, improve the timing of intervention, reduce severe complications, and improve patient outcomes.

Materials and Methods

Patient Data

This study was approved by the ethics committee of Leshan People's Hospital. We retrospectively collected clinical data from 366 patients admitted to Leshan People's Hospital between January 2018 and January 2026.

Inclusion and Exclusion Criteria

Inclusion criteria:

1. 1. Age ≥ 18 years.
2. 2. Diagnosis of acute intestinal obstruction, including adhesive or tumor-related obstruction, confirmed by imaging (e.g., CT) or intraoperatively.
3. 3. Initial conservative treatment lasting at least 24 hours.
4. 4. Clear evidence of failed conservative treatment (e.g., worsening abdominal pain, progressive distension, rising white blood cell count, imaging showing unresolved or worsened obstruction) and eventual surgery.
5. 5. Complete medical records, including admission notes, laboratory results, treatment plans, operative reports, and follow-up data.

Exclusion criteria:

1. 1. Diagnosis of intestinal strangulation, necrosis, perforation, or diffuse peritonitis at admission, or critically ill patients who proceeded directly to emergency surgery.
2. 2. Non-adhesive and non-tumor obstructions (e.g., intussusception, fecalith obstruction, foreign body obstruction).
3. 3. Incomplete medical records or missing key clinical data that precluded accurate assessment of outcome or predictor variables.
4. 4. Severe cardiac, pulmonary, hepatic, or renal insufficiency; coagulopathy; or immunosuppression that could affect complication assessment or prognosis.
5. 5. Pregnant or lactating women.
6. 6. Patients who died during conservative treatment without reaching surgical indications.
7. 7. First surgery was palliative or exploratory without relieving the obstruction.

Data Collection

The following demographic and clinical variables were collected: age, sex, BMI, history of abdominal surgery, history of chronic disease, development of peritonitis signs during conservative treatment, fever, heart rate, NLR at admission, 24-hour NLR increase after admission, CRP, obstruction site, obstruction

etiology, CT findings (degree of enteric dilation, bowel wall thickening, fecal sign, mesenteric vascular sign, ascites), and duration of conservative treatment. The outcome variable, Clavien–Dindo grade ≥ IIIa (including intestinal necrosis, perforation, sepsis, reoperation), was also recorded.

Statistical Analysis

Baseline demographic characteristics were stratified by the outcome (Clavien–Dindo ≥ IIIa). Normally distributed continuous data are presented as mean ± SD, non-normally distributed data as median (interquartile range). Categorical variables were compared using the chi-square test or Fisher's exact test; continuous variables using Welch's two-sample t-test or the rank-sum test. LASSO regression was used to select predictors of Clavien–Dindo ≥ IIIa and to construct a predictive nomogram. Model performance was assessed using receiver operating characteristic (ROC) curves and calibration curves. The area under the ROC curve (AUC) ranges from 0.5 (no discrimination) to 1.0 (perfect discrimination). Internal validation was performed using 10-fold cross-validation. The $riskRegression::Sc\ \text{or}\ e$ function was used to evaluate the logistic model and calculate the internally validated C-index/AUC with its 95% confidence interval. Calibration curves were plotted to assess agreement between predicted probabilities and observed outcomes. Decision curve analysis (DCA) was performed to determine the net benefit of the prediction model across risk thresholds. A two-sided $P < 0.05$ was considered statistically significant. All analyses were performed using R software (version 4.2.2).

Results

Baseline Patient Characteristics

A total of 366 patients were included and divided according to the outcome: 284 (77.6%) in the "no" group (no Clavien–Dindo ≥ IIIa) and 82 (22.4%) in the "yes" group. Demographic and clinical baseline characteristics are shown in Table 1. Mean age was 60 ± 17 years in the "no" group and 58 ± 16 years in the "yes" group (P = 0.312). In the "no" group, 141 (49.6%) were female and 143 (50.4%) male; in the "yes" group, 39 (47.6%) female and 43 (52.4%) male (P = 0.739). Mean BMI was 22.5 ± 4.3 kg/m² in the "no" group and 22.5 ± 3.8 kg/m² in the "yes" group (P = 0.989).

A history of abdominal surgery was significantly different between groups (P = 0.004). In the "no" group, 134 (47.2%) had no prior abdominal surgery and 150 (52.8%) had such a history; in the "yes" group, 24 (29.3%) had no history and 58 (70.7%) had a history, indicating a higher proportion of prior abdominal surgery among those who developed the outcome. In contrast, history of chronic disease was similarly distributed (P = 0.964). In the "no" group, 63 (22.2%) had no chronic disease and 221 (77.8%) had some chronic disease; in the "yes" group, 18 (22.0%) had no chronic disease and 64 (78.0%) had chronic disease, suggesting that chronic disease was common but not associated with the outcome.

Thus, in our cohort, age, sex, BMI, and chronic disease history were not significantly associated with the outcome, whereas a history of abdominal surgery was significantly more frequent in the "yes" group,

indicating its potential as an important clinical factor.

Table 1
Patient demographics and baseline characteristics

Characteristic	Clavien-Dindo≥IIIa		p-value
	no	yes	
	N = 284	N = 82	
Age, Mean ± SD	60 ± 17	58 ± 16	0.312[1]
Gender, n (%)			0.739[2]
female	141 (49.6%)	39 (47.6%)	
male	143 (50.4%)	43 (52.4%)	
BMI, Mean ± SD	22.5 ± 4.3	22.5 ± 3.8	0.989[1]
History of abdominal surgery, n (%)			0.004[2]
no	134 (47.2%)	24 (29.3%)	
yes	150 (52.8%)	58 (70.7%)	
History of chronic disease, n (%)			0.964[2]
no	63 (22.2%)	18 (22.0%)	
yes	221 (77.8%)	64 (78.0%)	
[1]Welch Two Sample t-test			
[2]Pearson's Chi-squared test			

Prediction Model Development

Candidate predictors included age, sex, BMI, history of abdominal surgery, history of chronic disease, development of peritonitis signs during conservative treatment, fever, heart rate, NLR at admission, 24-hour NLR increase after admission, CRP, obstruction site, obstruction etiology, CT degree of enteric dilation, CT bowel wall thickening, fecal sign, mesenteric vascular sign, ascites, and duration of conservative treatment. After LASSO regression, six potential predictors were selected (Fig. 1 and Fig. 2). Table 2 shows the regression coefficients.

(λ = 0.04055239538437 19).

Table 2
Coefficients from LASSO regression analysis

variable	Coefficient
(Intercept)	-6.4038244
Age	0.0000000
Gender_male	0.0000000
BMI	0.0000000
History.of.abdominal.surgery_yes	0.0199943
History.of.chronic.disease_yes	0.0000000
Peritonitis.signs.developing.during.conservative_yes	1.3621577
Fever_yes	0.0000000
Heart.rate	0.0470014
NLR.at.admission	0.0000000
X24.hour.NLR.increase.after.admission	0.4804782
CRP	0.0000000
Obstruction.site_intestinal	0.0000000
Obstruction.etiology_tumor	0.0000000
CT.enteric.dilation.degree	0.0000000
CT.bowel.wall.thickening	0.0000000
fecal.sign_yes	0.7879260
Mesenteric.vascular.sign_yes	0.8379687
Ascites_yes	0.0000000
Conservative.treatment.duration_≤48h	0.0000000

ROC curve analysis for each selected variable showed that all had AUC > 0.5. The 24-hour NLR increase after admission had the highest AUC (0.767, 95% CI: 0.713–0.820), followed by fecal sign (AUC = 0.700, 95% CI: 0.642–0.757) and heart rate (AUC = 0.658, 95% CI: 0.574–0.743). Peritonitis signs developing during conservative treatment (AUC = 0.616, 95% CI: 0.567–0.664), mesenteric vascular sign (AUC = 0.615, 95% CI: 0.565–0.664), and history of abdominal surgery (AUC = 0.590, 95% CI: 0.532–0.647) showed more limited predictive value (Fig. 4 and Table 3).

Table 3
AUC values and 95% confidence intervals for individual variables

Variable	AUC Value	AUC 95% Confidence Interval
History of abdominal surgery	0.590	(0.532–0.647)
Peritonitis signs developing during conservative	0.616	(0.567–0.664)
Heart rate	0.658	(0.574–0.743)
24-hour NLR increase after admission	0.767	(0.713–0.820)
fecal sign	0.700	(0.642–0.757)
Mesenteric vascular sign	0.615	(0.565–0.664)
AUC calculated using the model predictions; confidence intervals are estimated using DeLong's method.		

Multivariate logistic regression was then performed. Table 4 presents the results.

Table 4
Results of multivariate logistic regression

Characteristic	N	Event N	OR	95% CI	p-value
History of abdominal surgery					
no	158	24	—	—	
yes	208	58	2.10	1.03, 4.28	0.041
Peritonitis signs developing during conservative					
no	338	61	—	—	
yes	28	21	9.51	3.29, 27.45	< 0.001
Heart rate	366	82	1.09	1.05, 1.13	< 0.001
24-hour NLR increase after admission	366	82	2.35	1.75, 3.16	< 0.001
fecal sign					
no	234	27	—	—	
yes	132	55	3.94	1.89, 8.24	< 0.001
Mesenteric vascular sign					
no	333	60	—	—	
yes	33	22	4.80	1.62, 14.22	0.005
Abbreviations: CI = Confidence Interval, OR = Odds Ratio					

The final logistic regression model included six predictors (history of abdominal surgery, peritonitis signs developing during conservative treatment, heart rate, 24-hour NLR increase after admission, fecal sign, and mesenteric vascular sign), which were used to construct a nomogram (Fig. 5).

Multivariate logistic regression showed that a history of abdominal surgery (OR = 2.10, 95% CI 1.03–4.28, P = 0.041), development of peritonitis signs during conservative treatment (OR = 9.51, 95% CI 3.29–27.45, P < 0.001), heart rate (OR = 1.09, 95% CI 1.05–1.13, P < 0.001), 24-hour NLR increase after admission (OR = 2.35, 95% CI 1.75–3.16, P < 0.001), fecal sign (OR = 3.94, 95% CI 1.89–8.24, P < 0.001), and mesenteric vascular sign (OR = 4.80, 95% CI 1.62–14.22, P = 0.005) were independent predictors of Clavien–Dindo grade ≥ IIIa complications. Among these, peritonitis signs, heart rate, 24-hour NLR increase, and fecal sign showed very strong statistical significance (P < 0.001).

The ROC curve of the final prediction model is shown in Fig. 6. The model demonstrated excellent discrimination, with an AUC of 0.894 (95% CI: 0.851–0.936).

Internal Validation

Internal validation using 10-fold cross-validation yielded a C-index/AUC of 0.872 (95% CI 0.825–0.920), indicating good robustness and discriminative ability.

Calibration Analysis

The calibration curve of the nomogram is shown in Fig. 7. The curve closely followed the ideal diagonal line, indicating excellent agreement between predicted probabilities and observed outcomes.

Decision Curve Analysis

Decision curve analysis (DCA) for the nomogram is presented in Fig. 8. The DCA curve showed that the nomogram provides a significant net benefit across a range of threshold probabilities, supporting its clinical utility.

Discussion

Acute intestinal obstruction is a common acute abdominal disease in general surgery. Determining the optimal timing for conversion from conservative treatment to surgical intervention remains a major challenge in clinical practice. Previous studies mainly focused on identifying indications for surgery or predicting bowel necrosis. However, there is still a lack of effective quantitative tools for stratifying the risk of severe complications after failed conservative treatment, including bowel necrosis, perforation, sepsis, and reoperation, which are classified as Clavien-Dindo grade ≥IIIa events. In the present study, we integrated clinical, laboratory, and imaging variables to construct and internally validate a nomogram for predicting these severe complications. Our results showed that a history of abdominal surgery, newly developed peritonitis signs during conservative treatment, increased neutrophil-to-lymphocyte ratio

(NLR) within 24 hours after admission, tachycardia, and CT findings including the small bowel feces sign and mesenteric vascular sign were independent predictors of severe complications. The model showed excellent discriminative ability, with an AUC of 0.894 and an internally validated AUC of 0.872. These findings suggest that the model may serve as an evidence-based quantitative tool for early identification of high-risk patients and timely adjustment of treatment strategies.

Among the six independent predictors identified in this study, several findings were consistent with or complementary to previous studies on bowel ischemia and surgical risk. A history of abdominal surgery was confirmed as an independent risk factor. This agrees with previous reports showing that postoperative adhesions are a major cause of adhesive intestinal obstruction and strangulation. Among clinical signs, newly developed peritonitis during conservative treatment was the strongest predictor of severe complications, with an odds ratio of 9.51. This finding is consistent with the prospective scoring system developed by Wassmer et al., in which abdominal tenderness was identified as a strong predictor of bowel resection[23]. It also supports the basic surgical principle that peritonitis often indicates transmural bowel ischemia or perforation. Compared with isolated imaging findings, dynamic changes in peritoneal signs may more directly reflect disease progression. Tachycardia and increased 24-hour NLR together represented a “physiological-inflammatory” dimension associated with systemic stress, inflammatory response, and hypovolemia. Previous studies showed that serum lactate is closely related to bowel ischemia[24]. In our study, the short-term increase in NLR within 24 hours appeared to provide more timely information about disease progression than a single static measurement. This finding is consistent with the increasing use of combined inflammatory markers to improve clinical decision-making. A large cohort study also emphasized the importance of identifying patients who are not immediately treated surgically but still have a high risk of death or severe complications, so that early intervention can be provided[10].

Imaging findings also played an important role in the present model. Both the small bowel feces sign and the mesenteric vascular sign were significantly associated with severe complications. However, the interpretation of the small bowel feces sign differs among previous studies. Kim et al. reported that the absence of the small bowel feces sign was an independent predictor of failed conservative treatment in adhesive intestinal obstruction[25]. They suggested that the presence of this sign might indicate prolonged luminal stasis without severe vascular compromise. In contrast, our results showed that in patients who had already undergone conservative treatment, the presence of the feces sign was associated with more severe complications requiring surgical or interventional management. This apparent difference may be related to the more severe endpoint used in our study, namely Clavien-Dindo grade ≥IIIa complications. After intestinal obstruction occurs, luminal stasis may promote bacterial overgrowth and increased intraluminal pressure. This may worsen bowel wall edema and microcirculatory dysfunction, thereby accelerating progression from simple obstruction to strangulation and necrosis. The mesenteric vascular sign, characterized by twisting and crowding of mesenteric vessels, directly reflects vascular compression caused by closed-loop obstruction or volvulus. Previous meta-analyses showed that mesenteric edema and fluid are among the most sensitive CT findings for

strangulated intestinal obstruction[24]. In our multivariable analysis, the mesenteric vascular sign showed an odds ratio of 4.80, confirming its important value in identifying high-risk patients.

The present prediction model combined clinical signs, dynamic laboratory changes, and high-resolution imaging findings. This reflects the concept of multidimensional assessment and helps overcome the limitations of single indicators. For example, biomarkers such as lactate or CRP alone may be affected by renal dysfunction, sepsis, and other systemic conditions. In contrast, our model integrated indicators reflecting different pathophysiological processes, including inflammation, physiological stress, anatomical abnormalities, and vascular compromise. This improved overall predictive stability. From a clinical perspective, the model is practical because all required variables can be routinely obtained within the first 24 hours after admission. Clinicians may use the calculated risk score for dynamic risk stratification during conservative treatment. For patients with high-risk scores, more aggressive monitoring and intervention should be considered even if initial hemodynamic status appears stable. These strategies may include shortening the interval for repeat imaging or performing early diagnostic laparoscopy to avoid missing the optimal surgical window. This approach also supports the recommendation by Lee et al. that patients at high risk of mortality or severe complications should be identified early, even if surgery is not initially planned[10].

Several limitations should also be acknowledged. First, this was a retrospective single-center study. Therefore, selection bias and confounding factors were unavoidable. In addition, some information, such as the control status of chronic diseases, may not have been completely recorded in retrospective data. Second, although robust 10-fold cross-validation was used for internal validation, external validation in prospective multicenter cohorts is still necessary to assess the generalizability of the model across different populations and healthcare settings. Third, some variables traditionally considered clinically important, including age, body temperature, CRP level, and the anatomical cause of obstruction, did not remain significant in the final multivariable analysis. This result may be related to limited sample size or to the stronger predictive effects of other variables included in the model, such as peritonitis signs and dynamic NLR changes. Future subgroup analyses in larger cohorts are needed to further clarify these findings.

Future studies should focus on further optimization and validation of the present model. First, multicenter prospective studies are essential to confirm the external validity of the model and reduce the bias associated with retrospective analyses. Second, the current model mainly relies on clinical and imaging findings obtained within 24 hours after admission. Future research may include more organ-specific biomarkers, such as intestinal fatty acid-binding protein and D-lactate, which have shown potential value in predicting bowel ischemia[13, 26]. Combining these biomarkers with the current model may further improve sensitivity and specificity. Finally, with the development of artificial intelligence technologies, deep learning algorithms may help clinicians automatically identify and quantify CT findings such as the small bowel feces sign and mesenteric vascular sign, or even directly identify high-risk obstruction patterns[16]. This approach may reduce subjectivity in imaging interpretation and support the development of semi-automated or fully automated prediction systems. Ultimately,

integrating this nomogram into electronic medical record systems as a real-time clinical decision-support tool may allow bedside generation of individualized risk assessments and help translate these findings into improved patient outcomes.

Abbreviations

BMI
Body Mass Index
CT
Computed Tomography
NLR
Neutrophil-to-lymphocyte ratio
CRP
C-reactive protein
ROC
Receiver operating characteristic
AUC
Area under the curve
DCA
Decision curve analysis.

Declarations

Ethics approval and consent to participate

This study was approved by the ethics committee of Leshan People's Hospital. The research was conducted in compliance with the Declaration of Helsinki. The need for informed consent was waived by the ethics committee of Leshan People's Hospital due to the retrospective nature of the study.

Consent for publication

Not applicable.

Competing Interests

The authors declare that they have no competing interests.

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Author Contribution

M.Z. and J.D. conceptualized and designed the study. M.Z., J.D., and M.L. performed data acquisition and curation. Y.W. and W.Z. conducted the statistical analysis, including the LASSO regression and model development. K.L. verified the underlying data and contributed to the interpretation of imaging features. M.Z. and J.D. drafted the initial manuscript. M.L., Y.W., and W.Z. critically revised the manuscript for important intellectual content. M.Z. supervised the entire study and acted as the corresponding author. All authors reviewed and approved the final manuscript and agree to be accountable for all aspects of the work.

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Not applicable.

Data Availability

The clinical data that support the findings of this study were obtained from The People's Hospital of Leshan and are not publicly available due to ethical restrictions and patient privacy protection. Data contain sensitive patient information, and the ethics committee of The People's Hospital of Leshan has imposed restrictions on data sharing. De-identified data may be available from the corresponding author (Mingjie Zhu, email: 17811162@qq.com) upon reasonable request and with the approval of the hospital’s ethics committee.

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Figures

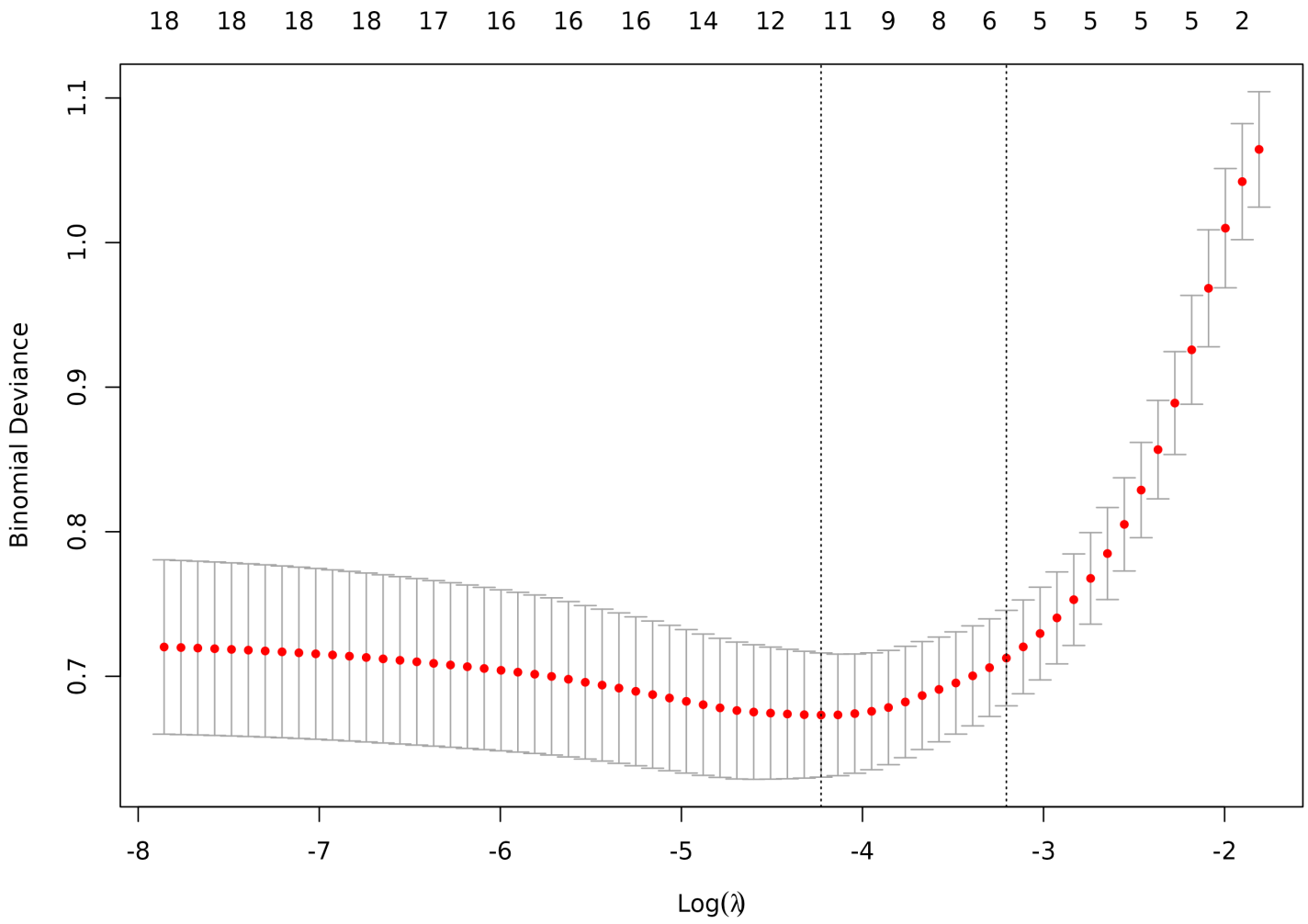


Figure 1

Variable selection using LASSO regression with 10-fold cross-validation

(λ= 0.0405523953843719).

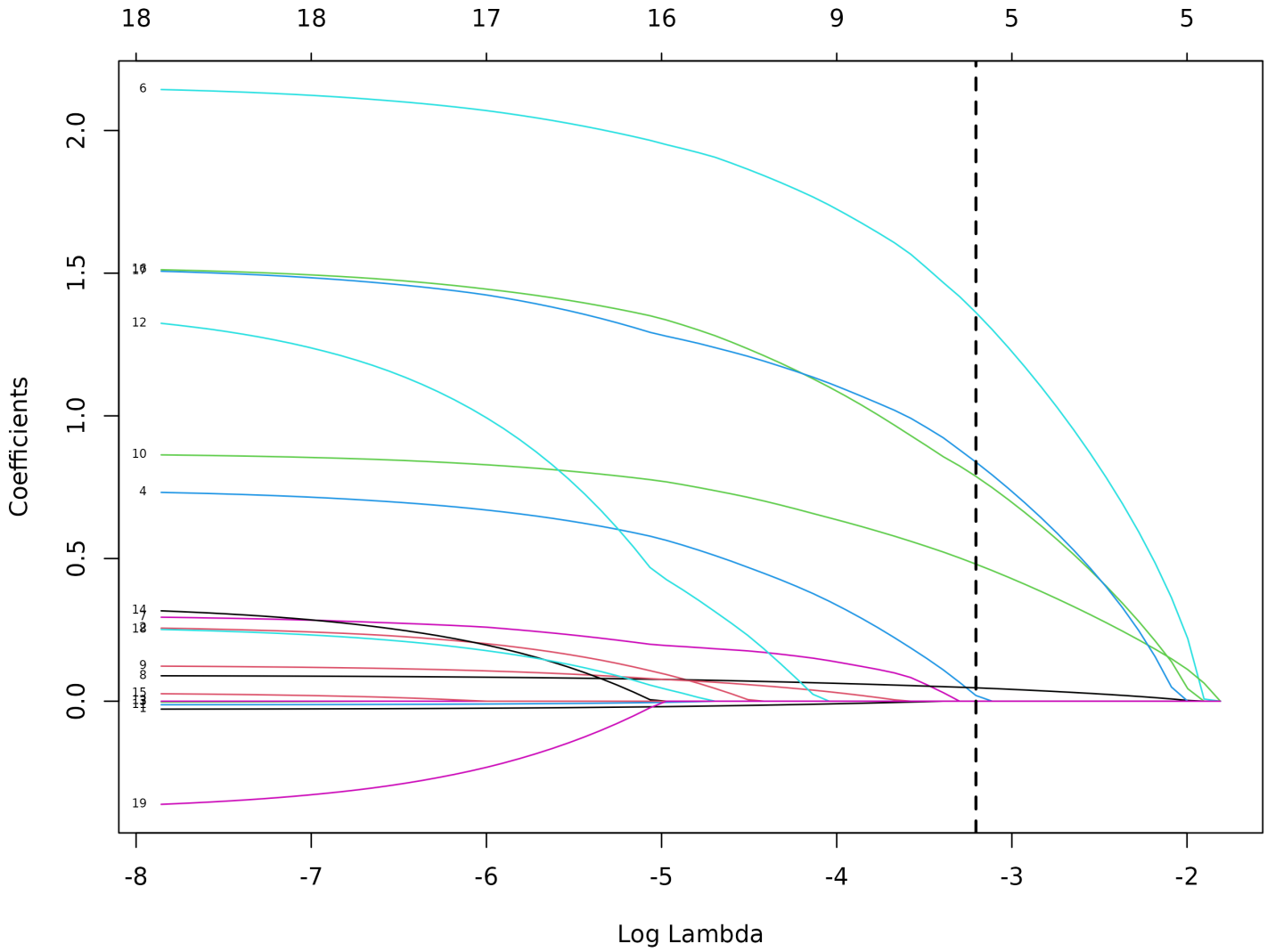


Figure 2

LASSO regression coefficient path diagram (λ = 0.0405523953843719).

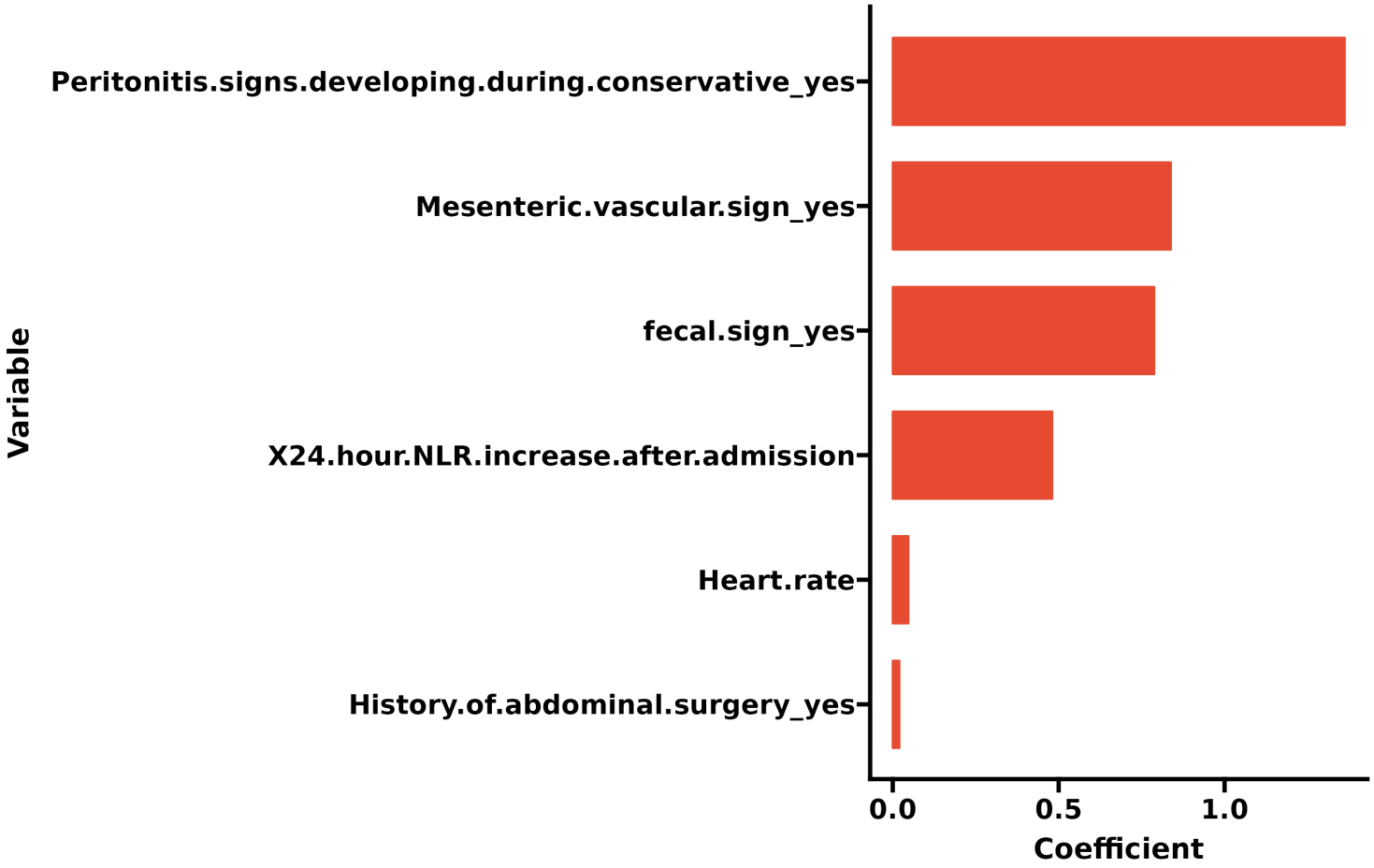


Figure 3

shows the non-zero coefficients after LASSO selection.

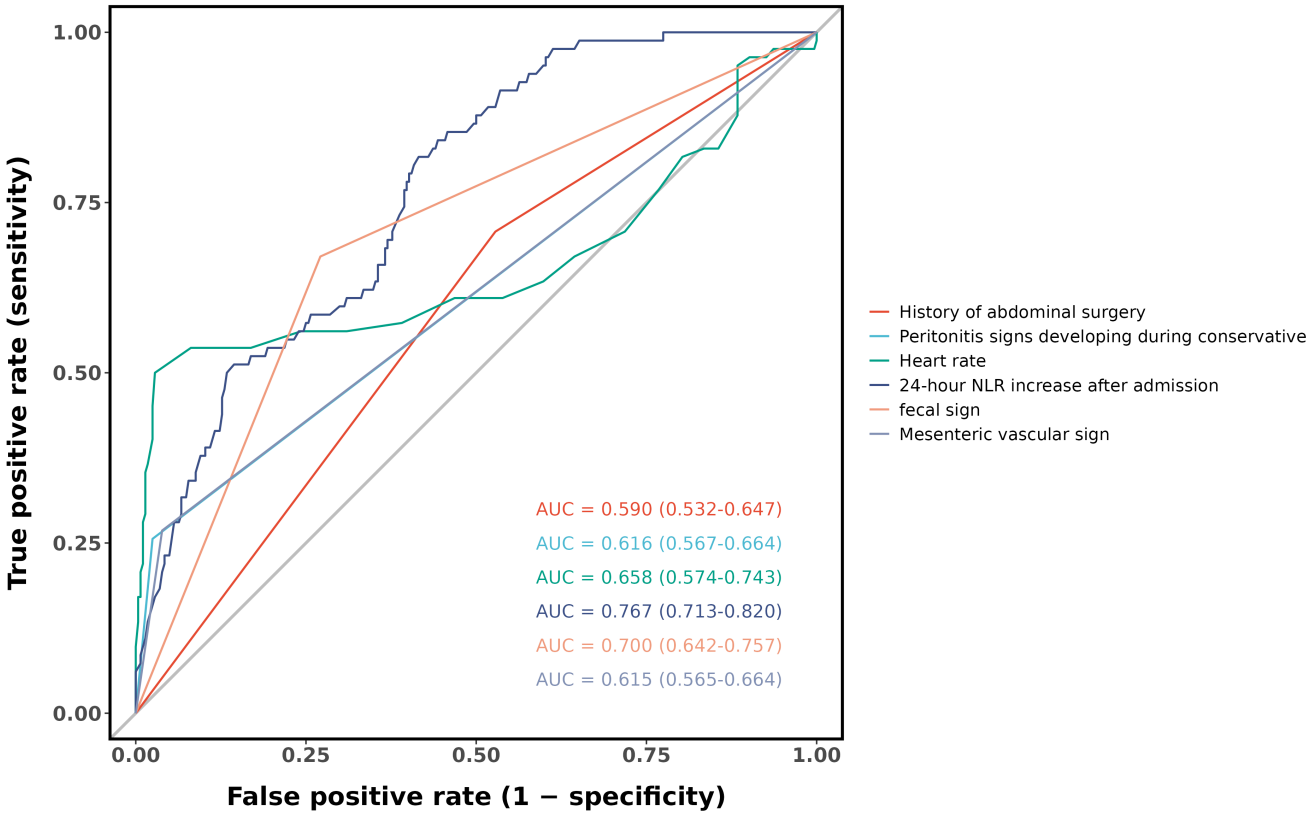


Figure 4

ROC curves for individual predictors, derived from univariate logistic regression.

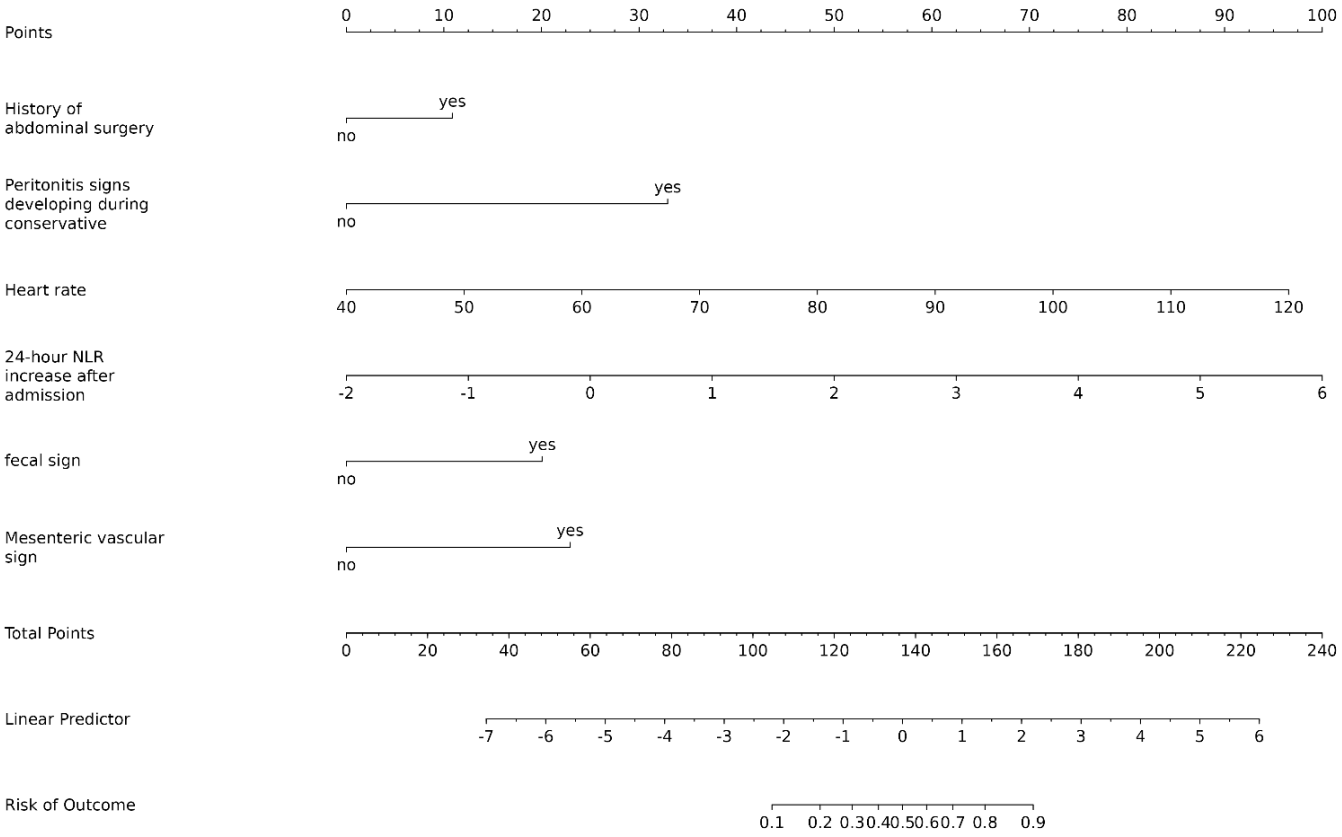


Figure 5

Nomogram for predicting severe complications.

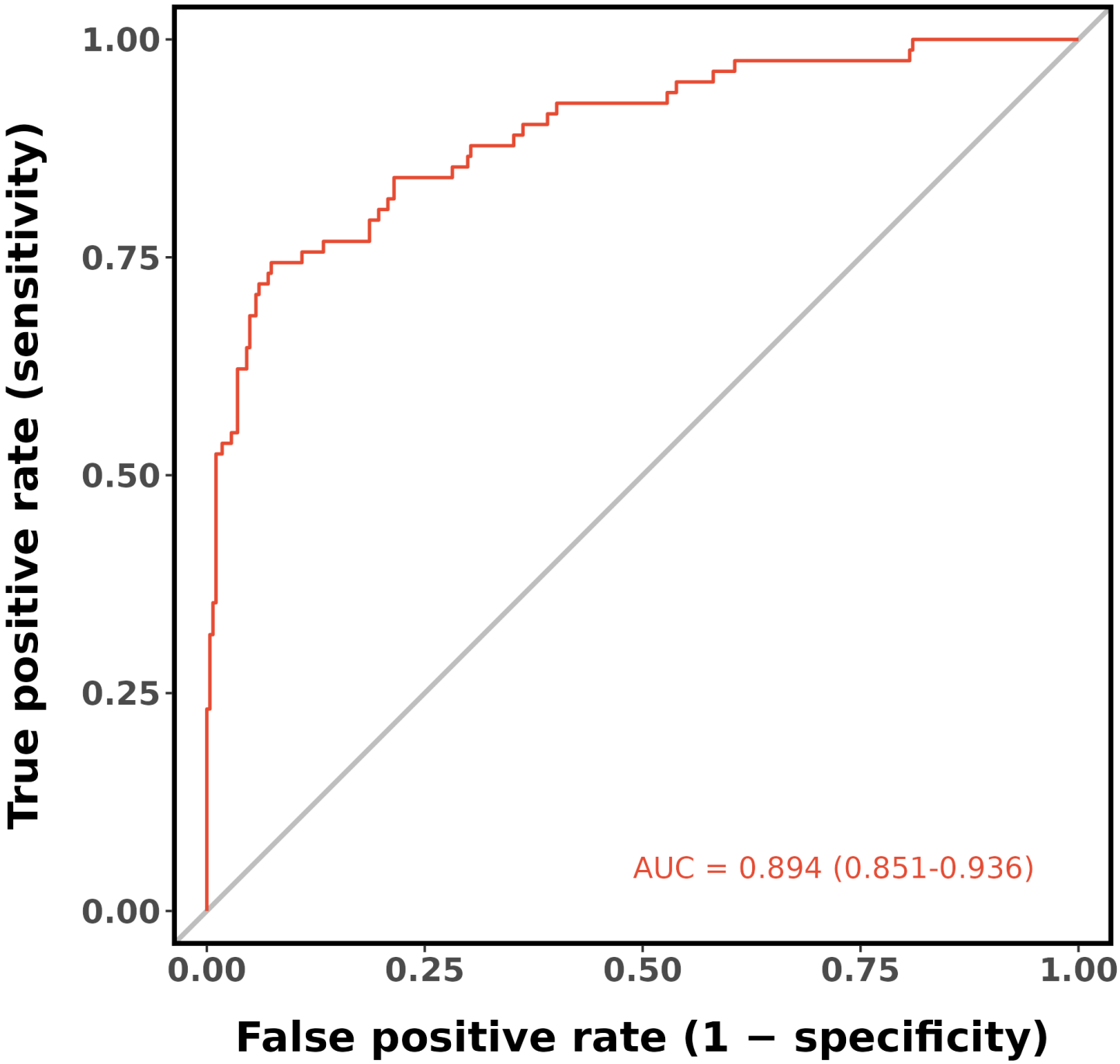


Figure 6

ROC curve of the prediction model.

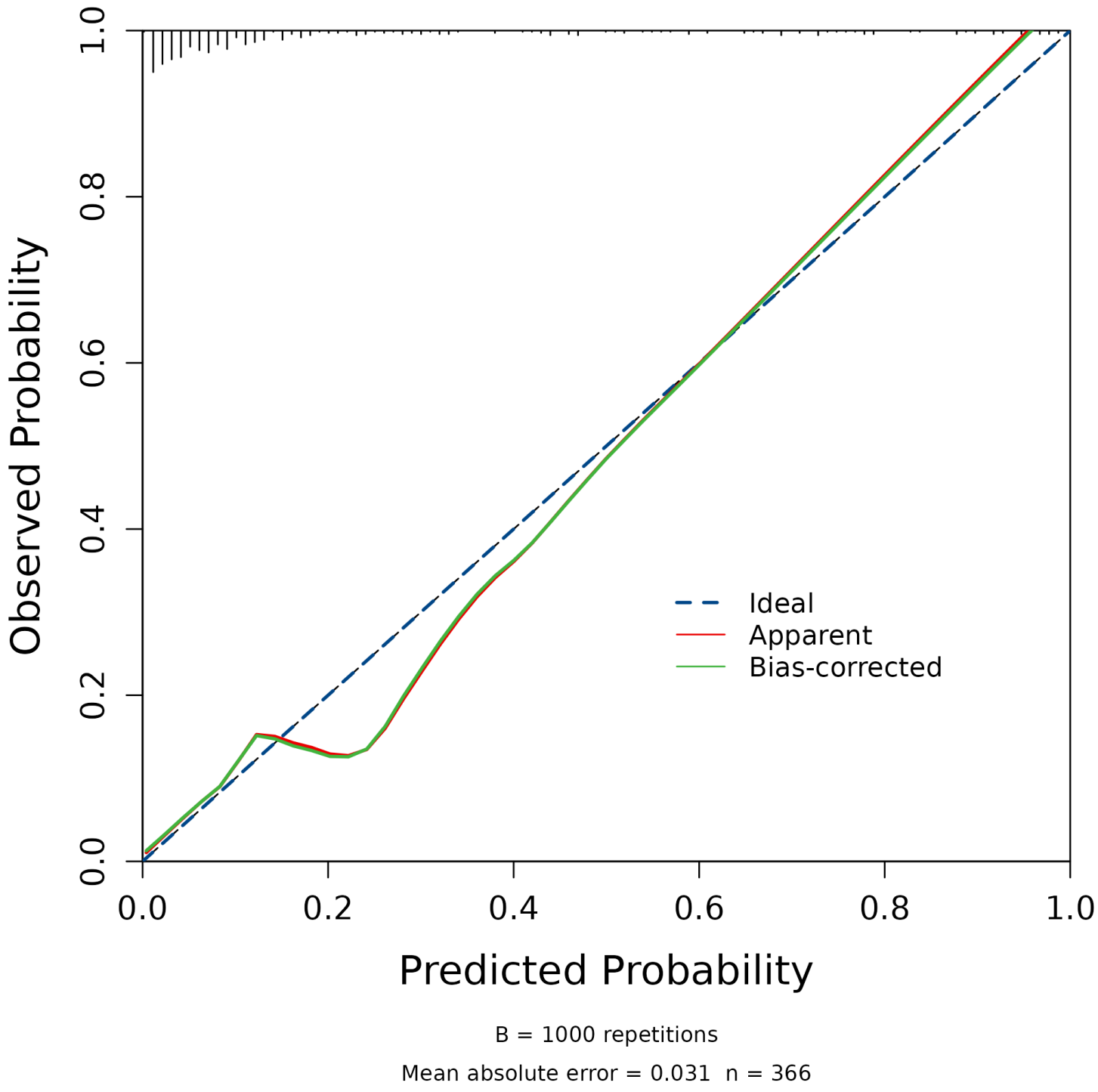


Figure 7

Calibration curve of the prediction model.

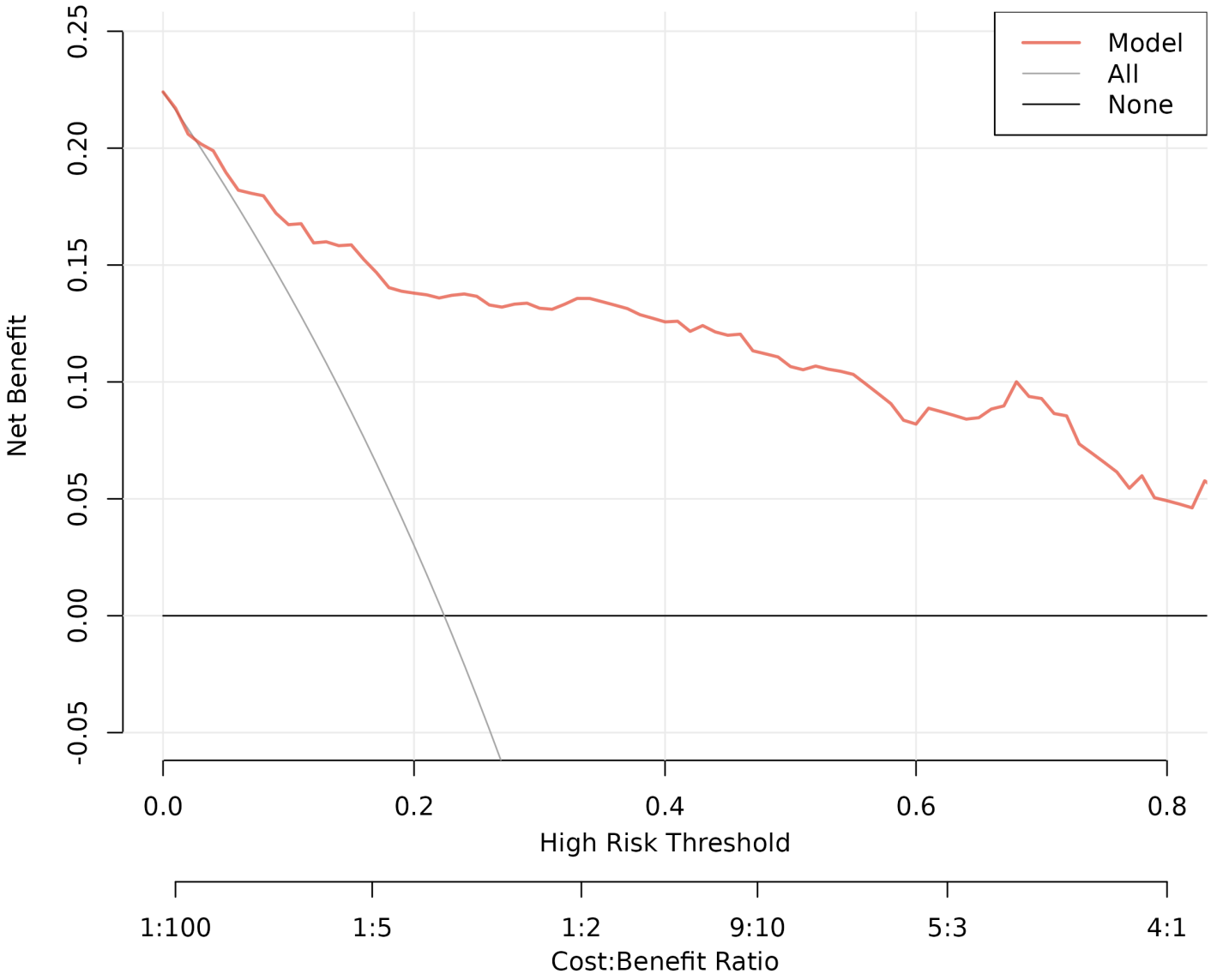


Figure 8

Decision curve analysis of the prediction model.

Supplementary Files

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- Appendix.docx