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Exploring perioperative risk factors for poor recovery of postoperative gastrointestinal function following gynecological surgery: A retrospective cohort study

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ABSTRACT

Purpose: To investigate perioperative risk factors that affect the recovery of postoperative gastrointestinal function in patients undergoing gynecological surgery and to establish a preoperative risk prediction scoring system.
Methods: In this retrospective cohort study, characteristics and perioperative factors of patients who underwent elective gynecological surgery at Union Hospital from January 2021 to March 2022 were extracted from electronic medical records. Patients were grouped according to the Intake, Feeling nauseated, Emesis, physical Exam, and Duration of symptoms (I-FEED) scoring system to compare collected data.
Results: In total, clinical data from 208 gynecological patients were extracted. The incidence of poor postoperative gastrointestinal recovery was 7.21 %. The number of previous abdominal surgeries (0.73 $\pm$ 0.06 vs 1.20 $\pm$ 0.24, $p = 0.044$), the incidence of malignant disease (20.2 % vs 53.3 %, $p = 0.003$), postoperative maximum WBC count (9.15 vs 12.44, $p = 0.005$) and postoperative minimum potassium (3.97 $\pm$ 0.36 vs 3.76 $\pm$ 0.37, $p = 0.036$) were not only associated with poor postoperative gastrointestinal recovery, but also malignant disease ($p = 0.000$), postoperative maximum WBC count ($p = 0.027$) and postoperative minimum potassium ($p = 0.024$) were significantly associated with the severity of postoperative gastrointestinal function. An increased number of previous abdominal surgeries and malignant primary disease could increase the risk of an I-FEED score >2 as independent risk factors.
Conclusion: Patients with poor postoperative GI function had poorer postoperative recovery outcomes. A preoperative score prediction system was established, in which patients with ≥ 2 points had a 19.4 % risk of poor postoperative gastrointestinal recovery. Higher-quality prospective studies should be performed to achieve more precise risk stratification and to construct a more accurate prediction system.

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1. Introduction

Enhanced Recovery After Surgery (ERAS) is an approach aimed at promoting early recovery in patients undergoing major surgery. It consists of three crucial components: preoperative, intraoperative, and postoperative procedures. Several studies have already confirmed that ERAS pathway benefits postoperative recovery [1–3]. Postoperative gastrointestinal (GI) function recovery is one of the important elements of the concept of ERAS. Numerous studies have examined perioperative management strategies can promote recovery of postoperative GI function in obstetrics, gastrointestinal surgery, and urology, including early postoperative feeding, preemptive analgesia, and preoperative carbohydrate loading [4–6].

The main symptoms of poor GI function include nausea and vomiting, intolerance to oral diet, delayed exhaustion and defecation. Studies have confirmed that poor recovery of postoperative GI function prolongs the length of hospital stay and increases the economic burden on patients [7]. However, the range of postoperative GI impairment is diverse due to different primary diseases, ranging from transient postoperative nausea and vomiting to severe postoperative GI dysfunction. Currently, clinical research on postoperative GI recovery often uses highly subjective indicators such as the first exhaust time and first defecation time as the research results, limiting the quality of the research to a large extent [8,9]. To improve the objectivity of the multifaceted assessment of postoperative GI function, the American Society for Enhanced Recovery and Perioperative Quality introduced the Intake, Feeling nauseated, Emesis, Physical Exam, and Duration of symptoms (I-FEED) scoring system. The I-FEED scoring system is used to categorize GI function by attributing points for each of above five components based on the clinical presentation of the patient. GI function was classified into three levels: normal (0–2), postoperative GI intolerance (3–5) and postoperative GI dysfunction ($\geq$6) [10]. The I-FEED scoring system was used to evaluate the impact of different perioperative fluid management on postoperative GI function in patients with elective colorectal resection, demonstrating effectiveness for evaluating GI function after colorectal surgery [11].

Many studies have confirmed that Postoperative GI recovery was affected by a variety of perioperative factors, including inflammatory reactions, electrolyte disturbances, neurogenic factors and so on [12–14]. Currently, the study population for risk factors influencing the recovery of postoperative GI function is mainly patients undergoing gastrointestinal surgery, such as patients undergoing elective colorectal resection. In 2013, Chapuis analyzed the clinical data of 2400 patients who underwent colorectal cancer resection and identified seven statistically significant risk factors. A retrospective analysis of 255 patients diagnosed with postoperative ileus after elective colorectal surgery by Vather et al. identified seven factors with significant correlations; however, there was no consistency or overlap between the results of these two studies [13,14]. Both studies investigated the factors influencing GI recovery after colorectal surgery; however, the results were not consistent and the complex intestinal manipulation of the GI tract altered the normal structure of the intestine, thus leading to the loss of function. This made it questionable to extrapolate risk factors associated with the recovery of GI function in patients with non-gastrointestinal surgeries. Because of the homogeneity of the target population in previous studies, we chose gynecologic patients who were not undergoing gastrointestinal surgery, which not only made the study population more diverse but also helped us determine whether any risk factors partially overlapped with the findings of earlier studies, and if so, the effect of these overlapping risk factors on postoperative gastrointestinal function could be demonstrated to be generalizable.

The purpose of this study was to explore perioperative risk factors affecting postoperative GI functional recovery for patients undergoing non-gastrointestinal surgery (gynecological surgery) and to perform a preoperative risk prediction scoring system based on selection of risk factors. The preoperative risk prediction scoring system can screen out high-risk groups for poor postoperative GI recovery before surgery, allowing gynecologists to take preoperative ERAS measures to reduce postoperative incidence and facilitate patients' postoperative recovery.

2. Materials and methods

2.1. Ethics standard

This was an observational retrospective study. Anonymous patient data were used and therefore the need for informed consent was waived. The study was approved by the Ethics Committee of Wuhan Union Hospital and has been registered at the China Clinical Trials Center (ChiCTR2200065525). The trial strictly adhered to the Declaration of Helsinki. We used the Strengthening the Reporting of Observational Studies in Epidemiology guidelines to report this study [15].

2.2. Patients

The following describes how gynecologic patients who met the selection criteria were identified. We first collected blood gas results tested in the post-anesthesia care unit (PACU) during the recovery from anesthesia from January 2021 to March 2022 at Wuhan Union Hospital, and then initially screened gynecologic patients. The patients who were older than 18 years and had an American Society of Anesthesiologists (ASA) classification of grade I-II were included. And patients with severe heart, lung and other organ dysfunction, poorly controlled long-term chronic diseases (e.g. diabetes, hypertension), and incomplete clinical data were excluded. What needs to be clarified is that some gynecological procedures require patients to take oral laxatives as part of their preoperative preparations and oral potassium supplementation is routinely administered. Perioperative factors include the demographic data, preoperative preparations, disease nature, surgical data (type of surgery, duration of surgery, intraoperative blood loss, urine volume), biochemical indicators (preoperative, recovery from anesthesia, and postoperative electrolyte, inflammation and glucose). The data of perioperative factors, outcomes, and complications were collected from the institutional review board–approved electronical medical database.

2.3. Objective and definitions

The purpose of this study was to explore perioperative risk factors affecting postoperative GI functional recovery for patients undergoing non-gastrointestinal surgery (gynecological surgery) and to perform a preoperative risk prediction scoring system based on selection of risk factors. I-FEED scores >2 indicate poor recovery of postoperative GI function. According to the laboratory results from our hospital's clinical laboratory department, inflammation is defined as an elevated WBC count accompanied by the serum C-reactive protein (CRP) >8 mg/L or a CRP >4 mg/L when combined with routine blood tests.

2.4. Statistical analysis

The Shapiro-Wilk test was used to test the normality of the distribution of quantitative data, which was expressed as a mean ± standard deviation (SD) if normally distributed and differences between two groups were compared with the Student's t-test. Otherwise, data were expressed as median (P_{25}, P_{75}) and differences were compared with the Mann-Whitney *U* test. Categorical data were expressed as frequency (%) and compared with the chi-squared test or Fisher's exact test.

A multivariable logistic regression (forward regression: LR method) was used to investigate the risk factors for postoperative gastrointestinal function recovery and postoperative complications after adjustment for probable causes of both exposure and outcome. The predictive value of the predicting model was evaluated by Receiver operating characteristic (ROC) curves, and the area

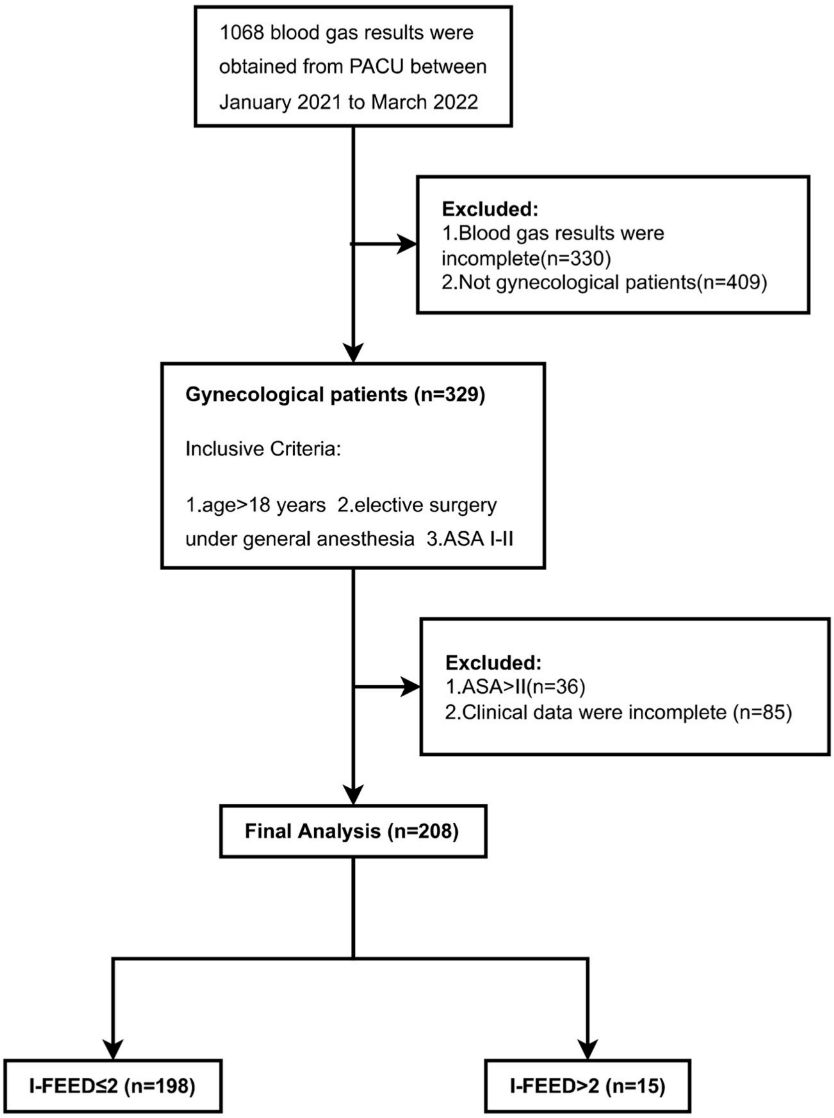

Fig. 1. Flow diagram showing the patient recruitment process.

under the ROC curve (AUC) was obtained. The fit of the model was assessed by the Hosmer-Lemeshow goodness-of-fit chi-squared test. In the logistic regression model, only subjects with a complete dataset for all variables were considered for analysis. $P < 0.05$ was considered statistically significant and all analyses were performed using SPSS version 26.0 software (IBM, Chicago, USA).

3. Results

A total of 1068 patients with blood gas tested in the PACU during the recovery from anesthesia were screened between January 2021 and March 2022; of these, 208 cases were eligible according to the screening criteria, with 193 in the I-FEED scores ≤2 group (92.79 %) and 15 in the I-FEED scores > 2 group (7.21 %). Fig. 1 shows an enrollment flow diagram.

3.1. Perioperative factors, outcomes and complications

Patients with I-FEED scores >2 had a significantly higher number of previous abdominal surgeries (1.20 ± 0.24 vs. 0.73 ± 0.06; p = 0.044), a higher rate of primary malignant diseases (53.3 % vs. 20.2 %; p = 0.003), a longer duration of surgery (p = 0.023) and a greater urinary volume (p = 0.012) than those with scores ≤2. In terms of blood routine and biochemistry, patients with I-FEED scores >2 had a significantly higher postoperative maximum WBC count (12.44 vs. 9.15; p = 0.005) and postoperative minimum blood glucose (5.25 vs. 4.90; p = 0.039), while postoperative minimum potassium (3.76 ± 0.37 vs. 3.97 ± 0.36; p = 0.036) was significantly

Table 1
Comparison of perioperative factors in patients from different I-FEED groups.

	≤2 (n = 193)	>2 (n = 15)	*p* value
Basic demographic data			
Age	45.14 ± 12.90	49.80 ± 16.09	0.187
BMI	22.89 (20.78,25.88)	24.18 (20.14,26.94)	0.334
History of diseases	44 (22.8 %)	6 (40.0 %)	0.133
Hypertension	21 (10.9 %)	2 (13.3 %)	1.000
History of gastrointestinal diseases	7 (3.6 %)	2 (13.3 %)	0.262
History of chronic medication use	35 (18.1 %)	2 (13.3 %)	0.906
Number of abdominal surgery	0.73 ± 0.06	1.20 ± 0.24	0.044[a]
Preoperative preparation			
Oral laxatives	172 (89.1 %)	14 (93.3 %)	0.940
Dose of oral laxatives	90.00 (90.00,180.00)	90.00 (90.00,157.50)	0.952
Times of enemas	2.00 (2.00,4.00)	2.50 (2.00,4.00)	0.129
General enemas	2.00 (2.00,2.00)	2.00 (2.00,2.00)	0.116
Cleansing enemas	0.00 (0.00,2.00)	0.00 (0.00,2.00)	0.371
Disease nature			
Primary malignant disease	39 (20.2 %)	8 (53.3 %)	0.003[a]
Type of surgery			0.06
Pelvic floor surgery and hysteroscopy	65 (33.7 %)	1 (6.7 %)	
Laparoscopy and laparotomy	128 (66.3 %)	14 (93.3 %)	
Surgical data			
Duration of surgery (min)	132.00 (88.00,192.00)	135.00 (90.25,244.25)	0.023[a]
Intraoperative blood loss	100.00 (50.00,200.00)	100.00 (47.50,275.00)	0.235
Urine volume	400.00 (250.00,500.00)	550.00 (462.50,750.0)	0.012[a]
Biochemical data			
Anesthetic recovery period			
pH	7.39 ± 0.07	7.38 ± 0.07	0.748
PaCO2	33.3 (29.1,38.4)	33.75 (28.72,38.37)	0.903
K^+	3.52 (3.41,3.74)	3.68 (3.55,3.74)	0.325
Pre-operation			
K^+	4.0472 ± 0.32	4.0487 ± 0.34	0.986
Post-operation			
WBC			
Maximum value	9.15 (6.89,11.85)	12.44 (9.27,18.22)	0.005[a]
K*$^+$*			
48 h	4.0622 ± 0.36	4.0613 ± 0.40	0.993
Minimum value	3.97 ± 0.36	3.76 ± 0.37	0.036[a]
Mean value	4.07 ± 0.47	3.92 ± 0.31	0.246
Na*$^+$*			
48 h	138.14 ± 2.52	135.99 ± 2.78	0.002[a]
Minimum value	137.50 (135.70,139.30)	134.90 (131.78,137.68)	0.021[a]
Mean value	138.10 (136.70,139.55)	136.10 (133.90,137.84)	0.013[a]
Glu			
Minimum value	4.90 (4.40,5.50)	5.25 (5.05,5.92)	0.039[a]

Abbreviations: BMI: body mass index, pH: the potential of hydrogen, PaCO2: partial pressure of carbon dioxide, WBC: white blood cell.

[a] Statistically significant (p < 0.05). Except for potassium-related values, only indices with significant differences are listed for both preoperative and postoperative electrolytes.

reduced. In addition, sodium ions were significantly lower at 48 h postoperatively (135.99 ± 2.78 vs. 138.14 ± 2.52; p = 0.002), along with the minimum value (134.90 vs. 137.50; p = 0.021) and mean value (136.10 vs. 138.10; p = 0.013) (Table 1, Fig. 2).

In terms of outcome indicators, there was no significant difference in the time to first flatus and feces when compared between the two groups, although the time to first getting out of bed (p = 0.022), time to liquid diet (p = 0.015) and postoperative hospital stay (p = 0.004) were significantly longer in patients with scores >2. Complication rates, such as abdominal pain (100.0 % vs. 58.0 %; p = 0.001), abdominal distension (66.7 % vs. 9.0 %; p = 0.000) and PONV (66.7 % vs. 8.5 %; p = 0.000) were significantly increased (Table 2, Fig. 3).

3.2. Subgroup analysis on participants with gynecological malignancies

There was a significant difference in the type of primary malignant disease between the two groups (p = 0.016). Patients with I-FEED scores >2 had a higher incidence of ovarian cancer (75.0 % vs. 38.5 %), endometrial cancer (25.0 % vs. 10.3 %) and complications including abdominal distention (75.0 % vs. 15.4 %; p = 0.002) and PONV (87.5 % vs. 17.9 %; p = 0.000). However, the duration of surgery was not differed significantly. In the oncological setting, the presence of procedures involving the bowel was higher in the I-FEED>2 group, but there were not differed significantly (37.5 % vs. 28.2 %; p = 0.921) (Table 3, Fig. 4). In additional, separate analyses on participants undergoing minor interventions for benign diseases between different I-FEED groups was shown in Table S1.

3.3. Subgroup analysis on the severity of poor postoperative gastrointestinal recovery

To explore whether the indicators with significant differences changed simultaneously with the severity of poor postoperative gastrointestinal recovery, we performed subgroup analyses according to I-FEED scores <2, 2 to 3, and ≥4 (Table 4, Fig. 5). Patients with more severe postoperative gastrointestinal dysfunction had a significantly higher incidence of gynecological malignant disease (66.7 % vs. 48.0 % vs. 17.5 %; p = 0.000). Although the number of previous abdominal surgeries was also higher, there was no significant difference regarding the duration of surgery and urinary volume. Postoperative maximum WBC count (8.32 vs. 10.07 vs. 10.47; p = 0.027) gradually increased and differed significantly, while postoperative minimum potassium (4.03 vs. 3.88 vs. 3.56; p = 0.024) decreased significantly with increasing severity. We also found that with increasing severity, the time to first get out of bed (2.00 vs. 2.00 vs. 3.00; p = 0.004), time to liquid diet (2.00 vs. 3.00 vs. 3.50; p = 0.018), and length of postoperative hospital stay (7.00 vs. 8.00 vs. 9.50; p = 0.001) were significantly longer. Furthermore, the incidence of postoperative complications such as abdominal pain (56.5 % vs. 84.0 % vs. 100.0 %; p = 0.002), abdominal distention (8.7 % vs. 36.0 % vs. 50.0 %; p = 0.000) and PONV (0.6 % vs.

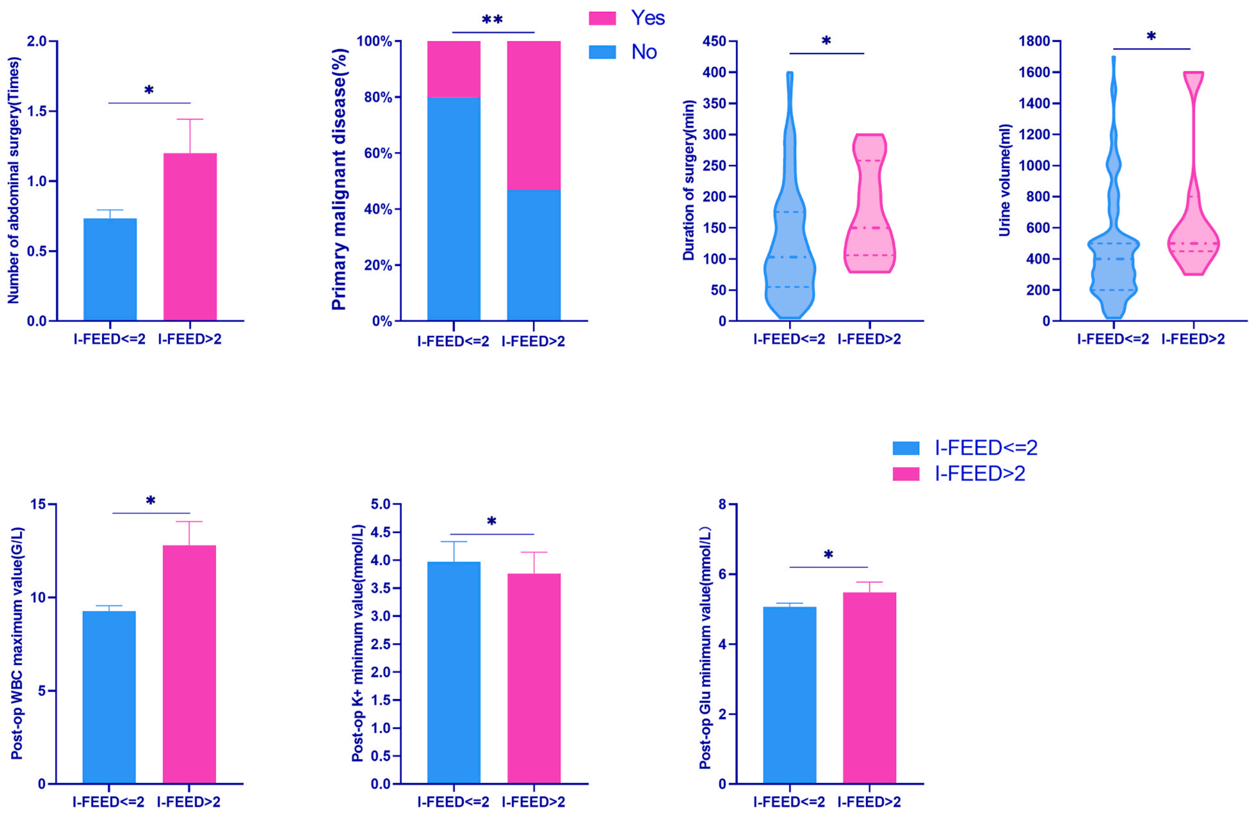

Fig. 2. Perioperative factors in Table 1 showing significant differences in patients from different I-FEED groups. *p < 0.05, **p < 0.005.

Table 2
Comparison of outcomes and complications in patients from different I-FEED groups.

	≤2 (n = 193)	>2 (n = 15)	*p* value
Outcomes			
Time to first flatus	2.00 (2.00,3.00)	2.00 (1.25,3.00)	0.339
Time to first feces	4.00 (3.00,4.00)	4.00 (2.25,5.00)	0.250
First time getting out of bed	2.00 (2.00,2.00)	2.00 (2.00,2.75)	0.022[a]
Time to liquid diet	2.00 (2.00,3.00)	3.00 (2.00,3.75)	0.015[a]
Postoperative hospital stay	7.00 (7.00,10.00)	8.00 (7.25,11.25)	0.004[a]
Complications			
Abdominal pain	112 (58.0 %)	15 (100.0 %)	0.00[a]
Abdominal distension	17 (9.0 %)	10 (66.7 %)	0.000[a]
PONV	16 (8.5 %)	10 (66.7 %)	0.000[a]
Inflammation	139 (79.0 %)	14 (93.3 %)	0.317

[a] Statistically significant (p < 0.05). Abbreviations: PONV: postoperative nausea and vomiting.

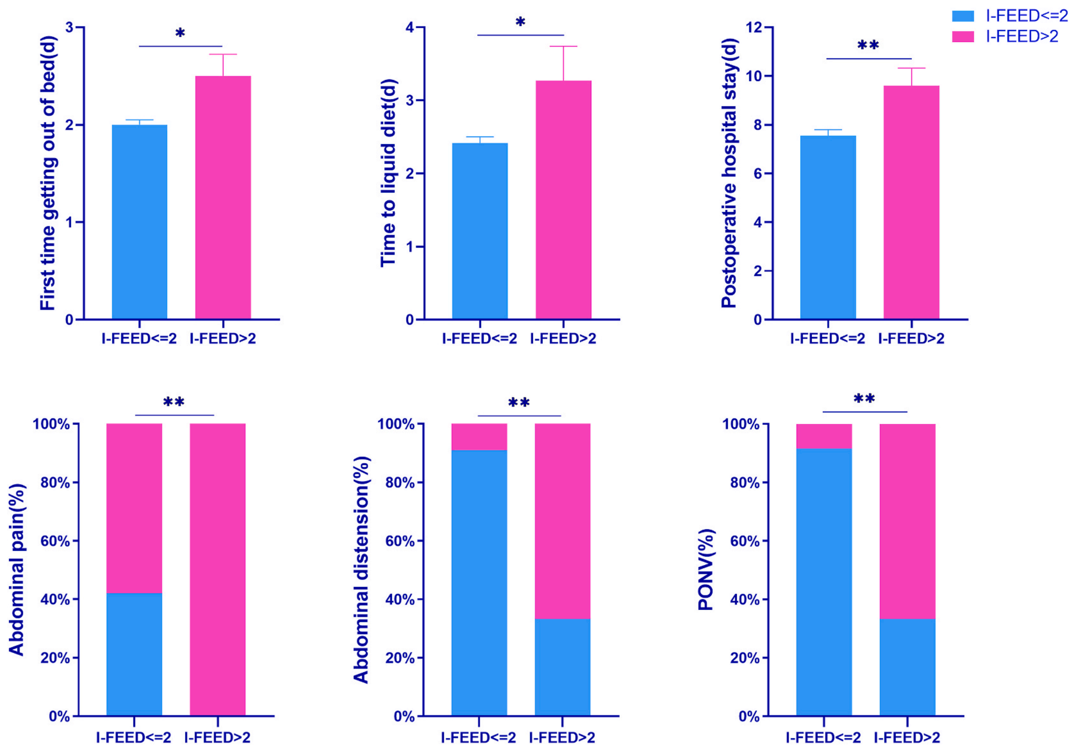

Fig. 3. Outcomes and complications in Table 2 showing significant differences in patients from different I-FEED groups. *p < 0.05, **p < 0.005.

80.0 % vs. 83.3 %; p = 0.000) were significantly increased.

3.4. Multivariate logistic regression analysis and preoperative scoring system

A multivariate logistic regression analysis was used to identify independent risk factors affecting gastrointestinal outcomes and the occurrence of complications (Table 5). For the I-FEED scores, a lower amount of preoperative oral laxatives (odds ratio [OR]: 0.983; 95 % confidence interval [CI]: 0.970–0997; p = 0.019), an increased number of previous abdominal surgeries (OR: 2.561; 95 % CI: 1.313–4.992; p = 0.006), malignant disease (OR: 12.242; 95 % CI: 2.573–58.251; p = 0.002) could increase the risk of an I-FEED score >2.

We created a preoperative scoring system based on the results of multivariable logistic regression that identified no preoperative oral laxatives, previous abdominal surgery and malignant diseases, assigning 1 point to each of these variables. A score of 0 predicted a 3.2 % risk of developing postoperative GI dysfunction. Patients with a score of 1 showed a risk of 5.5 %, and those with a value of 2 or more points had a risk of 19.4 % for the development of postoperative GI intolerance and dysfunction (Table 6). The area under the ROC curve (AUV) was 0.759 (95%CI 0.625–0.894; P = 0.001) (Fig. 6), the Hosmer-Lemeshow test was used to test the goodness of fit, and the test results showed that the model fit was good ($C^2 = 3.518$, p = 0.833).

Table 3
Separate analyses on patients with gynecological malignancies from different I-FEED groups.

	≤2 (n = 39)	>2 (n = 8)	*p* value
Preoperative preparation			
Dose of oral laxatives	177.69 ± 48.36	123.75 ± 46.58	0.006[a]
Surgical data			
Primary malignant disease			0.016[a]
ovarian cancer	15(38.5 %)	6(75.0 %)	
endometrial cancer	4(10.3 %)	2(25.0 %)	
cervical cancer	20(51.3 %)	0(0.0 %)	
the presence of procedures involving the bowel	11 (28.2 %)	3 (37.5 %)	0.921
Post-operation			
Na^+			
48 h	138.18 ± 3.49	134.56 ± 2.15	0.007[a]
Minimum value	135.91 ± 3.07	133.50 ± 2.75	0.046[a]
Mean value	138.02 ± 2.44	135.04 ± 1.95	0.002[a]
Complications			
Abdominal distension	6 (15.4 %)	6 (75.0 %)	0.002[a]
PONV	7 (17.9 %)	7 (87.5 %)	0.000[a]

[a] Statistically significant (p < 0.05). Except for the presence of procedures involving the bowel, only indices with significant differences are listed in Table 3.

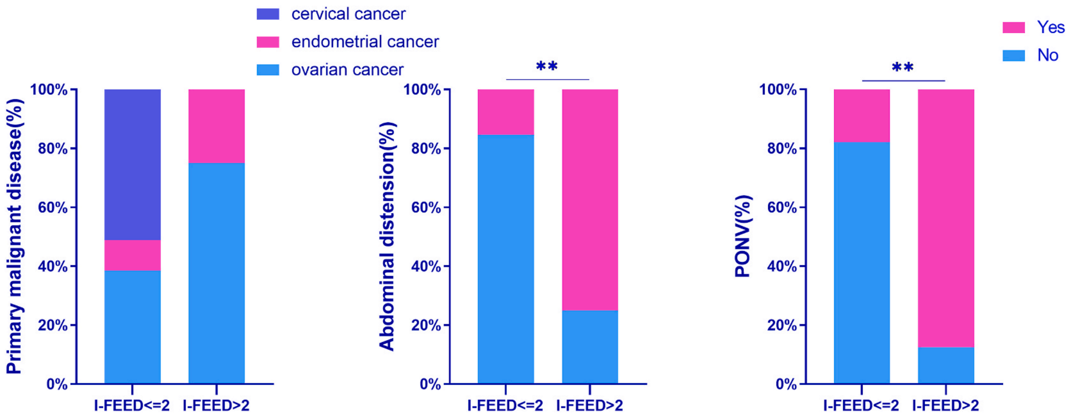

Fig. 4. Separate analyses on patients with gynecological malignancies from different I-FEED groups (Table 3). *p < 0.05, **p < 0.005.

4. Discussion

We found an incidence of 7.21 % for poor postoperative gastrointestinal recovery in gynecological patients, which was accompanied by poorer postoperative recovery outcomes. A higher number of previous abdominal surgeries and malignant primary disease may independently increase the risk of poor postoperative gastrointestinal recovery. The time to first getting out of bed, starting a liquid diet and postoperative hospital stay were significantly longer for those with poor postoperative GI function compared to those with normal GI function, as well as the incidence of postoperative complications, such as abdominal distension, abdominal pain and postoperative nausea and vomiting. The study established a preoperative scoring system, patients with a score of ≥2 points faced a 19.4 % risk of poor postoperative gastrointestinal recovery.

In this study, we found postoperative GI dysfunction prolonged hospital stay and increased postoperative discomfort, which was consistent with previous research [16,17]. A retrospective analysis of administrative databases to assess the impact of postoperative GI obstruction on healthcare resource utilization and costs was conducted by Iyer et al., in 2009 [7]. Of the 17,876 patients undergoing colectomy, postoperative GI obstruction occurred in 3115 (17.4 %) patients. The mean length of hospital stay was significantly longer for patients with postoperative GI obstruction compared to those without. Importantly, postoperative GI obstruction was found to be a significant predictor of hospitalization costs. Therefore, attention should also be paid to patients in good basic condition undergoing elective non-gastrointestinal surgery.

Secondly, we found that the time of postoperative GI function recovery was prolonged in patients with malignancy. The higher incidence of PONV in patients with malignant tumors is due to the increase of 5-hydroxytryptamine (5-HT) in gastrointestinal tissues caused by surgical operations, as 5-HT directly stimulates the chemosensory area of the vomiting center, resulting in nausea and vomiting [18]. Additionally, 5-HT is associated with mood disorders and autonomic dysfunction [19]. Different gynecological diseases have different effects on postoperative GI function. Cytoreductive surgery for ovarian cancer may have a more negative impact on gastrointestinal functional recovery compared to staging surgery for endometrial cancer or radical hysterectomy for cervical cancer.

Table 4
Subgroup analysis of factors in Table 1 showing significant differences.

	<2 (n = 177)	2-3 (n = 25)	> = 4 (n = 6)	*p* value
Number of abdominal surgery	1.00 (0.00,1.00)	1.00 (0.00,1.00)	1.5 (0.00,2.00)	0.350
Primary malignant disease	31 (17.5 %)	12 (48.0 %)[a]	4 (66.7 %)[a]	0.000
Duration of surgery (min)	103.00 (52.00,173.50)	150 (87.5220)	129 (100.75,227.50)	0.065
Urine volume	400 (200,500)	500 (300,600)	300 (300,400)	0.330
Post-operation				
WBC				
maximum value	8.32 (6.37,11.02)	10.07 (7.71,15.98)[a]	10.49 (7.41,16.22)	0.027
K^+				
Minimum value	4.03 (3.73,4.18)	3.88 (3.73,4.06)	3.56 (3.25,3.86)[a]	0.024
Na^+				
48 h	138.1 (136.7139.4)	137.9 (136,140.15)	135.4 (133.13,138.35)	0.187
Minimum value	137.65 (135.92,139.1)	136.3 (134.7139.15)	136 (131.05,138.35)	0.123
Mean value	138.1 (136.7139.46)	137.45 (136,139.92)	137.0 (133.05,138.51)	0.284
Glu	4.9 (4.4,5.5)	5.2 (4.8,6.0)	5.3 (4.15,5.65)	0.348
Minimum value				
Outcomes				
First time getting out of bed	2.00 (2.00,2.00)	2.00 (2.00,2.00)	3.00 (3.00,3.00)[a b]	0.004
Time to liquid diet	2.00 (2.00,3.00)	3.00 (2.00,3.00)[a]	3.50 (2.00,5.25)[a b]	0.018
Postoperative hospital stay	7.00 (5.00,8.00)	8.00 (7.00,11.00)[a]	9.50 (7.00,12.75)	0.001
Complications				
Abdominal pain	100 (56.5 %)	21 (84.0 %)[a]	6 (100.0 %)	0.002
Abdominal distention	15 (8.7 %)	9 (36.0 %)[a]	3 (50.0 %)[a]	0.000
PONV	1 (0.6 %)	20 (80.0 %)[a]	5 (83.3 %)[a]	0.000

[a] Statistically significant difference compared to I-FEED scores <2.
[b] Statistically significant difference compared to I-FEED scores of 2–3.

Endometriosis and a history of pelvic inflammatory disease are also likely to increase the possibility of pelvic adhesions, which can adversely affect GI function recovery.

Previous studies have demonstrated that undergoing abdominal surgery is an independent risk factor for postoperative intestinal obstruction, likely by increasing the likelihood of abdominal adhesions and the duration of surgery [20]. In addition, previous studies have shown that duration of surgery is related to postoperative GI function recovery, so we included it as one of the perioperative factors [21,22]. The duration of surgery in Table 1 was statistically significant. However, after subgroup analysis of malignant diseases and the severity (Tables 3 and 4), the results were not statistically different. This discrepancy may be attributed to the statistical difference accompanied by malignant diseases. Patients with an I-FEED score >2 have a higher proportion of malignant diseases and longer operation time, but this does not mean that operation time is a risk factor for poor postoperative GI function recovery.

This study found an association between postoperative minimum potassium levels and poor postoperative GI recovery. The lower the postoperative potassium level, the greater the degree of poor GI recovery, which was inextricably linked to smooth muscle cell contraction mechanisms. Potassium could promote smooth muscle cell depolarization, allowing voltage-dependent calcium channels to open and extracellular calcium to influx, followed by the contraction of smooth muscle cells [23]. However, the excitation-contraction coupling of gastrointestinal smooth muscle is significantly attenuated under hypokalemia. Previous clinical studies demonstrated the effect of perioperative hypokalemia on postoperative GI functional recovery [24,25]. In our study, routine preoperative oral potassium supplementation reduced the occurrence of perioperative hypokalemia in patients taking preoperative oral laxatives. We also found that the poor recovery group had a relatively high postoperative blood glucose level, which may be related to postoperative insulin resistance (PIR). PIR is a common metabolic disorder after elective surgery and is characterized by increased postoperative blood glucose levels and reduced insulin sensitivity [26]. Prolonged preoperative fasting for elective surgery can result in a loss of insulin sensitivity and an increased catabolic state in which protein and fat were broken down to compensate for the depletion of hepatic glycogen stores, thus producing endogenous glucose through glycogenolysis and gluconeogenesis. Additionally, postoperative insulin resistance can reduce postoperative intestinal function and increase complications such as fatigue and surgical site infection [26,27].

We constructed a preoperative predictive scoring system based on the independent risk factors associated with I-FEED score that can assess the probability of poor postoperative gastrointestinal function recovery in gynecological patients before surgery. In general, AUC >0.7 is considered sufficiently discriminatory for this scoring tool, and the Hosmer-Lemeshow test showed that the model fit was good. The scoring system allows gynecological practitioners to take targeted measures to promote postoperative recovery in patients with a higher probability. In 2016, the Enhanced Recovery After Surgery (ERAS) Society issued guidelines for perioperative care in gynecological/oncology surgery that detailed nursing measures to facilitate postoperative recovery [28,29]. However, these proven effective measures have not been adopted clinically in our hospital due to insufficient ERAS education in wards, difficulties with patients accepting the concept that differed from traditional clinical practice, and a shortage of nurses with insufficient time and energy to monitor patient compliance.

The strengths and limitations of the study should be acknowledged. In this study, grouping was based on I-FEED scores of composite indicators of gastrointestinal function, rather than subjective patient-reported data, and multivariable logistic regression avoided potential confounders, thus making independent risk factors for poor recovery of gastrointestinal function plausible. Furthermore, the

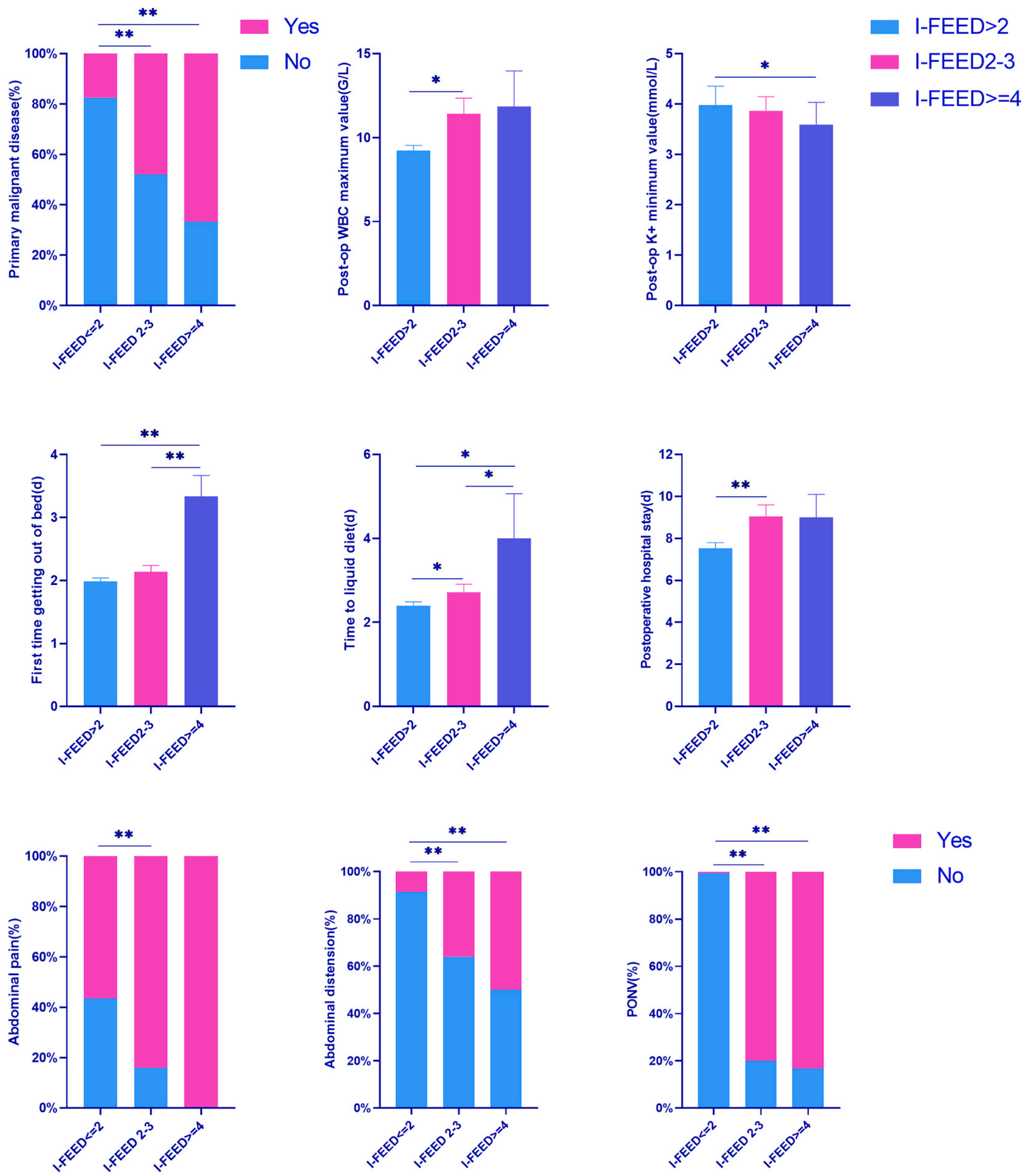

Fig. 5. Subgroup analyses on the severity of poor postoperative gastrointestinal recovery (Table 4). *p < 0.05, **p < 0.005.

different study population made the risk factors of postoperative GI function recovery more diversified, and verified the extrapolation of previous research results. Additionally, the preoperative risk scoring system was constructed which allowed gynecologists to take appropriate measures to reduce the incidence in high-risk population. The main limitation of our study is its retrospective nature with limited sample size. The low number of cases may be potential to introduce statistical biases. However, the appropriate statistical analysis method like multivariable logistic regression analysis was used to minimize bias. Additionally, all data were acquired from electronic medical records. Residents recorded patient outcome events using ‘day’ as the unit, thus resulting in a long time span and inevitable information bias. Moreover, there were the possible inclusion biases related to patient selection because we only included the patients without chronic diseases and organ dysfunction. Furthermore, the I-FEED score was carried out in a single hospital, it would be evaluated in other centers to become more significant. Validation sets are needed to further confirm the prediction models, and comparisons with the predictive effects of other prediction models are necessary.

5. Conclusion

The incidence of gynecological patients with poor postoperative gastrointestinal recovery was shown to be as high as 7.21 %

Table 5
Results of multivariate logistic regression of outcomes and complications.

	Factors	Parameter Estimate	Standard Error	OR (95%CI)	*p* value
Time to first flatus	Intraoperative blood loss	0.004	0.001	1.004 (1.003–1.007)	0.002
	Cleansing enemas	0.478	0.228	1.614 (1.033–2.521)	0.036
Time to first feces	Malignant disease	1.255	0.410	3.508 (1.570–7.841)	0.002
	Type of surgery	1.422	0.472	4.146 (1.643–10.462)	0.003
I-FEED	Dose of oral laxatives	−0.017	0.007	0.983 (0.970–0.997)	0.019
	Number of abdominal surgery	0.940	0.341	2.561 (1.313–4.992)	0.006
	Malignant disease	2.505	0.796	12.242 (2.573–58.251)	0.002
Abdominal pain	K^+48 h after surgery	−1.248	0.550	0.287 (0.098–0.843)	0.023
	Duration of surgery	0.006	0.003	1.006 (1.001–1.011)	0.023
	Inflammation	1.014	0.497	2.757 (1.041–7.305)	0.041
	BMI	1.164	0.059	1.179 (1.051–1.323)	0.005
Abdominal distention	Dose of oral laxatives	−0.011	0.005	0.989 (0.979–0.999)	0.035
	Malignant disease	1.808	0.600	6.099 (1.882–19.761)	0.003
PONV	$PaCO_2$	−0.104	0.050	0.901 (0.817–0.993)	0.035
	Malignant disease	3.060	0.758	21.335 (4.828–94.288)	0.000

Table 6
Likelihood of I-FEED scores >2 based on pre-operation scoring system.

Preoperative score value	Overall (n = 208)	I-FEED >2 negative (n = 193)	I-FEED >2 positive (n = 15)	*p* value
0	63 (30.3 %)	61 (96.8 %)	2 (3.2 %)	0.007
1	109 (52.4 %)	103 (94.5 %)	6 (5.5 %)	
≥2	36 (17.3 %)	29 (80.6 %)	7 (19.4 %)	

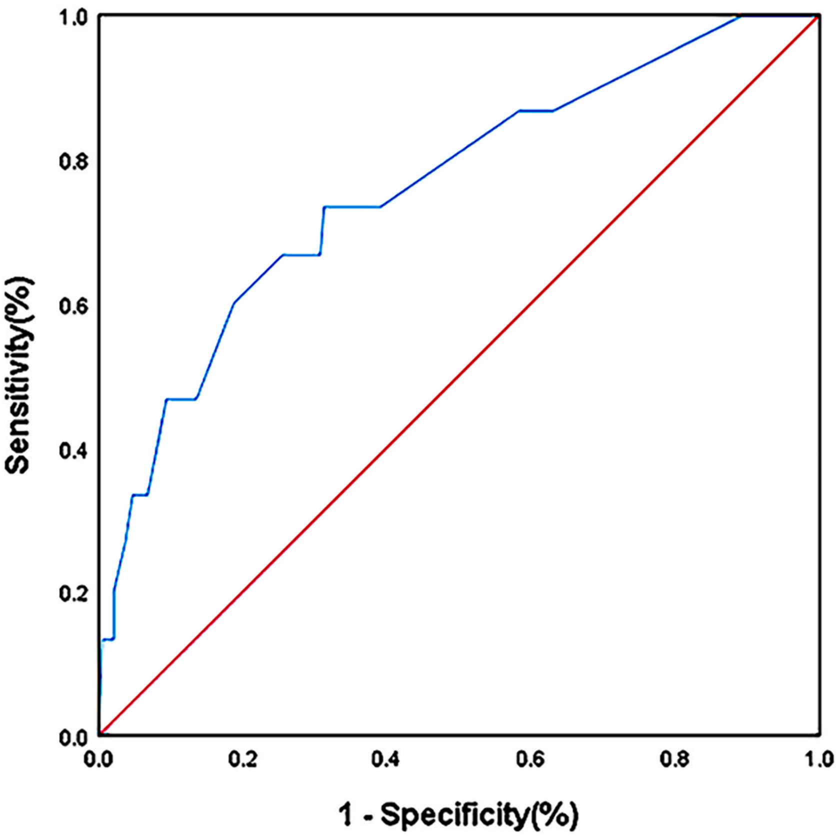

Fig. 6. Receiver operating characteristic (ROC) curve for logistic regression models predicting poor recovery of postoperative GI function.

accompanied with poorer postoperative recovery outcomes. We identified several risk factors, including the number of previous abdominal surgeries and malignant disease. A preoperative score prediction system was established; patients with ≥2 points had a 19.4 % risk of poor postoperative gastrointestinal recovery. Prospective studies need to be implemented to compensate for the deficiencies of this study and to precisely record the time of postoperative outcome events; this data would allow us to establish a more accurate predictive scoring system.

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Declaration of patient consent

Informed patient consent was waived of by the ethics committee as the data was anonymized and the retrospective nature of the study.

Registration of the research studies

The study has been registered at the China Clinical Trials Center (ChiCTR2200065525).

Ethical approval

The study was approved by the Ethics Committee of Wuhan Union Hospital (No. 2022-0789).

Data availability statement

Individual participant data will not be made available. The data analyzed during the current study will be available from the corresponding author on reasonable request.

CRediT authorship contribution statement

Beibei Wang: Writing – review & editing, Writing – original draft, Software, Methodology, Formal analysis, Data curation, Conceptualization. **Li Hu:** Investigation, Formal analysis, Data curation. **Xinyue Hu:** Software, Data curation. **Dong Han:** Software, Methodology, Data curation. **Jing Wu:** Writing – review & editing, Supervision, Resources, Project administration, Investigation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.heliyon.2023.e23706.

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