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Machine learning for temporary stoma after intestinal resection in surgical decision-making of Crohn's disease

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Abstract

Background Crohn's disease (CD) often necessitates surgical intervention, with temporary stoma creation after intestinal resection (IR) being a crucial decision. This study aimed to construct novel models based on machine learning (ML) to predict temporary stoma formation after IR for CD.

Methods Patient data who underwent IR for CD at our center between July 2017 and March 2023 were collected for inclusion in this retrospective study. Eligible CD patients were randomly divided into training and validation cohorts. Feature selection was executed using the least absolute shrinkage and selection operator. We employed three ML algorithms including traditional logistic regression, novel random forest and XG-Boost to create prediction models. The area under the curve (AUC), accuracy, sensitivity, specificity, precision, recall, and F1 score were used to evaluate these models. SHapley Additive exPlanation (SHAP) approach was used to assess feature importance.

Results A total of 252 patients with CD were included in the study, 150 of whom underwent temporary stoma creation after IR. Eight independent predictors emerged as the most valuable features. An AUC between 0.886 and 0.998 was noted among the three ML algorithms. The random forest (RF) algorithms demonstrated the most optimal performance (0.998 in the training cohort and 0.780 in the validation cohort). By employing the SHAP method, we identified the variables that contributed to the model and their correlation with temporary stoma formation after IR for CD.

Conclusions The proposed RF model showed a good predictive ability for identifying patients at high risk for temporary stoma formation after IR for CD, which can assist in surgical decision-making in CD management, provide personalized guidance for temporary stoma formation, and improve patient outcomes.

Keywords Crohn's disease, Stoma, Random forest, Machine learning, Surgical management

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Background

Crohn's disease (CD) is a chronic inflammatory bowel disorder characterized by transmural inflammation, which can lead to various complications, such as strictures, fistulas, and abscesses [1]. The incidence of CD is much higher in developed countries in North America and Europe than in Asia [2, 3]. However, over the past two decades, the incidence and prevalence of CD has increased dramatically in Asia, especially in developed regions and newly industrialized countries, including China [4–6]. Despite advancements in medical therapies, a significant proportion of patients with CD eventually require surgical intervention to manage disease-related complications or to improve their quality of life [7].

One crucial aspect of surgical management is the decision-making process regarding temporary stoma creation after intestinal resection (IR), which involves a second surgery for the restoration of intestinal continuity. The choice between proceeding with a primary anastomosis or adopting a two-stage approach remains a challenging clinical decision. The decision is currently usually based on the clinician's experience, taking into account individual patient characteristics, disease severity, presence of complications, and overall surgical risk. While some patients may benefit from immediate one-stage surgery, others may require staged procedures to minimize postoperative complications and optimize long-term outcomes, although the enterostomy can adversely impact on the patient's body image as well as lead to negative emotions and stress [8].

In this context, predictive models that aid surgical decision-making play a pivotal role in guiding clinicians towards the most appropriate treatment strategy for individual patients. Machine learning (ML), inspired by the human brain's pattern recognition strategies, offers an artificial intelligence-based technique to tackle classification problems. This involves adjusting the weights of hidden layers during training to minimize an error function [9]. ML has shown promise in predicting clinical outcomes across various medical conditions [10–12]. However, few studies have attempted to identify predictors of the need for an enterostomy after IR in patients with CD [13, 14] or have only established scoring systems [15], but none have developed a risk preoperative model utilizing advanced machine algorithms for this purpose based on preoperative patient disease characteristics as well as surgical strategies. In the present study, the factors influencing temporary stoma formation for CD patients who underwent IR were explored and novel ML model predicting temporary stoma formation in surgical management of CD was established and validated.

Patients and methods

Study Population

Patients with CD who underwent IR with either primary anastomosis or temporary stoma formation at our center from July 2017 to March 2023 were included in this retrospective analysis. Patient demographic information, preoperative clinical factors, surgical outcomes, and follow-up data were extracted from electronic medical records. The inclusion criteria were: (1) 10–80 years old; (2) postoperative histopathology confirmed the diagnosis of CD; (3) there were clear surgical indications during the operation, such as stenosis, fistula, abscess, perforation, bleeding, etc., and intestinal resection was performed. Exclusion criteria were: (1) patients undergoing permanent ostomy; (2) more than 20% of the data items were missing; (3) patients with stoma status upon admission. A total of 260 patients were screened, 8 patients were excluded, 1 patient received permanent ostomy surgery, 3 patients had ileostomy status at admission, and 4 patients had no postoperative follow-up data.

Data collection

Basic information (gender, age), disease data (duration of CD, Montreal classification), preoperative general status (body mass index (BMI), weight loss in 6 months prior to surgery, history of IR for CD, preoperative medication, nutritional and inflammatory indicators in hematology) were collected. In addition, surgical data were extracted from the database, including surgical priority, surgical approach, and type of resection. Postoperative outcomes such as postoperative complications within 30 days and BMI at the time of restoration of intestinal continuity and during postoperative follow-up were also collected.

Statistical analysis

Temporary stoma is defined as a protective stoma to avoid complications such as postoperative anastomotic fistula in patients, who would receive a secondary intestinal continuity surgery after at least 3 months of postoperative recuperation time. The paired T-test was utilized to compare the difference of BMI before and after surgery in the same patient. For this study, patients were randomly allocated into a training cohort (70%) and a validation cohort (30%). Feature selection was conducted employing the least absolute shrinkage and selection operator (LASSO), a prevalent technique. LASSO limits the sum of the absolute values of the coefficients to be below a fixed threshold, setting several regression coefficients to zero, thereby producing a more concise model. LASSO skillfully manages data with intricate covariance structures, preserving only the most crucial variables.

We assessed multicollinearity among potential predictive variables, selected via a LASSO regression feature selection procedure, using the variance inflation

factor (VIF). Subsequently, the final chosen variables were incorporated into the prediction models. We constructed and validated three ML algorithms, each using a different algorithm (logistic regression (LR), random forest (RF), extreme gradient boosting (XG-Boost)), with the aim of predicting temporary stoma creation in surgical management of CD. The entire process of model establishment is analyzed and processed using R software version 3.6.1. We compared three distinct ML algorithms mentioned above based on these selected predictor variables, from which the best model was chosen. We evaluated predictive accuracy using area under the curve (AUC). The validation cohort served to assess and compare the performance of each model. To ensure the reliability of the models, we utilized seven common evaluation criteria including AUC, accuracy, sensitivity, specificity, precision, recall, and F1 score. Further, Shapley Additive Explanations (SHAP) values were applied to ascertain the variable importance of each predictor and to visualize their association with temporary stoma creation in surgical management of CD.

Continuous variables were shown either as means (standard deviation), and analyzed with the two-tailed Student's t-test or the Mann-Whitney U test respectively. Represented as counts (percentage), categorical variables were examined using either the chi-square test or Fischer's exact test, depending on suitability. All statistical analyses were deemed significant at a P value of < 0.05. For variables with less than 5% missing data, we employed multiple imputation techniques to fill in the gaps. However, for variables with 5% or more missing data, we chose not to include them in our final analysis to ensure the reliability and validity of our results.

Results

Patient characteristics and surgical outcomes

The process of screening and analysis is shown in Fig. 1. The study cohort consisted of 252 CD patients, which were randomly assigned to the training cohort ($n = 176$, Tables 1 and 2) and the validation cohort ($n = 76$, Supplementary Tables 1, 2). Further, the patients were divided into temporary stoma formation group (Fig. 2A, B) and primary anastomosis group (Fig. 2D, E) according to whether they underwent primary anastomosis after IR. Overall, 59.5% (150/252) of patients did temporary stoma creation after IR, and the mean BMI of patients who underwent staged surgery was 18.7 ± 3.1 kg/m^2, and their mean BMI raised to 20.5 ± 3.3 kg/m^2 at the time of restoration of intestinal continuity after an average of 7.2 ± 4.3 months (Fig. 2C). Similarly, the mean BMI of patients who underwent primary anastomosis increased from 20.5 ± 3.7 kg/m^2 to 21.4 ± 3.5 kg/m^2 over an average follow-up period of 8.1 ± 6.1 months (Fig. 2F).

Clinical data from the training cohort of patients in the temporary stoma formation group were compared to that of patients in the primary anastomosis group (Tables 1 and 2). The results revealed that compared with the primary anastomosis group, most patients in the temporary stoma formation group experienced weight loss > 10% in 6 months prior to surgery, and had lower BMI, preoperative albumin (ALB) and hemoglobin, while higher preoperative C-reactive protein, erythrocyte sedimentation rate (ESR), and platelets. In addition, patients in the temporary stoma formation group had higher proportions of L2 and L3 in disease location, and B2P, B3, as well as B3P in disease behavior, compared with the primary anastomosis group. Moreover, the proportion of laparotomy (including conversion) and subtotal colectomy were higher in the staged surgery group (all $P < 0.05$).

Postoperative complications of Clavien-Dindo ≥ III occurred in 11 cases (4.4%) in all cohorts, including fistula in 2 cases, intra-abdominal septic complications (IASC) in 4 cases and hemorrhage in 5 cases. And there was no significant correlation between the major postoperative complications and the primary anastomosis or staged surgery. Fistulas and IASCs were treated with irrigation, drainage and antibiotics. Two cases of intra-abdominal hemorrhage were treated by re-operation, two cases of intestinal hemorrhage were treated by endoscopic intervention, and one case of intestinal hemorrhage was treated with hemostatic drugs. All patients recovered and discharged.

Variable selection

In this study, LASSO regression was employed for variable screening. The optimal λ value was determined through 10-fold cross-validation. In Fig. 3A, the left and right dotted lines correspond to λ min and λ 1se, respectively. A λ 1se of 0.04259802 was selected, resulting in a model with eight non-zero coefficient variables. Figure 3B illustrates the filtering of model variables as λ values change. Compared to the full model, the final model reduces redundant variables and improves prediction accuracy. Details are provided in Table 3.

Model construction and evaluation

After applying LASSO regression and accounting for multicollinearity, a total of eight indicators were identified (history of intestinal resection, weight loss > 10% in 6 months prior to surgery, disease location, disease behavior, type of resection, surgical priority, ESR, ALB), and then utilized in model construction.

In the training cohort, the AUCs of ML algorithm from high to low were: 0.998 (RF), 0.939 (XG-boost), and 0.886 (LR). In the validation cohort, the AUCs of ML algorithm from high to low were: 0.780 (RF), 0.764 (XG-boost), and 0.758 (LR). The RF algorithm was chosen as the best

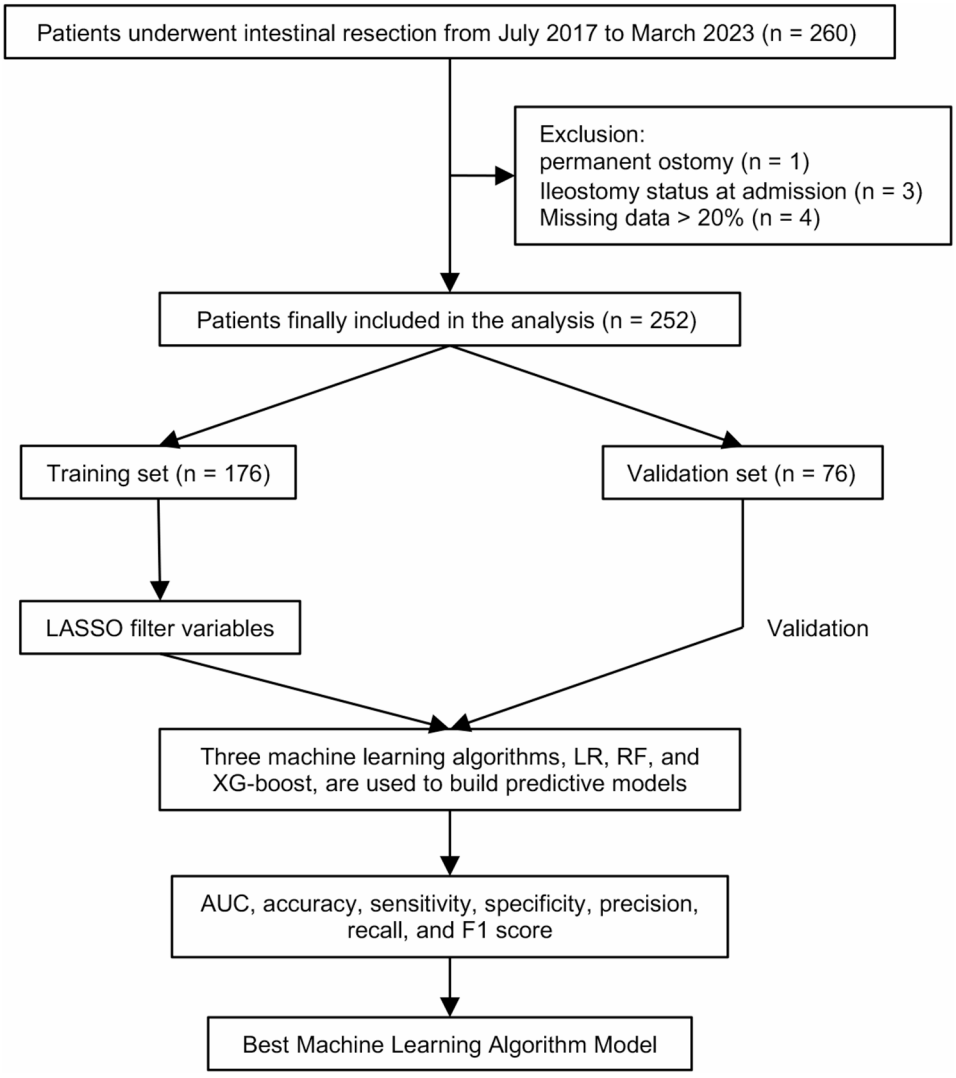

Fig. 1 Flowchart of data screening and analysis. LASSO: the least absolute shrinkage and selection operator; LR: logistic regression; RF: random forest; AUC: area under the curve

algorithm due to the highest AUC in both the training and validation cohorts (Fig. 4A, B).

Among the three algorithms, the algorithms ranked from highest to lowest sensitivity were 0.991 (RF), 0.849 (XG-boost), and 0.802 (LR). In terms of specificity and accuracy, the performance of the model was consistent with the sensitivity ranking, that is, the specificity from high to low was 1.000 (RF), 0.900 (XG-boost), and 0.828 (LR), and the accuracy was 0.971 (RF), 0.835 (XG-boost), and 0.789 (LR). The algorithms for F1 scoring from high to low were 0.963 (RF), 0.814 (LR), and 0.775 (XG-boost). In summary, RF algorithm exhibits superior performance in predicting temporary stoma formation in surgical management of CD (Table 4).

To better elucidate the associations depicting our prediction model, we further evaluated the RF model using SHAP. The results indicated that disease behavior made the most significant contribution to the model, followed by ESR, ALB, type of resection, weight loss > 10% in 6 months prior to surgery, disease location, history of intestinal resection, surgical priority (Fig. 4C).

Discussion

For surgery in patients with CD, a concern for both patients and doctors is whether a temporary stoma is needed. According to statistics, the 5-year incidence of ostomy in patients diagnosed with CD is about 3.5% [16]. Temporary stoma formation can help patients with CD effectively induce disease relief to improve quality of life [17], but at the same time, the presence of temporary stoma can also adversely affect the patient's life, including body image concerns, decreased social function and low self-esteem, resulting in negative emotions such as anxiety and depression [18, 19]. The decision-making process

Table 1 Demographic and Crohn disease data in patients from the training cohort undergoing intestinal resection

Variables	Total *n* (*n* = 176)	Temporary stoma (*n* = 106)	Primary anastomosis (*n* = 70)	*P* value
Sex				
Male	134 (76.1%)	77 (72.6%)	57 (81.4%)	0.181
Female	42 (23.9%)	29 (27.4%)	13 (18.6%)	
Age at surgery (years)	38.2 (± 12.9)	38.1 (± 12.6)	38.4 (± 13.4)	0.904
Duration of disease (years)	5.0 (± 5.2)	5.2 (± 5.6)	4.8 (± 4.4)	0.765
BMI (kg/m^2)	19.3 (± 3.7)	18.7 (± 3.4)	20.3 (± 4.1)	**0.003**
Weight loss > 10% in 6 months prior to surgery				
Yes	61 (34.7%)	45 (42.5%)	16 (22.9%)	**0.008**
No	115 (65.3%)	61 (57.5%)	54 (77.1%)	
History of intestinal resection	31 (17.6%)	14 (13.2%)	17 (24.3%)	0.059
Yes	145 (82.4%)	92 (86.8%)	53 (75.7%)	
No				
C reactive protein serum level (mg/L)	30.2 (± 41.3)	39.1 (± 48.1)	16.9 (± 22.3)	**< 0.001**
Erythrocyte sedimentation rate (mm/h)	30.5 (± 14.6)	36.5 (± 12.4)	21.3 (± 13.0)	**< 0.001**
Platelets (*10^9/L)	294.0 (± 117.1)	308.2 (± 119.3)	272.6 (± 111.0)	**0.034**
Hemoglobin level (g/L)	116.1 (± 20.6)	112.1 (± 20.5)	122.2 (± 19.3)	**0.001**
Serum albumin (g/L)	36.7 (± 5.4)	35.1 (± 5.0)	39.0 (± 5.1)	**< 0.001**
Preoperative therathpy (< 3 months before surgery)				
No preoperative therathpy	71 (40.3%)	44 (41.5%)	27 (38.6%)	0.895
Steroids*	1 (0.6%)	1 (0.9%)	0 (0%)	
Biologicals	47 (26.7%)	27 (25.5%)	20 (28.6%)	
Traditional immunosuppressant	45 (25.6%)	28 (26.4%)	17 (24.3%)	
Combotherapy	12 (6.8%)	6 (5.7%)	6 (8.6%)	
Montreal classification				
Age at diagnosis of CD (years)	14 (8.0%)	7 (6.6%)	7 (10.0%)	
A1 (< 17)	119 (67.6%)	75 (70.8%)	44 (62.9%)	0.509
A2 (17–40)	43 (24.4%)	24 (22.6%)	19 (27.1%)	
A3 (> 40)				
Disease location	30 (17.0%)	11 (10.4%)	19 (27.1%)	
L1 (ileal)	13 (7.4%)	11 (10.4%)	2 (2.9%)	**0.005**
L2 (colonic)	133 (75.6%)	84 (79.2%)	49 (70.0%)	
L3 (ileocolic)				
Disease behavior	60 (34.1%)	14 (13.2%)	46 (65.7%)	
B2 (stricturing)	86 (48.9%)	66 (62.3%)	20 (28.6%)	**< 0.001**
B3 (penetrating)	10 (5.7%)	7 (6.6%)	3 (4.3%)	
B2P (stricturing with perianal disease)	20 (11.4%)	19 (17.9%)	1 (1.4%)	
B3P (penetrating with perianal disease)				

Data are given as mean (± SD) or as n (%). BMI: body mass index; CD: Crohn disease; * >4weeks before surgery

regarding temporary stoma creation in CD presents challenges due to the lack of standardized guidelines or predictive models. Marking the location of the abdominal stoma before operation is conducive to postoperative recovery [20, 21]. Adequate preoperative information acquisition could enable informed decision-making [22]. Therefore, it is crucial to develop evidence-based tools that can aid clinicians in making informed decisions regarding temporary stoma creation, thereby improving treatment efficiency and quality of life for patients with CD.

Our findings suggested that disease behavior, primarily of B2P, B3, and B3P were associated with an increased chance of temporary stoma formation after IR for CD compared to B2. Intestinal inflammation caused by CD can invade the entire wall of the tube and, over time, can even penetrate the intestinal wall to form internal fistulas and abscesses [7]. Penetrating lesions are an independent risk factor for intra-abdominal septic complications (IASC) after CD surgery [23–25]. The incidence of IASC in patients with penetrating CD undergoing primary anastomosis was significantly higher than in patients undergoing staged surgery, and temporary ostomy was an independent protective factor [14]. The frequency of perianal complications in CD ranges from 17 to 43% of patients [26–28]. Temporary ileostomy has been well described as a treatment in perianal CD, which diverts the fecal stream from the colon, and may decrease downstream inflammation while medical therapy is optimized. However, fecal diversion without IR did not improve the outcome of perianal CD [29]. Therefore, for patients with penetrating CD or perianal CD, not only the target bowel

Table 2 Surgical data and postoperative outcome from the training cohort

Variables	*n* Total (*n* = 176)	Temporary stoma (*n* = 106)	Primary anastomosis (*n* = 70)	*P* value
Surgical priority				
Selective	169 (96.0%)	99 (93.4%)	70 (100%)	0.072
Emergency	7 (4.0%)	7 (6.6%)	0 (0%)	
Surgical approach	162 (92.0%)	94 (88.7%)	68 (97.1%)	
Laparoscopic	14 (8.0%)	12 (11.3%)	2 (2.9%)	**0.042**
Laparotomy (including conversion)				
Type of resection				
ICR	104 (59.1%)	60 (56.6%)	44 (62.9%)	**0.001**
Right hemicolectomy	23 (13.1%)	11 (10.4%)	12 (17.1%)	
Left-sided colectomy	4 (2.3%)	3 (2.8%)	1 (1.4%)	
Subtotal colectomy	21 (11.9%)	21 (19.8%)	0 (0%)	
Segmental resection of small bowel	24 (13.6%)	11 (10.4%)	13 (18.6%)	
Major postoperative complications (Clavien-Dindo ≥ III)				
Yes	8 (4.5%)	7 (6.6%)	1 (1.4%)	0.214
No	168 (95.5%)	99 (93.4%)	69 (98.6%)	
Length of hospital stay (days)	9.6 (± 4.0)	9.9 (± 4.9)	9.2 (± 1.7)	0.673

Data are given as mean (± SD) or as n (%). ICR: ileocolic resection

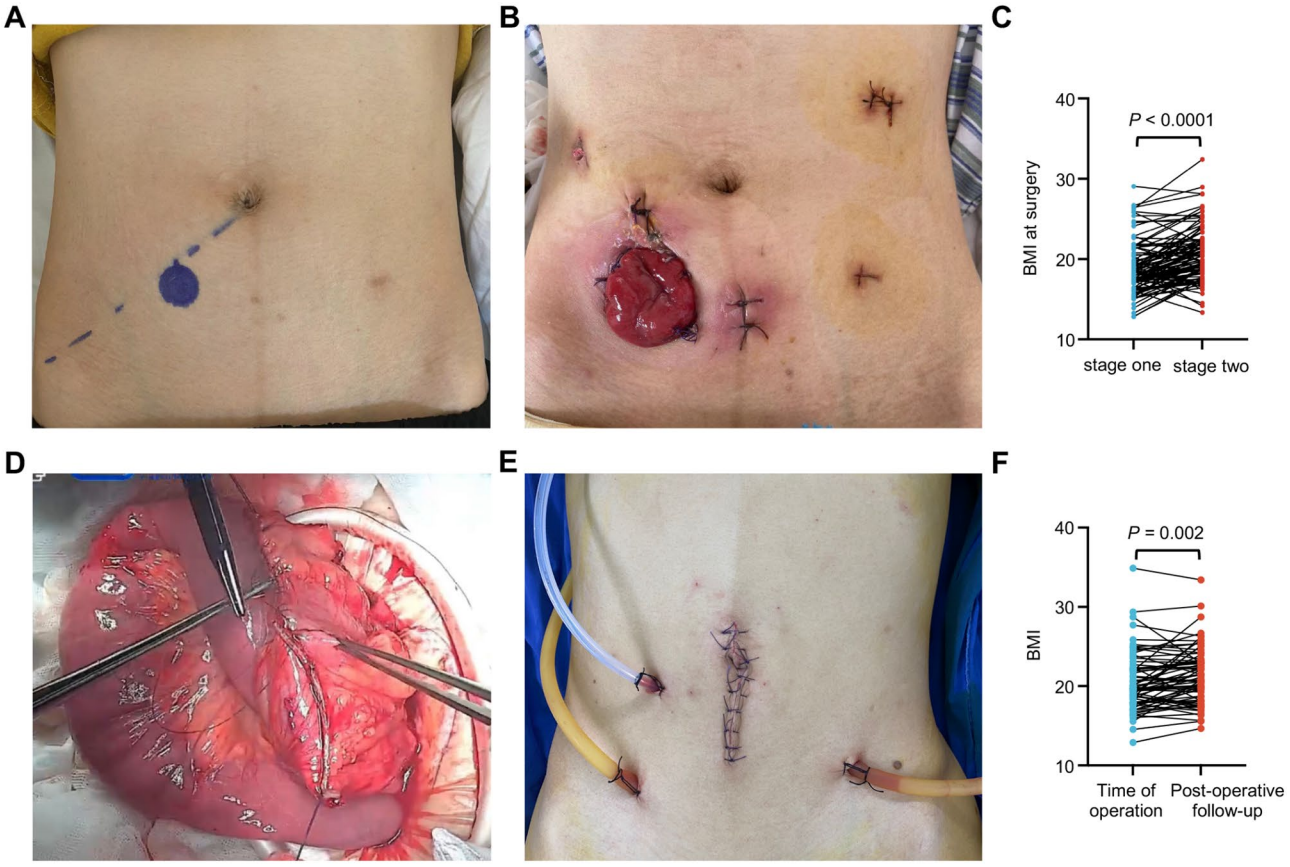

Fig. 2 Patients underwent IR with primary anastomosis, or temporary stoma creation followed by a second surgery for the restoration of intestinal continuity. (**A**) The stoma position was marked before surgery for patients who plan to undergo temporary stoma after IR, and the location of the ileal stoma is usually chosen in the right lower abdomen. (**B**) A stoma was made at the preoperative marked position. (**C**) Patients with staged surgery had significantly increased BMI when restoring intestinal continuity after an average of 7.2 ± 4.3 months. (**D**) Ileocolic side-to-side anastomosis was performed with hand-driven stapler, followed by manual suture, after IR for CD. (**E**) Abdominal incision of laparoscopic IR with primary anastomosis for CD. (**F**) The mean BMI of patients who underwent primary anastomosis increased over an average follow-up period of 8.1 ± 6.1 months. IR: intestinal resection; CD: Crohn's disease; BMI: body mass index

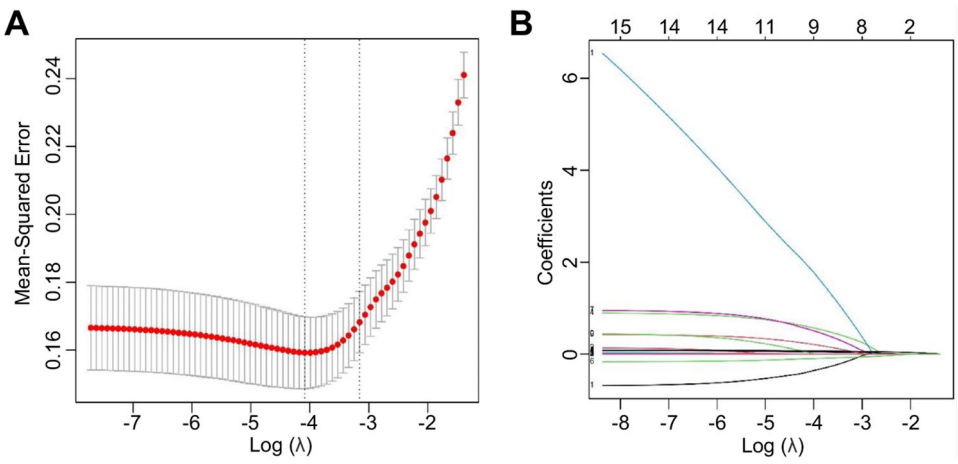

Fig. 3 The potential risk factors were selected using the LASSO regression. (**A**) Trend graph of variance filter coefficients. (**B**) Graph of cross-validation results

Table 3 Analysis of LASSO regression variable screening results

Variables	Coefficient
History of intestinal resection	-0.013032316
Weight loss > 10% in 6 months prior to surgery	0.059912828
Disease location	0.038614839
Disease behavior	0.004439939
Type of resection	0.012843765
Surgical priority	0.128031170
ESR	0.011529379
ALB	-0.011791626

LASSO: the least absolute shrinkage and selection operator; ESR: erythrocyte sedimentation rate; ALB: albumin

segment should be excised, but also the possibility of a temporary stoma should be fully considered.

Our findings indicated that preoperative hypoalbuminemia and a weight loss exceeding 10% in the 6 months preceding surgery were associated with a significantly higher risk of requiring a temporary stoma. Hypoalbuminemia, a marker of malnutrition and inflammation, has been linked to increased postoperative complications [25, 30] and shown to be associated with an increased likelihood of requiring a stoma [15]. Although BMI is the most frequently measured anthropometric nutritional parameter, there are different BMI values reported for IBD patients in the literature, indicating that BMI is not a specific or sensitive marker of malnutrition in IBD patients [31]. Studies have shown that significant weight loss prior to surgery, not BMI, is a risk factor for postoperative complications in CD [13, 32, 33]. And our results further supported the likelihood of temporary stoma formation after IR in patients with a significant weight loss before surgery. Considering that the recent severe weight loss is more indicative of the patient's preoperative nutritional status and disease severity, by combining preoperative ALB levels with a history of weight loss, a personalized treatment plan can be developed for patients with high nutritional risk, including intensive nutritional support and a two-stage surgical procedure to reduce postoperative complications, promote postoperative recovery, and improve the quality of life of patients with CD [34, 35].

CD can affect the entire gastrointestinal site, which requires different surgical approaches. In particular, the surgical management of colonic CD can be challenging due to the high risk of postoperative IASCs [36]. Notably, the effects of both disease location and type of resection on temporary stoma formation were included in the variables predicted by our model, especially colonic, and ileocolic CD, as well as the operation for colonic CD, were associated with a higher risk of stoma formation, especially after a subtotal colectomy with extensive colon lesions involvement. In the scoring system constructed by Dakshitha W et al. [15], simultaneous colon resection was also identified as a risk factor for staged surgery in CD patients. The high incidence of postoperative IASCs for colonic CD is significantly associated with primary anastomosis [37], which may be partly related to the poor nutritional status of patients with extensive diseased intestines [38]. In our study, patients who underwent subtotal colectomy had a significantly lower BMI than patients with other types of resections (17.2 vs. 19.8, $P<0.001$), in which case anastomotic reconstruction of the colon or ileum with rectum may be a risk factor. Especially when colon lesions are extensive, the possibility of proctitis should also be considered. Therefore, preoperative nutritional support and antibiotics should be optimized [39], to reduce postoperative complications. Meanwhile, planning for temporary stoma should be discussed in detail with patients undergoing colectomy.

Some studies have shown that repeated enterectomy elevates the risk of postoperative anastomotic fistula in patients with Crohn's disease (CD) [40, 41]. Similarly,

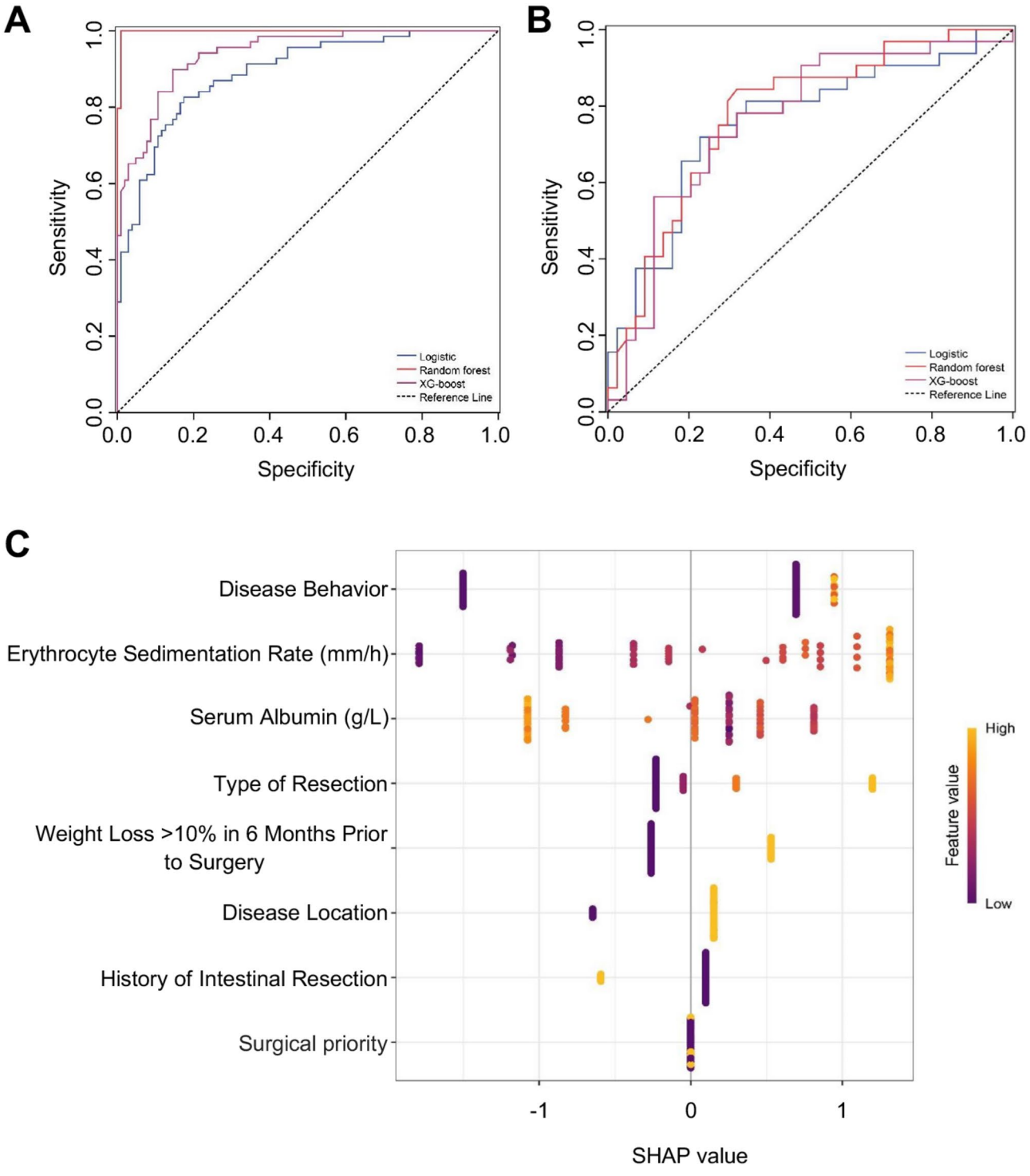

Fig. 4 Construction and assessment of ML model. (**A-B**) ROC curves for 3 ML algorithms in the training cohort and validation cohort. (**C**) Summary plot of SHAP values for the model constructed by RF. The vertical coordinates show the importance of the features, sorted by the importance of the variables in descending order, with the upper variables being more important to the model. For the horizontal position 'SHAP value' shows whether the impact of the value is associated with a higher or lower prediction. The colour of each SHAP value point indicates whether the observed value is higher (yellow) or lower (purple)

Table 4 Performance of the three machine learning algorithms in the training and validation cohorts for CD patients

Models	AUC	Sensitivity	Specificity	Accuracy	Precision	Recall	F1 score
Training cohort							
LR	0.886	0.802	0.828	0.789	0.870	0.764	0.814
RF	0.998	0.991	1.000	0.971	0.985	0.942	0.963
XG-boost	0.939	0.849	0.900	0.835	0.847	0.714	0.775
Validation cohort							
LR	0.758	0.773	0.719	0.723	0.794	0.704	0.746
RF	0.780	0.682	0.844	0.697	0.645	0.625	0.634
XG-boost	0.764	0.750	0.719	0.736	0.676	0.718	0.696

CD: Crohn's disease; AUC: area under the curve; LR: logistic regression; RF: random forest; XG-boost: extreme gradient boosting

emergency surgeries often heighten surgical risks due to abbreviated preoperative preparations, thereby increasing the likelihood of significant postoperative complications [25]. Our findings corroborate these observations, indicating that CD patients with a history of intestinal resection or those who have undergone emergency procedures are also at an increased risk of requiring a temporary stoma. This outcome is logically consistent with efforts to minimize the occurrence of postoperative anastomotic fistulas.

Notably, beyond the established risk factors of above mentioned, our findings also suggested that ESR, a marker of systemic inflammation, was also associated with an increased risk of requiring a temporary stoma after IR. Studies have shown that ESR is associated with fistula and stenosis complications in CD [42], as well as postoperative infectious complications [43]. Our study further showed that ESR was also significantly associated with temporary stoma formation after IR for CD. The ML model's inclusion of ESR addresses this need by providing clinicians with a quantitative tool to assess the risk of temporary stoma creation based on the patient's inflammatory status, and ESR is a good choice.

In terms of model construction, this study is the first paper to construct a novel ML model based on comprehensive clinical characteristics to predict the need for temporary stoma in patients undergoing IR for CD. All variables inserted in the prediction model can be used for clinicians' reference. The main limitations of this study lied in its retrospective nature and it was single-centered, potentially introducing selection bias and limiting generalizability. Additionally, the sample size of this study was not large, and only internal verification was used to evaluate the accuracy and effectiveness of the model. Future studies should employ larger sample sizes, and external validation across diverse cohorts is warranted to confirm our findings.

Conclusions

In this study, we present a novel ML-based predictive model designed to estimate the likelihood of temporary stoma creation in CD surgery. By synthesizing preoperative disease characteristics, patient status, and surgical strategy, our tool aims to bolster clinical decision-making and optimize patient care. Despite demonstrating potential benefits, the predictive accuracy of the model must be considered in light of the study's limitations. Specifically, its retrospective and single-center nature, along with the absence of external validation, necessitate cautious extrapolation of our findings. To ascertain the ML model's broader applicability and refine its predictive power, prospective validation across various populations and clinical settings is imperative. We remain dedicated to advancing this research, seeking to translate our preliminary findings into actionable insights for enhanced clinical practice.

Abbreviations

CD	Crohn's disease
IR	Intestinal resection
LASSO	The least absolute shrinkage and selection operator
LR	Logistic regression
RF	Random forest
XG-boost	Extreme gradient boosting
BMI	Body mass index
ROC	Receiver operating characteristic
AUC	Area under the curve
ALB	Albumin
ESR	Erythrocyte sedimentation rate
IASC	Intra-abdominal septic complications

Supplementary Information

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Supplementary Material 1

Supplementary Material 2

Supplementary Material 3

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Not applicable.

Author contributions

Wang FT contributed to manuscript writing and data collection, and data analysis; Gao RY, Wu XC and Wu TQ contributed to manuscript editing; Lin Y, Jiao YR and Li JY contributed to data collection; Yin L and Chen CQ contributed to conceptualization and supervision; all authors have read and approved the final manuscript.

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Data availability
The datasets used and analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
This study was approved by the Shanghai Tenth People's Hospital Ethics Committee (SHSY-IEC-5.0/24K9/P01), and the requirement for informed consent was waived because of the retrospective nature of this study.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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