The risk factors for post-polypectomy bleeding and establishment of a risk-scoring model for small colorectal polyps (<1.5cm) in an ambulatory surgery center: a retrospective analysis

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Research article

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Abstract

Background: As one of the most common complications of colonoscopy, the risk factors of post-polypectomy bleeding (PPB) has been rarely explored in an ambulatory surgery unit. We aim to develop a risk-scoring model to predict the risk of PPB forsmall colorectal polyps (<1.5cm) in an ambulatory surgery unit.

Methods: The patients with single small colorectal polyps (<1.5cm) who underwent endoscopic polypectomy in the Ambulatory Surgery Center of our hospital between January 2014 and June 2017 were included and retrospectively reviewed. We analyzed patient's clinical characteristics, morphological and pathological characteristics of polyps, polypectomy techniques, and the occurrence of PPB. Risk factors of PPB were identified with a multivariable logistic regression model. In addition, a risk-scoring system was developed and validated eventually.

Results: Among the 771 patients enrolled, 26 (3.4%) patients suffered PPB. The male gender, elderly age (≥ 60 years), using hot biopsy forceps as polypectomy technique adenoma in histopathology, complicated withhypertension, use of anticoagulant or antiplatelet agents, and early excessive activities significantly increased the risk of PPB ($P<0.05$) as indicated by the results of multivariable logistic regression analysis. The area under the ROC curve (AUC) in the model group (0.890) and validation group (0.924) indicated that the risk-scoring model could predict the occurrence of PPB effectively.

Conclusions: This risk-scoring method may help to predict the risk of PPB forsmall colorectal polyps, fit well in the Ambulatory Surgery Center, and provide a new approach to help reduce the incidence of hemorrhage after colorectal polypectomy.

Trial registration: This study was retrospectively registered and approved by the Ethics Committee of West China Hospital of Sichuan University (IRB number: ChiCTR1800020201).

Background

Colorectal polypectomy is currently considered an effective strategy to reduce the incidence of colorectal cancer. Colonoscopic polypectomy is routinely believed to be a safe procedure; however post-polypectomy bleeding (PPB), which is one of the most frequent complications after endoscopic operations, may cause serious problems and adverse consequences.

Ambulatory surgery provides high quality and efficient care for a wide variety of surgical procedures. During the last decades, ambulatory surgery has grown rapidly and now accounts for the majority of operations performed in endoscopic therapy in China. On the other hand, the safety of day surgery must be emphasized. Thus, the safety of colonoscopic polypectomy in the Day Surgery Unit should be taken into account when discussing cost-effective economy and rapid recovery.

Previous studies mostly involved multiple or large colorectal polyps among inpatients.The patients underwent the polypectomy in the Day Surgery Unit and were characterized with smaller size polyps (≤1.5 cm), younger population and limited complications. They were encouraged to perform appropriate activities and diets after the polypectomy as soon as possible. Consequently, it is essential to balance the safety and efficiency via investigating the risk factors of PPB based on day surgery. Furthermore, it would be valuable to establish a risk-scoring model of ambulatory surgery to predict the occurrence of PPB, as little research has described it ever before.

Methods

Patients

The records of 2,744 patients who presented with colorectal polyps and underwent an endoscopic colorectal polypectomy in the Day Surgery Unit of West China Hospital, Sichuan University from January 2014 to June 2017 (total 42 months) were reviewed and analyzed. Inclusion criteria were (1) patients with single colorectal polyp, (2) a polyp size ≤ 15mm and (3) aged between 14 and 80 years old. In addition, (4) all patients were required to meet the American Association of Anesthesiologists (ASA) score of less than 3. Patients (□) with multiple-colorectal polyps, (□) a laterally spreading tumor (LST), and (□) a history of inflammatory bowel disease (IBD) or (□) hemorrhagic disease were excluded. We also excluded (v) the cases of carcinoma which were pathologically confirmed after polypectomy, as well as (vi) the patients with incomplete clinical data.. Consequently, 771 patients were ultimately enrolled. We divided the patients into bleeding and non-bleeding groups according to the occurrence of PPB. A total of another 198 patients with colorectal polyps were included in the Day Surgery Unit from July 2017 to December 2017 as a validation cohort. The study flow is shown in Figure 1. Complete medical records of the patient-related characteristics, polyp-related characteristics, and polypectomy techniques, as well as the use of prophylactic clips during the endoscopic procedure, were collected. This study was approved by the Ethics Committee of West China Hospital of Sichuan University (IRB number: ChiCTR1800020201).

Endoscopic Colorectal Polypectomy

Written consent was obtained before the operation. If anticoagulant or antiplatelet agents were needed, such as aspirin, warfarin or clopidogrel, they were required to discontinue these at least 5 days before the operation. Endoscopic colorectal polypectomy was performed by electronic endoscopes (JIF-H260Z; Olympus Optical Co, Ltd, Tokyo, Japan) by experienced endoscopists who had performed at least 500 cases of endoscopic polypectomies. We routinely applied argon plasma coagulation (APC) (ERBE Co, Ltd, Germany) and hot biopsy forceps (HBF) (Stericlin Co, Ltd, Germany) for diminutive polyps (d≤5mm) and small polyps (d≤10mm), while larger sessile polyps (10mm□d≤15mm) were resected by endoscopic mucosal resection (EMR) and pedunculated polyps were removed by snares (SAS−1-S; COOK Co, Ltd, US). Hemostatic clips were selected when bleeding occurred during the operation or to prevent delayed hemorrhage.

Post-polypectomy Bleeding

In our study, PPB was confirmed with the presence of hematochezia, while melena or hemorrhoids were excluded. We also defined early PPB (EPPB) as hemorrhage within 24 hours of the colorectal polypectomy and delayed PPB (DPPB) was referred to as hemorrhage during 24 hours to 4 weeks after the endoscopic operation. Follow-up telephone calls within 4 weeks were conducted regularly on the 2nd day, 7th day, 14th day, and 28th day after discharge from the hospital.

Patient-related Factors

We collected the patients demographic characteristics, including gender and age. In addition, the factors of antithrombotic agents, history of smoking and alcohol consumption, postoperative activities and diet were compared between two groups. Smoking was defined as a continuous or cumulative smoking habit for 6 months or more in one’s lifetime. Alcohol consumption referred to drinking 10 grams per day on average. Comorbidities of hypertension, diabetes mellitus, cerebrovascular disease, coronary heart disease, hyperlipidemia, chronic obstructive pulmonary disease (COPD), and rheumatoid diseases were also reviewed. Improper postoperative activities referred to intense exercise or heavy physical activity within the 2 weeks after endoscopic operations. Inappropriate diet was defined as starting oral feeding within 6 hours or having spicy or greasy food within 1 week after the operation.

Polyp-related Factors

The size, location, gross morphology and the histopathology of the colorectal polyps were carefully documented. An open-biopsy forcep of 6mm was used as standard to measure the polyp size. The polyp location contained ascending colon (cecum was included), transverse colon (hepatic flexure and splenic flexure were included), descending colon, sigmoid colon, and rectum. The morphology of the polyp was categorized into four types (Yamada □, Yamada □, Yamada □, and Yamada □) according to the criteria of Japanese Yamada Classification. Polyps were classified histopathologically as adenomatous (tubular, tubulovillous, and villous) or hyperplastic, inflammatory, and others (hamartomatous, retentional, etc.).

Statistical Analysis

All statistical analysis were performed with SPSS software version 24.0 (SPSS Institute, Chicago, IL). Categorical variables were compared with the Fisher exact test or the χ^2 test. Continuous variables were compared with either the unpaired Student t test or the Mann-Whitney U test. The odds ratios for delayed post-polypectomy hemorrhage were calculated by unconditional logistic regression. In addition, multivariable logistic regression analysis was performed to identify independent variables associated with PPB. The score-based prediction rule was generated from the new logistic regression equations by using a regression coefficient-based scoring method []. The total score for each patient represented the sum of the score for each independent risk factor. The calibration was evaluated with the Hosmer-Lemeshow (H-L) goodness-of-fit test. To evaluate the predictive performance of the scoring model, the receiver operating characteristic (ROC) curve and the area under the ROC (AUC) were adopted. An AUC of 1.0 indicated perfect concordance, while an AUC of 0.5 indicated no relationship. Meanwhile, external validation of the model was performed by measuring the discriminatory ability with AUC.

Results

Baseline Characteristics

During the study period, a total of 771 single-polyp patients underwent colorectal polypectomy with 771 polyps being completely removed. The baseline characteristics of the patients are shown in Table 1. Males counted for 42.2% (325/771) of this cohort and the median age was 44 (40, 61) years old. The colorectal polyps were located frequently in the left-half colon which contained the descending colon (197/771，25.6%) and sigmoid colon (203/771, 26.3%). The median polyp size was 0.6 (0.5, 0.8) cm. In addition, we adopted HBF (227/771, 29.4%) and EMR (306/771, 39.7%) more frequently than APC (147/771, 19.1%) and snare (91/771, 11.8%) to resect the lesions. Furthermore, 76 (9.9%) patients had prophylactic clips applied to prevent delayed hemorrhage during the procedure. Among this cohort, 12 (1.6%) patients had a long-term history of anticoagulant/antiplatelet therapy in spite of 5-days withdrawal before the colorectal polypectomy. Moreover, 124 (16.1%) patients were investigated to have intense postoperative activities, and 72 (9.3%) patients were found to have an inappropriate postoperative diet.

Overall, PPB occurred in 26 patients (3.4%) while DPPB developed in 23 patients. PPB appeared to take placed as on day 7 (5, 10) after the polypectomy, of which 15 (57.7%) patients had received endoscopic hemostatic procedures. Only one patient underwent a blood transfusion, and none required selective arterial embolization or surgery. The results showed that gender, age, early postoperative activity, and hypertension were statistically different between the bleeding and non-bleeding groups ($P<0.05$).

Risk Factors of PPB

As revealed in the univariate analyses, the gender and age of the patients, complication of hypertension, history of alcohol, and early postoperative activity differed significantly ($P<0.05$) between the bleeding and non-bleeding groups. In terms of multivariate logistic regression analysis, gender of male, age older than 60, histopathology of adenomatous polyps, polypectomy technique of HBF, complication of hypertension, use of anticoagulant/antiplatelet agents, and early excessive postoperative activities appeared to be the independent risk factors, which were associated with PPB, whereas location, size, morphology, applicaton of prophylactic clips, other comorbidities, history of smoking or alcohol, as well as inappropriate diet were not statistically significant (Table 2).

Establishment of the Risk-Scoring Model for Predicting Colorectal PPB

Risk factors that represented statistical significance were utilized to develop the risk-scoring model to predict the possibility of colorectal PPB. The β coefficients of variables with $p<0.05$ in the multivariate logistic regression analysis were used to generate the model. Point values were assigned to the identified independent risk factors as follows: male (OR: 7.295, 1 point), aged beyond 60 years (OR: 10.615, 1 point), adenoma (OR: 4.931, 1 point), HBF (OR:5.659, 1 point), early intense activity (OR: 9.601, 1 points), hypertension (OR: 6.827, 1 point), and anticoagulant or antiplatelet durgs (OR: 51.435, 2 points) which was revealed in Table 3.

Risk stratification based on the total points contains the low risk group (0–2 points, 0.5%), intermediate risk group (3–4 points, 8.1%), and high risk group (> 4 points, 50.0%). With regard to the 771 patients who underwent colorectal polyp resection, the risk scores ranged from 0 to 6 (Table 4(A)). The risk for PPB increased from 1.0% to 100.0% along with the total risk score of each patient. Subsequently, the risk score was categorized as low risk (0–2 point), intermediate risk (3–4 points), and high risk (>4 points) for PPB. As a result, the rates of PPB for each risk category were 0.5%, 8.1%, and 50.0%, respectively (Table 4(B)), with a significantly increasing trend of risk from the low to high risk groups. The predictive accuracy of the risk score for PPB was 0.890 (95%CI, 0.806–0.960) measured by AUC (Figure 2). In addition, our prediction model calibrated well with the Hosmer-Lemeshow goodness-of-fit test (χ^2 = 1.030, P = 0.794).

External Validation of the Risk Scoring Model

A total of another 198 patients with colorectal polyps were included in the Day Surgery Unit from July 2017 to December 2017 as an external validation cohort. The percentage of the risk for PPB in each calculated score and AUC were 0.924 in the validation dataset (Figure 2).

Discussion

The current study of a large cohort established a novel, simple-to-use risk-scoring system of colorectal PPB, which comprises various aspects of clinical features. Our finding is one of the largest cohorts to investigate the frequent but serious adverse event of PPB in the Ambulatory Surgery Center. We have dedicated to risk stratification based on these significant clinical risk factors, and established a predictive model that can be applied to the safety of polypectomy in the Ambulatory Surgery Center.

We found that advanced age and hypertension in patients were independent risk factors for PPB. In recent years, although patients with colorectal polyps tended to be younger, PPB continued to occur in the elder patients because of poor vascular compliance [,,]. In addition, the various cardiovascular and cerebrovascular diseases associated with advanced age and hypertension might bring about impaired blood vessel wall and abnormal coagulation function [].

Based on the findings of previous studies, large size was a significant polyp-related factor that has been unequivocally proven to increase the risk of delayed bleeding. Buddingh KT [3] thought that the risk increased by 13% for every 1mm increase in polyp diameter (OR:1.13, 95%CI 1.05–1.20, P<0.001). However, we did not come to a similar conclusion as we believe that a limited colorectal polyp size of 15mm would not play such a vital role. The significant associations between colorectal adenomatous polyps and postoperative bleeding in our study, in particular, have been previously corroborated []. Adenomatous polyps, reported by Uno Y [], had more blood vessels exposed upon removal of the polyp, which was probably related to PPB.

Moreover, we also demonstrated that HBF had an obviously higher risk of PPB compared with EMR or snare excision. Traditional HBF is routinely performed in China for polypectomy while western application is rare. HBF technique involves the use of insulated monopolar electrocoagulating forceps to simultaneously biopsy and electrocoagulate the tissue []. Recently, Panteris V [] aroused a debatable topic associated with the abandonment of HBF for polypectomy of diminutive or small colorectal polyps. The new recommendation released by European Society of Gastrointestinal Endoscopy (ESGE) [] is expected to against their use of HBF based on the GRADE system of clinical evidence. The reasons include unacceptably high risks of adverse events such as deep thermal injury and delayed bleeding, as well as incomplete resection and inadequate tissue sampling for histology, in comparison with snare excision []. In addition, the placement of prophylactic clips had no benefit on reducing the incidence of PPB in the light of our findings.

According to risk stratification of endoscopic procedures, endoscopic polypectomy is defined as high risk procedure. What is more, for patients receiving anticoagulation or antiplatelet therapy, the risk of haemorrhage sharply increases. The challenge is to weigh the benefits against risks of thromboembolism and PPB. We found that the use of anticoagulant or antiplatelet drugs led to a higher risk of bleeding, which was consistent with several reported studies [,,]. In particular, bridge anticoagulation is necessary in patients with high thromboembolic risks who are undergoing polypectomy [,]. The recent BRIDGE trial, which showed that bridging anticoagulation is associated with a significantly higher risk of hemorrhage []. Regrettably, we did not classify the categories of antithrombotic drugs, such as warfarin, aspirin or clopidogrel. In future, we may pay close attention to the potential risk of PPB in patients receiving antithrombotic therapy although these drugs has been strictly discontinued and restarted. We consider that it is necessary to delay discharge or extend the follow-up time to ensure the safety of these special patients who received colorectal polypectomy in ambulatory surgery unit.

We also demonstrated that intense exercise or heavy physical activity within 2 weeks after polypectomy was associated with delayed bleeding. In clinical practice, we emphasize the importance of post-polypectomy recovery at home, especially the guidance of discharge instructions within 7 days. We advocate the efficient and safe hospital clinical pathway of day surgery, meanwhile greater emphasis needs to be placed on standardized discharge criteria and high quality discharge follow-up based on clinical risk assessment.

Although our study provides a reliable risk-scoring model of PPB, it has several limitations. An inherent potential bias was inevitable as the study is retrospective despite parital data being collected prospectively. Furthermore, bridge anticoagulation and the time to restart the antithrombotic therapy should be considered as significant variables associated with PPB for a more complete risk-scoring system.

Conclusions

In summary, this was the first study to clarify the risk factors of PPB in the certain populaton of ambulatory surgery. We aimed to promote the development and growth of high quality ambulatory surgery. To this end, this risk-scoring model has resulted in the founding of new association of ambulatory surgery and endoscopic therapy. The significance of this study is that a predictive model was developed, which could provide more valuable clinical information for making a better decision about revising the access criteria and follow-up after discharge. Furthermore, high efficiency, remarkable safety and cost reduction of ambulatory surgery have been improving the access of the general population to utilize of endoscopic treatment with colorectal polyps.

Abbreviations

PPB post-polypectomy bleeding

ROC receiver operating characteristic

AUC area under the ROC curve

HBF hot biopsy forceps

LST laterally spreading tumor

IBD inflammatory bowel disease

APC argon plasma coagulation

EMR endoscopic mucosal resection

EPPB early PPB

DPPB delayed PPB

COPD chronic obstructive pulmonary disease

H-L Hosmer-Lemeshow

Declarations

Ethics approval and consent to participate

This study was retrospectively registered and approved by the Ethics Committee of West China Hospital of Sichuan University (IRB number: ChiCTR1800020201). Consent to participate was waived due to the fact that this is a retrospectively study with no risk to participants, where the research will not affect the rights or welfare of the participants.

Consent for publication

Not applicable.

Availability of data and materials

The datasets analysed during the current study are not publicly available, but are available from the corresponding author on reasonable request.

Competing interests

Tiantian Lei, Hailin Yan, Qing Lu, Yilan Wang, Hongsheng Ma and Jinlin Yang have no conpeting interest or financial ties to disclose.

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Authors’ Contributions

JY and HM designed the research. TL analyzed the data and wrote the paper. TL, HY, YW, QL performed the research. TL, HY and QL performed the follow-ups. HM and JY revised this manuscript. All authors read and approved the final manuscript.

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Tables

Table 1. Baseline characteristics of patients and univariate analysis of risk factors for PPB

Variables	Total N=771	Non-bleeding N=745 (%)	Bleeding N=26 (%)	P-value
Patient-related factors				
gender*				
Female	446	441 (59.2)	5 (19.2)	□0.001
Male	325	304 (40.8)	21 (80.8)	
Age	44 (40,61)			□0.001
Polyp-related factors				
Location				
Transverse colon [a]	121	117 (15.7)	4 (15.4)	0.64
Descending colon[b]	197	186 (25.0)	11 (42.3)	
ascending colon	97	96 (12.9)	1 (3.8)	
sigmoid colon	203	197 (26.4)	6 (23.1)	
rectum	153	149 (20.0)	4 (15.4)	
size[†]	0.6 (0.5,0.8)			0.513
morphology				
Yamada type □	236	225 (30.2)	11 (42.3)	0.554
Yamada type □	343	336 (45.1)	7 (26.9)	
Yamada type □	149	143 (19.2)	6 (23.1)	
Yamada type □	43	41 (5.5)	2 (7.7)	
Histopathology				
Inflammatory polyps	168	165 (22.1)	3 (11.5)	0.153
Hyperplastic polyps	177	173 (23.2)	4 (15.4)	
Adenomatous polyps	367	349 (46.8)	18 (69.2)	
Others[‡]	59	58 (7.8)	1 (3.8)	
Polypectomy technique				
APC	147	147 (19.7)	0 (0.0)	
Hot biopsy forceps	227	208 (27.9)	19 (73.1)	
Snare	91	88 (11.8)	3 (11.5)	
EMR	306	302 (40.5)	4 (15.4)	
Clips				
Yes	76	75 (10.1)	1 (3.8)	0.477
No	695	670 (89.9)	25 (96.2)	
Comorbidities				
Hypertension				
Yes	129	116 (15.6)	13 (50.0)	□0.001
No	642	629 (84.4)	13 (50.0)	
Diabetes mellitus				
Yes	42	41 (5.5)	1 (3.8)	□0.999
No	729	704 (94.5)	25 (96.2)	
Cerebrovascular disease				
Yes	8	7 (0.9)	1 (3.8)	□0.999
No	763	738 (98.9)	25 (100.0)	
Coronary heart disease				
Yes	27	26 (3.5)	1 (3.8)	□0.999
No	744	719 (96.5)	25 (96.2)	
Hyperlipidemia				
Yes	64	62 (8.3)	2 (7.7)	□0.999
No	707	683 (91.7)	24 (92.3)	
COPD				
Yes	10	10 (1.3)	0 (0.0)	□0.999

No	761	735 (98.7)	26 (100.0)	
Rheumatoid diseases				
Yes	13	13 (1.7)	0 (0.0)	>0.999
No	758	732 (98.3)	26 (100.0)	
Anticoagulant/antiplatelet drugs				
Yes	12	11 (1.5)	1 (3.8)	0.878
No	759	734 (98.5)	25 (96.2)	
Smoking				
Yes	116	109 (14.6)	7 (26.9)	0.085
No	655	636 (85.4)	19 (73.1)	
Alcohol				
Yes	116	108 (14.5)	8 (30.8)	0.023
No	655	637 (85.5)	18 (69.2)	
Improper activity				
Yes	124	112 (15.0)	12 (46.2)	<0.001
No	647	633 (85.0)	14 (53.8)	
Inappropriate diet				
Yes	72	71 (9.5)	1 (3.8)	0.525
No	699	674 (90.5)	25 (96.2)	

"†" : Mann-Whitney U-test was performed; "*" : The difference was statistically significant.
"‡":"others"contained hamartomatous polyps and retention polyps.
"a": hepatic flexure and Splenic flexure were included; "b" :Cecum was included.

Table 2. Multivariate Logistic Regression Analysis of risk factors for PPB

Variables	No.of patients	No. of PPB	OR (95%CI)	P-value
Patient-related factors				
gender*				
Female	446	5	1 (Reference)	
Male	325	21	7.295 (2.087-25.498)	0.002
age†*				
n□40	174	3	1 (Reference)	
40≤ n□60	386	7	1.315 (0.213-8.128)	0.768
n ≥60	211	16	10.615 (1.684-66.927)	0.012
Polyp-related factors				
Location				
Transverse colon#	121	4	1 (Reference)	
Descending colon	197	11	2.707 (0.564-12.985)	0.213
Ascending colon	97	1	0.106 (0.006-1.913)	0.128
Sigmoid colon	203	6	1.369 (0.246-7.622)	0.720
rectum	153	4	0.996 (0.171-5.793)	0.996
size†				
d□0.5cm	167	5	1 (Reference)	
0.5≤d□1cm	527	19	1.126 (0.254-4.985)	0.876
d≥1cm	77	2	2.298 (0.201-26.289)	0.503
morphology				
Yamada type □	236	11	1 (Reference)	
Yamada type □	343	7	0.315 (0.081-1.228)	0.096
Yamada type □	149	6	0.779 (0.159-3.812)	0.758
Yamada type □	43	2	1.479 (0.109-20.073)	0.769
Histopathology				
Inflammatory polyps	167	3	1 (Reference)	
Hyperplastic polyps	177	4	1.767 (0.279-11.198)	0.546
Adenomatous polyps	368	18	4.931 (1.056-23.026)	0.042
Others‡	59	1	2.223 (0.160-30.799)	0.552
Polypectomy technique				
EMR	306	4	1 (Reference)	
APC	147	0	0.000 (0.000-□999.99)	0.995
Hot biopsy forceps	227	19	5.659 (1.239-25.843)	0.025
Snare	91	3	2.149 (0.349-13.244)	0.410
Clips	76	1	0.081 (0.002-2.850)	0.166
Comorbidities				
Hypertension	129	13	6.827 (2.136-21.817)	0.001
Diabetes mellitus	42	1	2.932 (0.262-32.791)	0.383
Cerebrovascular disease	8	1	0.748 (0.020-28.671)	0.876
Coronary heart disease	27	1	1.288 (0.038-43.590)	0.888
Hyperlipidemia	64	2	0.721 (0.105-4.965)	0.739
COPD	10	0	0.000 (0.000-□999.99)	0.999
Rheumatoid diseases	13	0	0.000 (0.000-□999.99)	0.999
Anticoagulant/antiplatelet drugs	12	1	51.435 (1.119-□999.99)	0.044
smoking	116	7	2.353 (0.684-8.091)	0.174
Alcohol	116	8	1.342 (0.386-4.670)	0.644
Improper activity	124	12	9.601 (2.997-30.760)	0.001
Inappropriate diet	72	1	0.234 (0.022-2.464)	0.226

OR, Odds ratio; CI, confidence interval

Table 3. Establishment of the risk-scoring model for PPB.

Risk factors	*P* value	β coefficient	Points
Male	0.002	1.987	1
n ≥ 60	0.012	2.362	1
Adenomatous polyps	0.042	1.596	1
Hot biopsy forceps	0.025	1.733	1
Hypertension	0.001	1.921	1
Anticoagulant/antiplatelet drugs	0.044	3.940	2
Improper activity	□0.001	2.262	1

Table 4. Distribution of risk scores and risk classification for PPB in the development cohort

(A)

Total points	No. of patients (n=771)	No. of PPB (n=26)	Rate of PPB(%)
0	97	1	1.0
1	218	0	0.0
2	225	2	0.9
3	142	5	3.5
4	43	10	23.3
5	14	6	42.9
6	2	2	100.0

(B)

Risk category	Total points	No. of patients (n=771)	No. of PPB (n=26)	Rate of PPB (%)
low risk	0-2	570	3	0.5
intermediate risk	3-4	185	15	8.1
high risk	>4	16	8	50.0

Figures

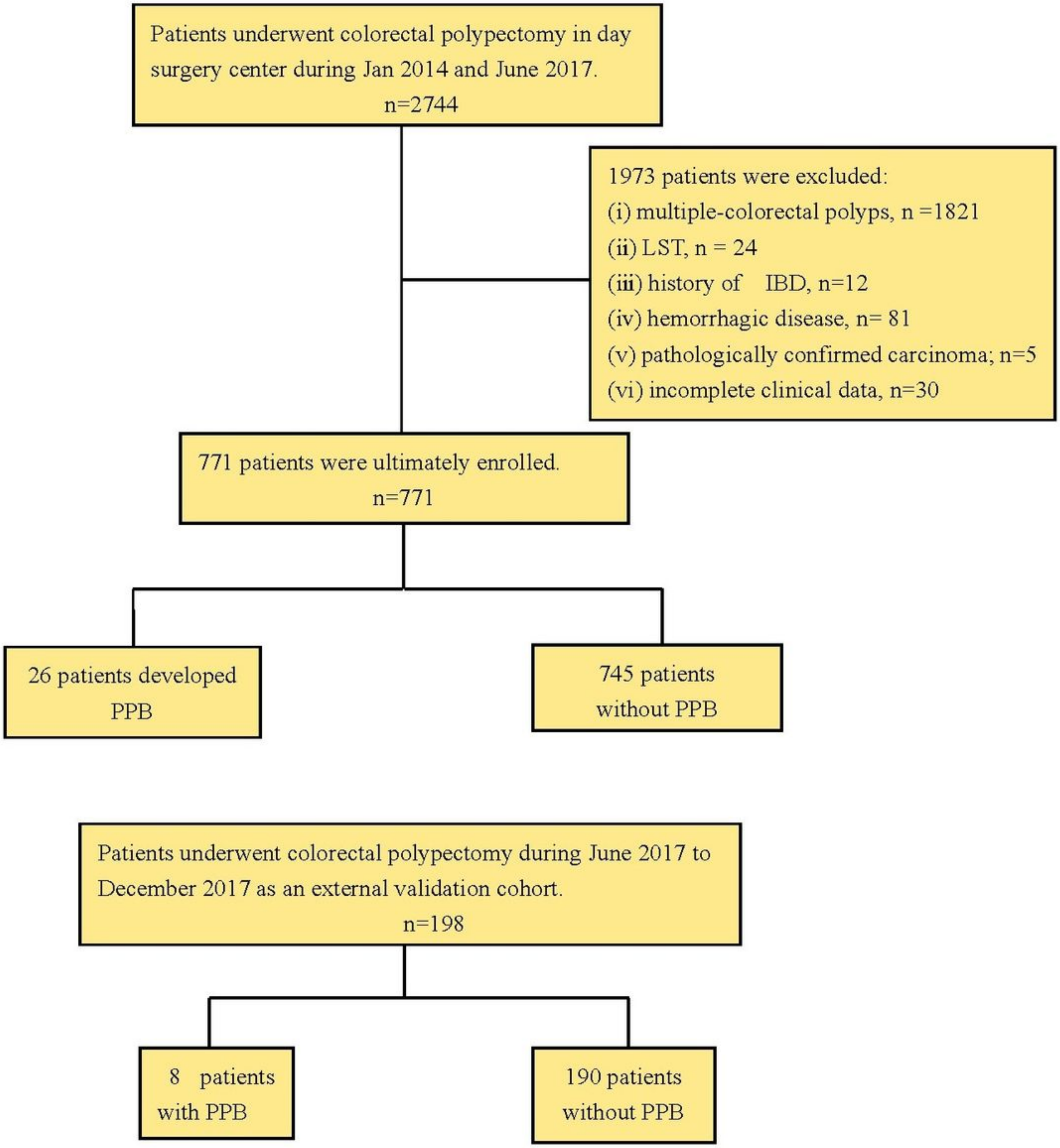

Figure 1

Study flow chart.

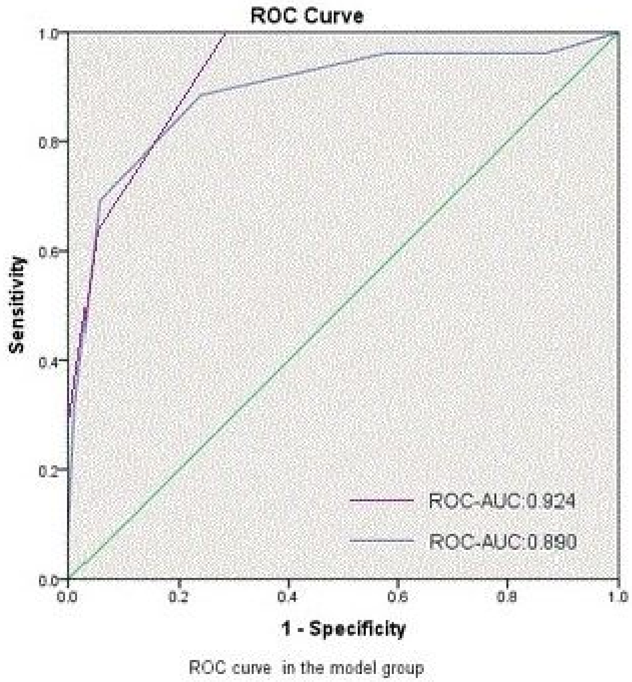

Figure 2

ROC curve and ROC-AUC in the model group and validation group.