Research Square

Preprints are preliminary reports that have not undergone peer review.
They should not be considered conclusive, used to inform clinical practice,
or referenced by the media as validated information.

Risk factors for early postoperative ileus following laparoscopic gynecological surgery: development of a prediction nomogram — a retrospective cohort study

Qihuang Liu
Guangzhou Hospital of Integrated Traditional Chinese and Western Medicine
Jingyi Gu
Guangzhou Hospital of Integrated Traditional Chinese and Western Medicine
Ruili Luo
Guangzhou Hospital of Integrated Traditional Chinese and Western Medicine
Jianghong Liang
Liangjianghong2026@163.com

Guangzhou Hospital of Integrated Traditional Chinese and Western Medicine

Research Article

Keywords: post-operative ileus, laparoscopy, gynecological surgery, logistic regression, nomogram, risk factors

Posted Date: June 18th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-9726867/v1

License: This work is licensed under a Creative Commons Attribution 4.0 International License.
Read Full License

Additional Declarations: No competing interests reported.

Abstract

Background

Post-operative ileus (POI) is a significant complication following abdominal and pelvic surgery, yet no validated prediction tool exists specifically for patients undergoing laparoscopic gynecological procedures. This study aimed to identify independent risk factors for POI and develop a clinical nomogram for individualized risk prediction.

Methods

A retrospective cohort study was conducted on 342 consecutive patients who underwent laparoscopic gynecological surgery at a single tertiary center. Patients were classified into POI (n = 35, 10.2%) and non-POI (n = 307, 89.8%) groups. Continuous variables were compared using independent-sample t-test or Mann-Whitney U test, and categorical variables using Chi-square or Fisher's exact test. Independent risk factors were identified through multivariate binary logistic regression. A nomogram was constructed and its discriminative ability was evaluated by the area under the receiver-operating characteristic curve (AUC), with calibration assessed by calibration curves and the Hosmer-Lemeshow test.

Results

Four independent risk factors were identified: postoperative white blood cell count (OR = 1.295, 95% CI 1.148–1.462, P < 0.001), 24-hour drainage volume (OR = 1.010, 95% CI 1.001–1.018, P = 0.029), constipation (OR = 11.972, 95% CI 3.317–43.211, P < 0.001), and intestinal adhesion (OR = 29.986, 95% CI 9.622–93.447, P < 0.001). The nomogram showed excellent discrimination (AUC = 0.957, 95% bootstrap CI: 0.932–0.982) and good calibration (Hosmer-Lemeshow χ^2 = 3.307, P = 0.914).

Conclusions

Postoperative WBC elevation, increased drainage volume, pre-existing constipation, and intraoperative intestinal adhesion are independently associated with POI after laparoscopic gynecological surgery. The nomogram provides a practical tool for individualized risk stratification to facilitate early preventive interventions.

Trial registration:

Not applicable (observational study).

1. BACKGROUND

Post-operative ileus (POI) is one of the most clinically significant complications following abdominal and pelvic surgery, characterized by transient inhibition of coordinated bowel motility that leads to absent or delayed passage of flatus and stool, abdominal distension, nausea, vomiting, and an inability to tolerate oral intake [1]. Although POI was historically considered an inevitable sequela of abdominal operations, its occurrence after laparoscopic procedures—where tissue handling and bowel manipulation are markedly reduced compared with open surgery—represents a clinically important problem with considerable heterogeneity in incidence and severity [2, 3].

Laparoscopic approaches have become the cornerstone of modern gynecological surgery, offering well-documented advantages in terms of reduced blood loss, shorter hospitalization, less post-operative pain, and faster return to daily activities compared with conventional laparotomy [4, 5]. Nevertheless, POI following laparoscopic gynecological procedures occurs at a non-trivial rate and is associated with prolonged hospital stay, increased healthcare costs, patient discomfort, risk of escalation to mechanical obstruction, and potential need for reoperation [6, 7]. The exact mechanisms underlying POI in the minimally invasive setting are multifactorial, involving neurogenic inhibitory reflexes, inflammatory mediator release, opioid-induced intestinal hypomotility, and electrolyte disturbances [8].

Despite the clinical importance of POI, no well-validated, disease-specific prediction tool exists for patients undergoing laparoscopic gynecological surgery. Current knowledge is largely extrapolated from colorectal or general surgical cohorts [9], and individual risk stratification remains challenging in the gynecological context where patient profiles—including uterine pathology, pelvic adhesion burden, and hormonal milieu—differ substantially. Early identification of high-risk patients would allow clinicians to implement targeted prophylactic strategies, such as optimized fluid management, selective nasogastric tube placement, enhanced recovery after surgery (ERAS) protocols, and closer post-operative monitoring [10].

A nomogram is a graphical representation of a multivariate prediction model that generates an individualized numerical probability of a clinical outcome and has been widely adopted in oncology and surgical research for its intuitive usability at the bedside [11]. To our knowledge, no nomogram has been specifically developed or validated for predicting POI in laparoscopic gynecological surgery patients.

The aims of this study were therefore: (1) to identify independent clinical, operative, and laboratory risk factors for POI in patients undergoing laparoscopic gynecological procedures through rigorous univariate and multivariate logistic regression analyses; and (2) to incorporate these factors into a nomogram that clinicians can use for pre-discharge risk prediction and individualized patient counselling.

2. METHODS

2.1 Study Design and Patient Population

This was a single-center, retrospective cohort study conducted at Guangzhou Hospital of integrated Traditional Chinese and Western Medicine. All consecutive patients who underwent laparoscopic gynecological surgery between March 2021 and March 2025 were screened for eligibility. Inclusion criteria were: (1) age ≥ 18 years; (2) elective or semi-elective laparoscopic procedure performed under general anesthesia; (3) availability of complete pre-operative, intra-operative, and post-operative laboratory and clinical data;and (4) patients undergoing minimally invasive surgery for benign gynecological diseases. Exclusion criteria were: (1) conversion to laparotomy; (2) concurrent bowel resection or anastomosis; (3) pre-existing inflammatory bowel disease, prior pelvic radiation, or mechanical small-bowel obstruction at admission; and (4) incomplete data in key study variables. The study was approved by the Institutional Review Board of Guangzhou Hospital of integrated Traditional Chinese and Western Medicine (approval number: GZTCWM2025018), and the requirement for individual informed consent was waived given the retrospective observational design.

2.2 Study Outcome

The primary outcome was the occurrence of POI, defined as the absence of passage of flatus or stool and/or inability to tolerate a regular diet for ≥ 3 consecutive days post-operatively, with radiographic confirmation (plain abdominal radiograph and/or CT scan) demonstrating dilated bowel loops without evidence of mechanical obstruction, as per the International Consensus Definition [12]. Patients fulfilling this criterion were allocated to the POI group (n = 35); all others constituted the control group (n = 307).

2.3 Data Collection

Pre-operative variables collected included: age, height, body weight, body mass index (BMI), history of constipation (defined as < 3 spontaneous complete bowel movements per week for ≥ 3 months), prior abdominal or pelvic surgery, diabetes mellitus, hypertension, white blood cell count (WBC), neutrophil percentage (NEU%), hemoglobin (Hb), serum potassium (K^+), serum calcium (Ca^{2+}), alanine aminotransferase (ALT), aspartate aminotransferase (AST), and serum creatinine. Intra-operative variables included: operative time, intraoperative blood loss, presence of peritoneal adhesions, and presence of intestinal adhesions (both recorded by the operating surgeon at the time of surgery). Post-operative variables included: WBC, NEU%, Hb, K^+, Ca^{2+}, and 24-hour abdominal drainage volume.

2.4 Statistical Analysis

Continuous variables were tested for normality using the Shapiro-Wilk test (sample size ≤ 50) or the D'Agostino-Pearson omnibus normality test (sample size > 50). Normally distributed continuous variables were expressed as mean ± standard deviation (SD) and compared between groups using an independent-sample t-test. Non-normally distributed variables were expressed as median (interquartile range [IQR], 25th–75th percentile) and compared with the Mann-Whitney U test. Categorical variables were expressed as frequency and percentage; between-group comparisons used the Pearson Chi-square test or Fisher's exact test when any expected cell count was < 5.

To identify independent risk factors for POI, a two-stage logistic regression approach was adopted. First, univariate binary logistic regression was performed for all candidate variables. Variables with $P < 0.1$ in the univariate analysis were entered into a multivariable binary logistic regression model using a forced-entry approach to minimize the risk of excluding relevant confounders. Odds ratios (OR) with 95% confidence intervals (CI) were calculated. The final model included variables that retained statistical significance at $P < 0.05$ in the multivariable model.

A nomogram was constructed based on the multivariable logistic regression model using the identified independent predictors. Model performance was evaluated as follows: discriminative ability was quantified by the AUC of the receiver-operating characteristic (ROC) curve, with a 95% bootstrap confidence interval estimated from 1,000 bootstrap resamples; calibration was assessed using the Hosmer-Lemeshow goodness-of-fit test ($P > 0.05$ indicating good calibration) and calibration curves with 95% bootstrap confidence bands. The optimal probability threshold was identified by the Youden Index (maximum of sensitivity + specificity − 1). All analyses were performed using Python 3.12 (statsmodels 0.14, scikit-learn 1.3). A two-tailed P value < 0.05 was considered statistically significant.

3. RESULTS

3.1 Patient Characteristics

A total of 342 patients met the inclusion criteria and were enrolled. Of these, 35 (10.2%) developed POI and 307 (89.8%) did not. The overall incidence of POI in our laparoscopic gynecological cohort was 10.2%. All patients were female. Baseline demographic, clinical, operative, and laboratory characteristics stratified by POI status are presented in Table 1.

Table 1
Comparison of clinical and laboratory characteristics between the POI and non-POI groups.

Variable	Ileus Group (n = 35)	Control Group (n = 307)	P Value	Test
Continuous Variables				
Age (years)	46.00 (41.50, 50.50)	42.00 (38.00, 47.00)	0.012	MWU
BMI (kg/m²)	22.77 (20.41, 23.78)	22.27 (20.03, 24.64)	0.675	MWU
Operative time (min)	182.00 (156.50, 210.50)	135.00 (110.00, 165.00)	< 0.001*	MWU
Intraoperative blood loss (mL)	180.00 (125.00, 215.00)	50.00 (20.00, 100.00)	< 0.001*	MWU
Preoperative WBC (×10⁹/L)	7.59 (5.98, 9.79)	6.38 (5.30, 7.59)	0.063	MWU
Preoperative NEU%	0.66 (0.59, 0.78)	0.64 (0.58, 0.71)	0.051	MWU
Preoperative Hb (g/L)	119.00 (109.00, 128.50)	116.00 (99.00, 130.00)	0.347	MWU
Preoperative K^+ (mmol/L)	3.81 (3.70, 4.05)	3.95 (3.80, 4.13)	0.47	MWU
Preoperative Ca^{2+} (mmol/L)	2.21 (2.17, 2.33)	2.33 (2.24, 2.40)	0.33	MWU
Preoperative ALT (U/L)	16.00 (10.00, 19.00)	14.00 (11.00, 20.00)	0.737	MWU
Preoperative AST (U/L)	19.00 (16.50, 23.00)	20.00 (17.00, 24.00)	0.759	MWU
Preoperative creatinine (μmol/L)	52.17 (48.00, 61.50)	53.00 (48.25, 58.65)	0.750	MWU
Postoperative WBC (×10⁹/L)	15.31 (12.26, 16.22)	10.07 (8.15, 12.11)	< 0.001*	MWU
Postoperative NEU%	0.88 (0.85, 0.91)	0.81 (0.75, 0.85)	< 0.001*	MWU
Postoperative Hb (g/L)	95.00 (75.00, 105.00)	105.00 (88.00, 117.00)	0.001*	MWU
24-h drainage volume (mL)	72.00 (59.00, 99.50)	33.00 (17.00, 65.00)	< 0.001*	MWU
Categorical Variables				
Constipation, n (%)	16 (45.7%)	15 (4.9%)	< 0.001*	Fisher
Prior abdominal surgery, n (%)	12 (34.3%)	123 (40.1%)	0.631	χ^2
Diabetes mellitus, n (%)	1 (2.9%)	7 (2.3%)	0.582	Fisher

Note: *Continuous variables are expressed as median (IQR: P_{25}–P_{75}); categorical variables as n (%). MWU: Mann-Whitney U test; χ^2: Pearson chi-square; Fisher: Fisher's exact test. * P < 0.05.*

Variable	Ileus Group (n = 35)	Control Group (n = 307)	P Value	Test
Continuous Variables				
Hypertension, n (%)	5 (14.3%)	14 (4.6%)	0.064	Fisher
Peritoneal adhesion, n (%)	31 (88.6%)	219 (71.3%)	0.048*	χ^2
Intestinal adhesion, n (%)	29 (82.9%)	35 (11.4%)	< 0.001*	χ^2
Note: *Continuous variables are expressed as median (IQR: P_{25}–P_{75}); categorical variables as n (%). MWU: Mann-Whitney U test; χ^2: Pearson chi-square; Fisher: Fisher's exact test. * P < 0.05.*				

3.2 Univariate Logistic Regression Analysis

The results of univariate binary logistic regression are presented in Table 2. Variables significantly associated with POI at P < 0.1 were: operative time (OR = 1.014, P < 0.001), intraoperative blood loss (OR = 1.002, P < 0.001), postoperative WBC (OR = 1.284, P < 0.001), postoperative Hb (OR = 0.968, P = 0.001), 24-hour drainage volume (OR = 1.010, P = 0.002), constipation (OR = 16.393, P < 0.001), peritoneal adhesion (OR = 3.114, P = 0.038), and intestinal adhesion (OR = 37.562, P < 0.001). These 8 variables were subsequently entered into the multivariate model.

Table 2
Univariate binary logistic regression analysis for post-operative ileus.

Variable	OR	95% CI	P Value
Operative time (min)	1.014	1.008–1.020	< 0.001*
Intraoperative blood loss (mL)	1.002	1.001–1.003	< 0.001*
Preoperative WBC (×10⁹/L)	1.284	1.115–1.479	< 0.001*
Postoperative Hb (g/L)	0.968	0.949–0.987	0.001*
24-h drainage volume (mL)	1.010	1.003–1.015	0.002*
Constipation	16.393	7.052–38.106	< 0.001*
Peritoneal adhesion	3.114	1.068–9.081	0.038*
Intestinal adhesion	37.562	14.572–96.822	< 0.001*
Note: *OR: odds ratio; CI: confidence interval. * P < 0.05.*			

3.3 Multivariate Logistic Regression Analysis

After multivariate binary logistic regression analysis (n = 326 with complete data for all 8 candidate variables), four variables remained independently associated with POI (Table 3): postoperative WBC (OR = 1.295, 95% CI 1.148–1.462, P < 0.001), 24-hour post-operative abdominal drainage volume (OR = 1.010, 95% CI 1.001–1.018, P = 0.029), constipation (OR = 11.972, 95% CI 3.317–43.211, P < 0.001), and

intestinal adhesion (OR = 29.986, 95% CI 9.622–93.447, P < 0.001). The overall model fit was excellent (log-likelihood ratio χ^2 = 120.0, P < 0.001, Nagelkerke R^2 = 0.623).

Table 3
Independent risk factors for post-operative ileus: multivariable binary logistic regression analysis.

Variable	β Coefficient	OR	95% CI	P Value
Postoperative WBC (×10⁹/L)	0.259	1.295	1.148–1.462	< 0.001*
24-h drainage volume (mL)	0.009	1.010	1.001–1.018	0.029*
Constipation	2.483	11.972	3.317–43.211	< 0.001*
Intestinal adhesion	3.401	29.986	9.622–93.447	< 0.001*

Note: *OR: odds ratio; CI: confidence interval. β: logistic regression coefficient. The model included 326 patients with complete case data for all 8 candidate variables. * P < 0.05. Overall model: LR χ^2 = 120.0, df = 4, P < 0.001.*

3.4 Nomogram Construction

A nomogram incorporating the four predictors from the final logistic regression model was constructed (Fig. 1). For each variable, a point score is assigned from the top ruler scale, and the sum of all scores is projected onto the total points axis. The corresponding predicted probability of POI can then be read directly from the probability axis at the bottom. Intestinal adhesion (OR = 29.986) was the strongest contributor, followed by constipation (OR = 11.972), postoperative WBC (OR = 1.295), and 24-hour drainage volume (OR = 1.010).

3.5 Model Evaluation: Discriminative Ability and Calibration

The ROC curve of the nomogram prediction model yielded an AUC of 0.957 (95% bootstrap CI: 0.932–0.982), indicating excellent discrimination between patients who did and did not develop POI (Fig. 2, Panel A). At the optimal probability threshold determined by the Youden Index, the model achieved a sensitivity of 0.886 and specificity of 0.935. The Hosmer-Lemeshow goodness-of-fit test yielded χ^2 = 3.307 with P = 0.914, providing no evidence of lack of fit and confirming excellent model calibration. The calibration curve demonstrated close agreement between predicted and observed probabilities across the entire risk spectrum (Fig. 2, Panel B), with the bootstrap 95% confidence band remaining narrow and overlapping the ideal diagonal, further supporting model validity in this dataset.

4. DISCUSSION

This retrospective cohort study identified four independent risk factors for POI following laparoscopic gynecological surgery: postoperative WBC, 24-hour drainage volume, constipation, and intestinal adhesion—and incorporated them into a nomogram that demonstrated outstanding discriminative performance (AUC = 0.957) and excellent calibration (Hosmer-Lemeshow P = 0.914). To our knowledge,

this is the first disease-specific prediction model for POI in the laparoscopic gynecological surgery setting.

4.1 Interpretation of Independent Risk Factors

Postoperative WBC (OR = 1.295 per $\times 10^9$/L increment) emerged as the most robust continuous predictor of POI. Elevated WBC reflects a sustained systemic inflammatory response, which promotes the release of prostaglandins, cytokines (notably IL-1β, IL-6, TNF-α), and other inflammatory mediators that suppress smooth-muscle contractility and inhibit propulsive peristalsis [12]. The magnitude and persistence of the postoperative inflammatory response has been previously correlated with ileus duration in colorectal surgery [13], and our findings extend this relationship to the minimally invasive gynecological setting.

Elevated 24-hour drainage volume (OR = 1.010 per mL) is a surrogate for extensive peritoneal trauma, hemostatic difficulty, and possibly incomplete hemostasis or lymphorrhea. Higher drainage volumes indicate greater intraoperative tissue disruption, which amplifies the local inflammatory milieu within the peritoneal cavity, directly inhibiting enteric nervous system function and impeding gut motility [14]. Moreover, high drainage volumes may necessitate prolonged bed rest, reduced ambulation, and greater reliance on opioid analgesics—all recognized contributors to POI [15].

Constipation was the second strongest categorical predictor (OR = 11.972). Pre-operative constipation implies a baseline state of impaired colonic motility and, potentially, alterations in enteric neuromuscular function that render the patient particularly susceptible to further inhibitory insults from surgery and anesthesia [16]. Several ERAS guidelines now recommend pre-operative bowel optimization including laxative therapy and dietary modification in constipated patients scheduled for major pelvic procedures [17]; our results support the individualization of such interventions based on pre-operative constipation status.

Intestinal adhesion was by far the strongest risk factor (OR = 29.986), which is clinically intuitive. Direct involvement of the small or large bowel in adhesion formation—whether as a component of endometriosis, prior inflammation, or previous surgery—mechanically tethers intestinal loops, compromises mesenteric blood supply, and creates focal areas of mural ischemia that impede peristalsis [18]. The lysis of intestinal adhesions during laparoscopy, while necessary, induces local serosal trauma and inflammation, further aggravating motility disruption. Surgeons should be particularly vigilant when intestinal adhesions are encountered, and multi-disciplinary peri-operative planning involving consultation with colorectal surgery should be considered in complex cases.

4.2 Clinical Implications of the Nomogram

The nomogram translates the multivariable model into a user-friendly scoring tool that can be completed at the bedside within minutes using routine clinical and laboratory data. A clinician can assign points for each of the four predictors from the scales and read off the corresponding probability of POI directly. This enables pre-discharge risk stratification: patients with a predicted probability exceeding the optimal

threshold (~ 0.22 based on our ROC analysis) could be targeted for earlier interventions such as more aggressive ambulation encouragement, early enteral nutrition, selective use of gum chewing or alvimopan, electrolyte optimization, and avoidance of systemic opioids where possible [19]. Patients with very high predicted risk (e.g., those with both constipation and intestinal adhesion) should be flagged for close early post-operative monitoring and ERAS bundle implementation.

4.3 Model Performance

An AUC of 0.957 in our study is notably higher than that reported in POI prediction models in the general surgical literature, where AUCs typically range from 0.70 to 0.85 [9]. This likely reflects the relatively homogeneous laparoscopic gynecological cohort, the availability of both pre-operative and post-operative predictors, and the strong discriminative power of intestinal adhesion as a categorical predictor. The Hosmer-Lemeshow P of 0.914 and the tight calibration curve provide strong evidence that the model accurately estimates absolute risk across the probability spectrum. Nonetheless, internal validation via bootstrap resampling is not a substitute for external validation, and future prospective studies in independent gynecological laparoscopy cohorts are needed to assess generalizability.

4.4 Strengths and Limitations

The strengths of this study include a well-defined primary outcome based on the International Consensus Definition, a comprehensive panel of candidate predictors including both preoperative and postoperative laboratory variables, rigorous two-stage regression analysis, and high-quality assessment of model calibration. Limitations include the retrospective single-center design, which may introduce selection and ascertainment bias. The relatively small number of POI events (n = 35) limits the number of predictors that can be reliably incorporated into the model (approximately 4 predictors by the one-in-10 rule for logistic regression), raising the possibility of overfitting (events per variable (EPV) = 8.8, below the recommended threshold of 10). Variables with high missing rates (≥ 25%), including cardiac ejection fraction and pre-operative troponin, were excluded from the analysis, which may have omitted clinically relevant predictors. The study population was exclusively female and restricted to laparoscopic gynecological procedures, limiting direct extrapolation to male patients or other surgical specialties. Finally, external validation in independent prospective cohorts is required before routine clinical implementation of the nomogram.

5. CONCLUSION

Postoperative white blood cell count elevation, increased 24-hour abdominal drainage volume, pre-existing constipation, and intraoperative intestinal adhesion are independent risk factors for post-operative ileus following laparoscopic gynecological surgery. The nomogram derived from these four predictors exhibits excellent discriminative ability (AUC = 0.957) and outstanding calibration (Hosmer-Lemeshow P = 0.914), providing a practical, evidence-based bedside tool for individualized POI risk prediction. Prospective multicenter external validation is warranted to confirm its generalizability and clinical utility.

Abbreviations

Abbreviation	Full Form
ALT	Alanine aminotransferase
AST	Aspartate aminotransferase
AUC	Area under the curve
BMI	Body mass index
CI	Confidence interval
CT	Computed tomography
Hb	Hemoglobin
IL	Interleukin
IQR	Interquartile range
LR	Likelihood ratio
MLE	Maximum likelihood estimation
NEU%	Neutrophil percentage
OR	Odds ratio
POI	Post-operative ileus
ROC	Receiver operating characteristic
SD	Standard deviation
TNF	Tumor necrosis factor
WBC	White blood cell coun

Declarations

Ethics approval and consent to participate

This study was approved by the Ethics Committee of Guangzhou Hospital of Integrated Traditional Chinese and Western Medicine. Informed consent was waived due to the retrospective nature of the study and the use of anonymized clinical data.

Consent for publication

Not applicable. This manuscript does not contain any individual person's data in any form (including individual details, images, or videos).

Availability of data and materials

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

Competing interests

The authors declare that they have no competing interests.

Funding

This study was supported by the Science and Technology Program of Huadu District, Guangzhou (Project: "Mechanism of Puerarin in Protecting Pelvic Floor Tissue Collagen Metabolism by Promoting Pelvic Floor Fibroblast Autophagy").

Authors' contributions

QL: Conceptualization, data curation, formal analysis, methodology, writing — original draft. JG: Data curation, investigation, writing — review & editing. RL: Data curation, investigation, writing — review & editing. JL: Conceptualization, supervision, project administration, writing — review & editing. All authors read and approved the final manuscript.

Acknowledgements

Not applicable.

References

1. Gustafsson UO, Scott MJ, Hubner M, et al. Guidelines for perioperative care in elective colorectal surgery: Enhanced Recovery After Surgery (ERAS®) Society recommendations: 2018. World J Surg. 2019;43(3):659–95.
2. Wolthuis AM, Bislenghi G, Fieuws S, et al. Incidence of prolonged postoperative ileus after colorectal surgery: a systematic review and meta-analysis. Colorectal Dis. 2016;18(1):O1–9.
3. Vather R, Trivedi S, Bissett I. Defining postoperative ileus: results of a systematic review and global survey. J Gastrointest Surg. 2013;17(5):962–72.
4. Bhave Chittawar P, Franik S, Pouwer AW et al. Minimally invasive surgical techniques versus open myomectomy for uterine fibroids. Cochrane Database Syst Rev. 2014;(10):CD004638.
5. Ghezzi F, Cromi A, Siesto G, et al. Laparoscopic hysterectomy for endometrial cancer: analysis of surgical outcomes in 1,006 consecutive procedures. Eur J Surg Oncol. 2010;36(9):857–62.
6. Iyer S, Saunders WB, Stemkowski S. Economic burden of postoperative ileus associated with colectomy in the United States. J Manag Care Pharm. 2009;15(6):485–94.
7. Holte K, Kehlet H. Postoperative ileus: a preventable event. Br J Surg. 2000;87(11):1480–93.

8. Kehlet H, Holte K. Review of postoperative ileus. Am J Surg. 2001;182(5A Suppl):S3–10.
9. Chapuis PH, Bokey L, Keshava A, et al. Risk factors for prolonged ileus after resection of colorectal cancer: an observational study of 2141 consecutive cases. Ann Surg. 2013;257(5):909–15.
10. Carmichael JC, Keller DS, Baldini G, et al. Clinical practice guidelines for enhanced recovery after colon and rectal surgery from the American Society of Colon and Rectal Surgeons and Society of American Gastrointestinal and Endoscopic Surgeons. Dis Colon Rectum. 2017;60(8):761–84.
11. Iasonos A, Schrag D, Raj GV, et al. How to build and interpret a nomogram for cancer prognosis. J Clin Oncol. 2008;26(8):1364–70.
12. Moore BA, Otterbein LE, Turler A, et al. Inhaled carbon monoxide suppresses the development of postoperative ileus in the murine small intestine. Gastroenterology. 2003;124(2):377–91.
13. Clavien PA, Barkun J, de Oliveira ML, et al. The Clavien-Dindo classification of surgical complications: five-year experience. Ann Surg. 2009;250(2):187–96.
14. van Bree SH, Vlug MS, Bemelman WA, et al. Faster recovery of gastrointestinal transit after laparoscopy compared with open surgery is partly independent of dietary intake. Br J Surg. 2011;98(12):1683–90.
15. Barletta JF, Senagore AJ. Reducing the burden of postoperative ileus: the role of multimodal opioid-sparing pain management. Dis Colon Rectum. 2014;57(12):1524–37.
16. Knowles CH, Lindberg G, Pinto E, et al. New perspectives in the diagnosis and management of enteric neuropathies. Nat Rev Gastroenterol Hepatol. 2013;10(4):206–18.
17. Ljungqvist O, Scott M, Fearon KC. Enhanced recovery after surgery: a review. JAMA Surg. 2017;152(3):292–8.
18. diZerega GS, Campeau JD. Peritoneal repair and post-surgical adhesion formation. Hum Reprod Update. 2001;7(6):547–55.
19. Grass F, Slieker J, Frauche P, et al. Postoperative ileus in colorectal surgery: she who defecates first, wins. Int J Colorectal Dis. 2016;31(12):1891–7.
20. Millan M, Biondo S, Fraccalvieri D, et al. Risk factors for prolonged postoperative ileus after colorectal cancer surgery. World J Surg. 2012;36(1):179–85.

Figures

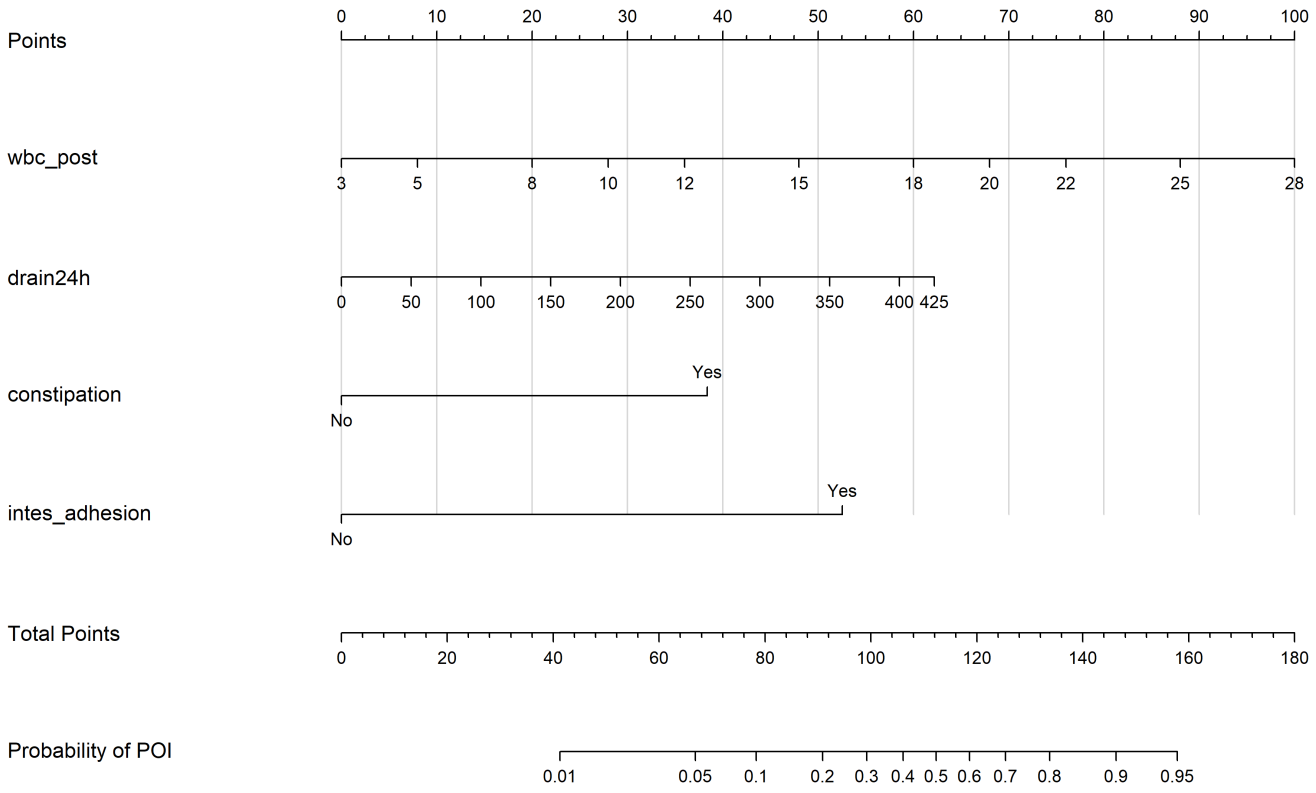


Figure 1

Nomogram for individualized prediction of post-operative ileus (POI) following laparoscopic gynecological surgery. For each predictor variable, draw a vertical line upward to the 'Points' axis to obtain the corresponding point score. Sum the points for all predictors to obtain the 'Total Points' score, then draw a vertical line downward to the 'Predicted Probability' axis to read the estimated probability of POI.

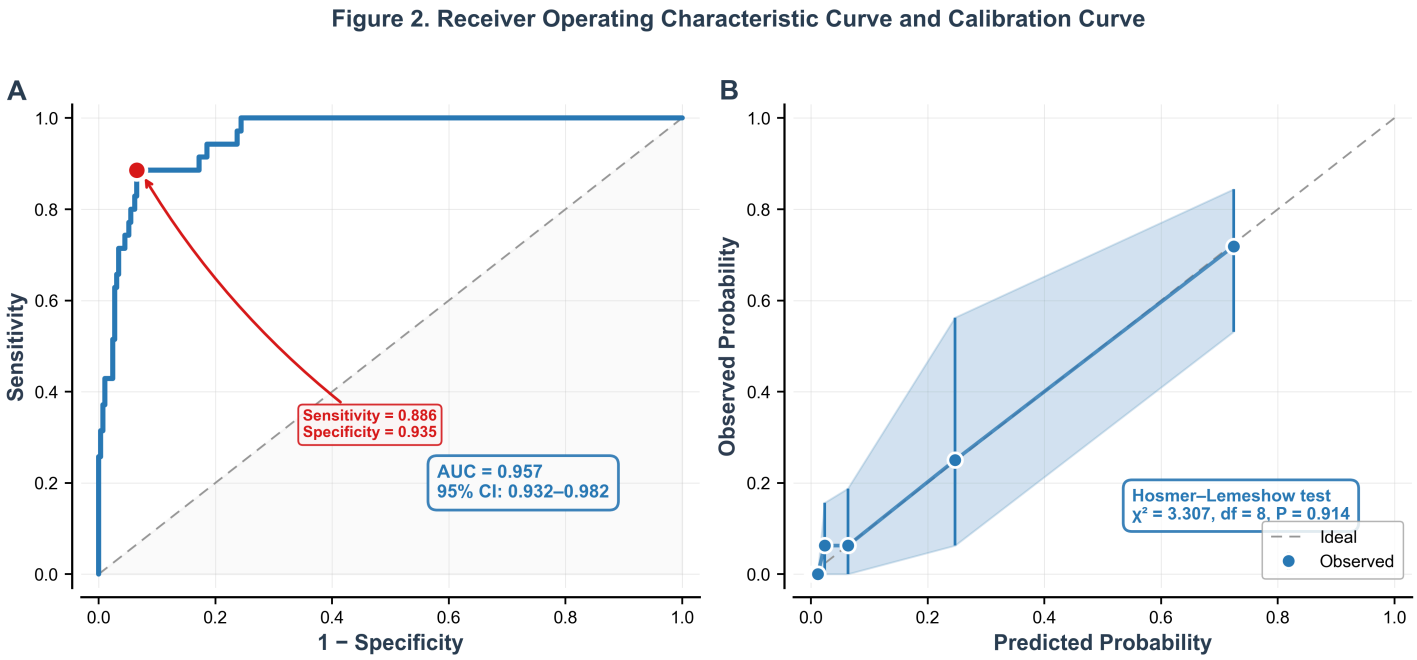


Figure 2

Model performance evaluation. (A) ROC curve of the nomogram prediction model for post-operative ileus. The AUC was 0.957 (95% bootstrap CI: 0.932–0.982). The red point indicates the optimal decision threshold (Youden Index). (B) Calibration curve comparing predicted probability vs. observed frequency of post-operative ileus across deciles of predicted risk. The shaded region represents the 95% bootstrap confidence band. Hosmer-Lemeshow $\chi^2 = 3.307$, P = 0.914.